

**PRODUCTION EFFICIENCY, COMMERCIALIZATION AND ITS
IMPACT ON FOOD SECURITY OF SMALLHOLDER PULSE
PRODUCERS IN EAST GOJJAM ZONE, AMHARA REGION,
ETHIOPIA**

PhD. DISSERTATION

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**NOVEMBER, 2019
HARAMAYA UNIVERSITY, HARAMAYA**

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IMPACT ON FOOD SECURITY OF SMALLHOLDER PULSE
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ETHIOPIA**

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DOCTOR OF PHILOSOPHY
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**NOVEMBER, 2019
HARAMAYA UNIVERSITY, HARAMAYA**

HARAMAYA UNIVERSITY
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We hereby certify that we have read and evaluated this dissertation entitled “*Production Efficiency, Commercialization and Its Impact on Food Security of Smallholder Pulse Producers in East Gojjam Zone, Amhara Region, Ethiopia*” and has been prepared under our guidance by Assefa Tilahun. We recommend that it be submitted as fulfilling the dissertation requirement.

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DEDICATION

I would like to dedicate this dissertation to my sister, Alemitu Tilahun!

STATEMENT OF THE AUTHOR

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BIOGRAPHICAL SKETCH

The author was born in March, 1985 in Akena kebele in Awi zone Amhara Region. He attended his education (grade1-8) at Dangia primary school and grade 9-12 at Enjibara high school in Enjibara town. He joined Bahir Dar University and graduated his B.A degree in Economics in 2009 E.C. He was employed at Mertu Lemariam ATVET College and served for 7 years as Lecture position. Then he joined Haramaya University to pursue his MSc. Degree in Agricultural Economics in 2010 E.C. After completing his postgraduate study, he was employed by Wolaita Sodo University as a lecturer in the department of Agricultural Economics in October in 2013. He taught a number of undergraduate agribusiness and agricultural economics courses. After a year, he moved to University of Gondar and taught a number of undergraduate agricultural economics and agribusiness and value chain courses and conducts a number of researches. On top of rendering his professional services, the author has given a community services together with trainings. He then joined Haramaya University in October 2016/17 to pursue a study leading to the degree of *Doctor of Philosophy in Agricultural Economics*.

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ABBREVATIONS AND ACRONYMS

AE	Allocative Efficiency
ANOVA	Analysis of Variance
BCC	Banker Charnes and Cooper
BoARD	Bureau of Agriculture and Rural Development
CCR	Charnes, Cooper, and Rhodes
CI	Commercialization Index
CSA	Central Statistical Agency
DEA	Data Envelopment Analysis
DEAP	Data Envelopment Analysis Program
DMU	Decision Making Unit
DPPA	Disaster Prevention and Preparedness Agency
EE	Economic Efficiency
ECX	Ethiopian Commodity Exchange Authority
ERCA	Ethiopian Revenue and Custom Authority
LR	Likelihood Ratio
ML	Maximum Likelihood
MLE	Maximum Likelihood Estimation
MoFED	Ministry of Finance and Economic Development
PABRA	Pan African bean Research Alliance
SFA	Stochastic Frontier Analysis
TE	Technical Efficiency
TLU	Tropical Livestock Unit
UNECA	United Nation Economic Commission for Africa

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ABSTRACT

This study examines pulse producers production efficiency, commercialization and its impact on food security using a cross-sectional data obtained from 385 randomly and proportionately selected sampled households from East Gojjam zone, Amhara National Regional State of Ethiopia. Data were analyzed using descriptive statistics and econometric models including two limit Tobit, double hurdle, Binary Logit, Seemingly Unrelated Regression and Generalized Propensity Score. The mean technical, allocative and economic efficiency scores were found to be 72, 56 and 40 percent, respectively. This indicated that there exist substantial inefficiencies in pulse production in the study area. Technical, allocative and economic efficiencies are significantly affected by sex, education level, extension services, landholding size, access to improved seed, market information, livestock holding, off/non-farm participation and distance to development office. The mean commercialization index for the sample households was 0.345 which shows that on average a household sold 34.5% of his/her pulse produce. As a result, farm households' output commercialization levels fall in semi-commercial farming system. About 36.9%, 47.3% and 15.8% of the sampled households were categorized under low, medium and high commercialization levels respectively. The results of the first-hurdle showed that sex, landholding size, access to improved seed, market information and quantity of pulse produced influenced households' decision of market orientation behavior positively and significantly whereas distance to main road influenced it negatively. On the other hand, the results of second-hurdle indicated that the level of crop market orientation was positively and significantly influenced by education status, landholding size, extension contact, market information and quantity of pulse produced but it was influenced by distance to market negatively and significantly. Two limit Tobit model result showed that households' pulse output commercialization was positively and significantly influenced by access to improved seed, cooperative membership, landholding size, market information access and quantity of pulse produced and it was negatively and significantly influenced by family size and livestock owned. The survey result also revealed that 65.5% of the sample households were food insecure and 35.5% were food secure. In addition, the mean energy available per AE for the sampled households was 1625.5 Kcal. Food security of the farm households was positively and significantly influenced by credit access, chemical/pesticide used and income from pulses whereas it was negatively and significantly influenced by family size and distance to market. The simultaneous estimation result showed that there existed a positive relationship among commercialization with efficiency and food security. Moreover, the Generalized Propensity Score model result indicated that commercialization

has a positive and significant impact on food security of the smallholder pulse producers. Based on the findings, the study suggests that the government and stakeholders should focus on strengthening the provision of formal and informal education, promoting and empowering females, strengthen and clout policies on improving rural family planning ,strengthening the existing extension package program, strengthen the existing farmer cooperatives to reinforce farmer-to-farmer knowledge sharing, enhancing farmer's resource endowment, promotion of improved pulse varieties, improving crop-livestock production system and using recommended agronomic practices in pulse farming.

Keywords: Pulse, Efficiency, Market orientation, Commercialization, Food security, Double hurdle, Tobit, GPS, East Gojjam zone

1. INTRODUCTION

1.1. Background of the Study

Agriculture is main economic pillars of the Ethiopian economy and the overall economic growth of the country is highly dependent on the success of the agriculture sector. The sector represents 38.5% of the GDP of the country and about 72.7% of the population gains their livelihood directly or indirectly from agricultural production (NPC, 2016). Moreover, Ethiopian agriculture is dominated by smallholder farming which accounts for 85% of households farming less than 2 ha and 40% less than 0.5 ha (FAO, 2014).

Ethiopia is one of the top ten producers of total pulses in the world, the second largest producer of faba beans after China, the fifth largest producer of chickpeas and the second largest producer of pulses in the common market for eastern and southern African countries (COMESA region) following Sudan (USAID, 2010). In Ethiopia, pulses are the third largest export crop behind coffee and oil seed (Boere *et al.*, 2015).

According to CSA (2018) agricultural sample survey report in the main cropping season (Meher) of 2017/2018 about 8.32 million smallholder farmers cultivated 1.60 million hectares of land (12.61% of the total cultivated land) with pulse crops, from which about 29.80 million quintals of pulses (9.73% of the total harvested grain crop) was harvested. Faba beans, haricot beans, chickpea and field peas take the first four largest proportions which is about 9.21, 5.20, 4.99 and 3.68 million quintals respectively. Oromia, Amhara, SNNPR, and Tigray regions are the first four leading regions in producing pulses crops in the country. The total cultivated area under pulses in Amhara, Oromia, SNNPR, and Tigray regions was 42.40%, 39.91%, 14.75% and 2.3% million hectares of land, respectively. Considering the volume of production these four regions, Oromia, Amhara, SNNPR and Tigray regions take the largest percentage proportions which are 43.7%, 39.47% 13.31% and 1.19% respectively. Amhara and Oromia regions alone produce 83.17% of pulse crops.

Pulse crops, which occupy about 13% of cultivated land are critical to smallholder farmers' livelihoods in Ethiopia as these crops play a critical role in agricultural production,

economic growth through income generation and food security (Sitou and Mywish, 2011). Among the pulses, faba bean, field pea, chickpea, lentil, and grass pea are categorized as highland pulses and grown in the cooler highlands. These crops contribute to smallholder farmers' income, as higher-value crops than cereals and to diet, as a cost-effective source of protein that accounts for approximately 15% of protein intake (Tewodros, 2014). Pulses offer natural soil maintenance benefits through nitrogen-fixing which improves yields of cereals through crop rotation and can also result in savings for smallholder farmers from less fertilizer use. In addition to this, pulses used as feed resources for livestock which is the bottleneck to livestock production in the highlands of Ethiopia (Alemneh *et al.*, 2016).

Pulses contribute to smallholder livelihoods in multiple ways. Firstly, pulses can play a significant role in improving smallholders' food security, as an affordable source of protein (pulses make up approximately 15 percent of the average Ethiopian diet). Secondly, pulses can have an income benefit for smallholders, both in terms of diversification and because they yield a higher gross margin than cereals. Compared from the income benefits of diversifying from cereals (wheat, barley) to pulses (faba beans and chickpeas) for one smallholder farmer, results demonstrate that pulses are generally more profitable than cereals, giving smallholders an economic incentive to increase pulse production. As a protein source, pulses are more affordable for smallholders than meat, fish, and dairy products and for the 40 percent of Ethiopians who practice orthodox christianity, pulses become the single largest source of protein during the fasting period (FAO Stat, 2010). Pulses are central in many Ethiopian dishes, e.g. *shiro*, a popular pulse based sauce. Moreover, Ethiopians have a fasting period of over 200 days a year, and a range of pulses is consumed during this fasting period. Population growth, urbanization and income growth, in Ethiopia is expected to increase the demand for consumption of more processed pulse based foods (Koroma *et al.*, 2016; Alemneh *et al.*, 2017). More recently, in Ethiopia pulses became a substitute for meat due to exceptionally high prices of beef and mutton; households could have shifted to the consumption of pulses. Pulses are often consumed by the low-income groups because they cannot afford meat products (FAO, 2015).

The first Growth and Transformation Plan (GTP) of Ethiopia also gave special emphasis to agricultural growth to achieve food security and poverty alleviation (2010-2015). One of the core goals of GTP is agricultural growth program which aims at increasing productivity

to bring agricultural growth at the national level and maintain agriculture as a source of economic growth (MoFED, 2010).

Despite such policies focus on the sector over the last two decades, its productivity is constrained by lack of appropriate and affordable agricultural technologies, inefficiency in production, poor infrastructure, inefficient marketing systems, land degradation, rapidly expanding population, and inaccessibility to agricultural inputs such as improved/hybrid seeds, fertilizers and agro-chemicals (Arega and Rashid, 2005; Yu and Nin-Pratt, 2014). In addition, climate change, which is the principal causes for erratic rainfall and recurrent drought, is also another aggravating factor in the prevalence of low production and productivity of the sector (Abera, 2011). Besides, the sector mostly depends on rain-fed production system that is dominated by smallholders (MOA, 2011). As a result, the growth in agricultural output has failed to provide food for the fast growing population and thus aggravated the food insecurity situation in the country (Jon, 2007; Rehima *et al.*, 2013).

Improvement of agricultural productivity provides an important solution in addressing the problems of food insecurity and poverty, and enhancing the development of agriculture in Ethiopia. Consequently, attempts are being channeled in ways by which increased agricultural productivity can be achieved through promoting the use of improved agricultural technologies and improving the efficiency of production of pulse crops in Ethiopia (Yu and Nin-Pratt, 2014).

Commercialization of smallholder farming can essentially be described as a virtuous cycle in which farmers intensify their use of productive assets by enhancing technologies on their farms to achieve greater output per unit of land and labor expended, in producing greater farm surpluses (or transition from deficit to surplus producers), in order to expand their participation in markets, and ultimately raise their incomes and living standards (FAO, 2014). Commercialization of smallholder farmers has been viewed by the government as the major source of agricultural growth in Ethiopia. The government of Ethiopia implemented agricultural commercialization clusters with the primary goal of commercialization of smallholders' agriculture and agro-industrial development and offering a strategic entry point for private sector engagement (Pauw, 2017).

Smallholder commercialization occurs when a farmer participates in agricultural markets either as a seller or buyer. This can be achieved when a portion of the agricultural produce from the farmers is marketed and/or when part of the inputs are acquired from the agricultural markets (Pingali, 1997; Osmani and Hossain, 2015). Smallholder commercialization can be ensued in two ways; either by increasing productivity and marketed surplus of the food crops or by focusing on cash crops (Osmani and Hossain 2015; Sharma and Wardhan, 2015).

Commercialization may influence nutrition through various channels including changes in income, the availability of own-produced foods and gender roles within the farm household (von Braun and Kennedy, 1994; Carletto et al., 2015).

Through productivity and market improvements, the critical role of pulses in smallholder livelihood and food security can be expanded. The current productivity of pulses falls significantly below the demonstrated potential. For example, current average chickpea yields are 1.2 metric tons per hectare. Estimates suggest that productivity gains from improvements in planting techniques could double overall pulse production to two million tons over a period of five years. This gain in productivity would not only increase smallholder income by 40 to 70% per hectare but would also ensure greater food security through meeting domestic pulse demand. In addition, Ethiopia could expand its foreign market presence through increased production levels, which will lead to at least doubling of its current annual exports of about 140,000 tons. Even under conservative assumption of proportionate increase in domestic consumption and export, doubling production will result in at least doubling of export earnings from US\$90 million to US\$180. If the domestic production remains at the current level, export earnings will be far greater (CSA, 2012).

The concept of food security was originated in the mid-1970s. The initial focus of food security was primarily on food availability and to some degree the price stability of basic food stuffs at the international and national level (Clay, 2002; FAO, 2005). Thus, in the 1970s the issue of food security was the national food supply's capacity to meet the population's energy and nutrient needs. The concept of household food security has been understood by many development workers as the availability of food in the world market place and on the food production systems of developing countries (Bedeke, 2012).

As indicated by Africa Food Security and Hunger/Undernourishment Multiple Indicator Scorecard, Ethiopia ranked as first in having the highest number of people in state of undernourishment/ hunger. Ethiopia is the fourth African country in which the population were being undernourished/ in hunger (ADB, 2014). The livelihoods of rural Ethiopian people are highly sensitive to climate. Food insecurity patterns are seasonal and linked to rainfall patterns, with hunger trends declining significantly after the rainy seasons. Climate related shocks affect productivity, hamper economic progress and exacerbate existing social and economic problems (Anderson *et al.*, 2015).

Food insecurity situation in Ethiopia is highly linked to severe, recurring food shortage and famine, which are associated to recurrent drought. Droughts and other related disasters (such as crop failure, water shortage, and livestock disease, land degradation, limited household assets, low income) are significant triggers which increase vulnerability to food security and undermined livelihoods (MoARD, 2009). UNICEF (2014) reported that about 10% of Ethiopia's citizens are chronically food insecure and this figure rises to more than 15% during the frequent drought years. WFP (2014) found long-term effects of chronic malnutrition cost Ethiopia approximately 16.5% of its GDP each year.

Food insecurity is an enduring, critical challenge in Ethiopia which is Africa's second populous country after Nigeria. Over 80% of Ethiopian population live in rural areas and are heavily dependent on rain-fed agriculture; this makes them extremely vulnerable to changes in weather conditions (Anderson *et al.*, 2009). The current El Niño drought conditions led to a sharp deterioration in food security; the estimated number of food insecure people was 4.5 million due to this vulnerable shock in August, 2015 and by the end of the same year this figure had more than doubled (FAO, 2015).

Catley *et al.* (2016) reported that the 2015 El Niño drought is one of the strongest droughts that have been recorded in Ethiopian history were more than 27 million people become food insecure and total population of 18.1 million people require food assistance in 2016. Furthermore, there is evidence that climate is already changing leading to serious drought. The drought pattern has been 10 years in case for Ethiopia, but at present time the cycle period is becoming shorter and shorter which leads to serious food security problems in every three years (Abayineh and Belay, 2017).

The Government of Ethiopia released the 2015 Humanitarian Requirement Document (HRD) which identifies humanitarian food and non-food requirements for vulnerable groups in the country following on the multi-sectoral ground assessment conducted at the end of 2014 (UNICEF, 2015). According to HRD an estimated 2.9 million people require relief food assistance in 2015 which showed an increase from 2.7 million for the same period in 2014.

1.2. Statement of the Problem

The unique features of sub-Saharan African agriculture that represent special challenges in terms of agricultural performance include:- dominance of weathered soils of poor inherent fertility; predominance of rain-fed agriculture, little irrigation and very limited mechanization; heterogeneity and diversity of farming systems and poorly functioning markets for inputs and outputs (Binswanger-Mkhize, 2009).

Ethiopian agriculture is dominated by subsistence, low input-low output, rain-fed farming system. Most smallholder farmers in Ethiopia were still cultivate using hoe and rely heavily on family labor. The farming system is focused on producing food staples to meet subsistence needs. In many parts of the country, market participation of smallholder family farms are limited and agricultural markets are fragmented and not well integrated into wider market systems, which increases transaction costs and reduces farmers' incentive to produce for the market (Bezabih, 2010; Mitku, 2014).

The majority of farmers in Ethiopia are subsistence smallholders, with little separation between production and consumption decisions (Muller, 2014). Smallholders in Ethiopia are known for their resource constraints such as capital, inputs and technology; their heavy dependence on household labor; their subsistence-orientation and their exposure to risk such as reduced yields, crop failure and low prices (Mahelet, 2007; Diao *et al.*, 2010).

The majority of the Ethiopian population is dependent on rain-fed agriculture as the major source of livelihood, but the agricultural production and productivity showed a declining trend from the 1960s onwards. Until the 1950s, Ethiopia was sufficient in staple food and indeed exporter of food crops. From the early 1960s onwards, developing countries like

Ethiopia has experienced poverty and chronic food insecurity mainly caused by high population growth, land degradation, lack of appropriate technologies, land tenure insecurity, scarcity of farmland, drought, variability and unpredictability of rainfall (Fransen and Kuschminder, 2009).

At the farm level, productivity appears to be severely constrained by many factors. One factor is limited or no use of chemical fertilizers for pulses (e.g., phosphates) - Studies in Ethiopia and elsewhere have demonstrated the productivity benefits for pulses from phosphate fertilizers (e.g., super- phosphates) in particular. Fertilizer use in Ethiopia is comparatively low, averaging 25 kg/ha of nutrients and much of this is currently applied on cereals. Lack of fertilizer use can be subscribed to a limited access to credit, lack of import (especially of phosphate fertilizers) into the country and lack of awareness of the benefits of the use of such fertilizers. Very limited availability of improved seeds (most pulses are grown from unimproved cultivars with low genetic potential). The use of conventional agronomic practices (e.g., sub-optimal crop rotations, poor seed bed preparation) is another factor. While agronomic practices such as the timing of plowing, fertilizer and insecticide applications, crop rotation, and weeding and harvesting are critically important to achieve optimum productivity, many farmers seem unaware of their benefits. Limited knowledge of best practices for overall agronomic practices and post-harvest management has resulted in poor quality, low yielding pulses (Chilot *et al.*, 2010).

The application of chemical fertilizer and improved seeds is quite limited despite government efforts to promote the adoption of modern and intensive agricultural practices. There is limited access by smallholder farmers to agricultural inputs, financial services, improved production technologies, irrigation and agricultural markets. These problems combined with poor land management practices have led to severe crop productivity (Chanyalew *et al.*, 2010).

The potential of pulses such as beans, peas, chickpeas, lentils, and other pulse crops help to address future global food security, nutrition and environmental sustainability needs has been acknowledged through the UN declaration of the 2016 International Year of Pulses. However, the full set of benefits that pulse crops can offer has not been systematically characterized. For both large and small farmers, pulses represent important economic opportunities to boost income and reduce risk by diversifying their crop and income stream

portfolio. Pulses could help address future needs for protein, help minimize soil degradation, and support diversification in food production and consumption. The livelihood and development impacts of increased pulse production and consumption must be better understood by the food sector, by pulse producers, and by governments, based on empirical evidence and known examples in both developed and developing countries (Gabrielle, 2016).

Despite the importance agriculture transformation, smallholder farmers face many challenges either in the production or the commercialization process. Such challenges make some observers pessimistic about agricultural development approaches that focus on smallholders (Diao *et al.*, 2010; Collier and Dercon, 2014). The transformation for agriculture based growth requires the use of production technology, finances, logistics, and marketing skills and facilities to which smallholder farmers do not have easy access. In most cases, the limited access is a consequence of institutions related factors such as poor access to extension and financial services as well as lack of good infrastructure (Poulton *et al.*, 2010).

Though market liberalization policies were aimed at opening up new market-led opportunities for economic growth, their results were mixed in most countries. Many smallholder producers continue to engage in subsistence agriculture and thus unable to benefit from commercialization opportunities presented by the liberalized markets (Olwande and Mathenge, 2011; Wollvertton *et al.*, 2014).

The dynamics and feasibility of smallholder commercialization in improving food security situation is an important policy issue. The commercial behavior of smallholders and the commercialization scale at which they are operating is also a critical research question to be addressed since smallholder commercialization policies are usually designed under such conditions. Various studies on smallholder commercialization generally suggest that there is very low scale of commercialization in Ethiopian agriculture with differentiated factors determining the market orientation and commercialization decisions of rural households (Mamo *et al.*, 2009; Bedaso *et al.*, 2012).

According to Abu (2015) smallholder commercialization requires more than just well-functioning output markets, but also efficient and low cost factor markets that truly reflect

opportunity cost of farm inputs. Such conditions are usually a problem in the poor regions especially in Africa, whereby smallholders may not be able to purchase inputs due to liquidity problems or higher transaction costs and malfunctioning markets (Latruffe and Desjeux, 2014).

Through increasing household market participation, commercialization of smallholder agriculture has a direct and usually positive impact on value chain actors such as input suppliers, output traders, transporters, processors, financiers and others. The positive impacts could be due to economies of scale created from increased demand and supply that tend to decrease average cost per unit of operation. Negative effects could arise due to the fact that these commodities usually demand higher use of external inputs such as pesticides and herbicides that could have an adverse effect on the environment (Moti *et al.*, 2009).

MoFED (2013) reported that among the varieties of shocks Ethiopian households face, food insecurity and food price shocks are the most common ones. Half of the food insecure population of the Sub Saharan Africa is found in Ethiopia, which is one of the seven food insecure country in Sub Sahara Africa. As pointed out above UND (2013) also reported, in human development index, Ethiopia ranked 173rd out of 186 countries. On the other extreme it seems a paradox to hear that Ethiopia is one among the seven fastest growing country in the world while it is also being reported that in Human Development Index (HDI) Ethiopia is at the lower level. An accurate assessment of food insecurity, in terms of identifying who the food insecure are as well their number, location and the underlying causes of food insecurity will enable stakeholders to design appropriate interventions (WFP, 2014).

Numerous studies have confirmed that there is a presence of food insecurity problem in Ethiopia with a wide range of area to be covered and large number of people to be attended for different identified causes of the food security problem. Among these causal factors per capita land holding with increasing population growth, livestock availability, education, per capita income of the households from agricultural and non-agricultural activities, soil fertility, conflict, are the major and commonly mentioned factors (Madeley, 2010).

Past empirical studies did not explicitly estimate the impact of agricultural commercialization on the food security status and poverty among the sampled rural farm

households rather most of the studies focused on the determinants of crop market participation decisions (de Landry *et al.*, 2011). There have been efforts to develop agricultural production through input use, promotion of small scale irrigation based horticultural crops production and provision of training to farmers so as to increase farm output and enhance crop commercialization towards achieving increased household income and food security. Some information is available in the literature on the household income and livelihood in areas of relatively abundant rains and better to markets access (Mitiku, 2014; Aman *et al.*, 2014). According to CSA (2016) report, Amhara region is the second largest pulse producer next to Oromia Region. In Amhara region, East Gojjam zone is also the second pulse producer zone next to North Shewa zone even though the production system was at small scale level. The study by Achenif *et al.*, (2016) showed that the livelihood and food security situation of the rural population in Amhara region is getting unstable; and smallholder farmers remain prone to income risk. Thus, with the ever-increasing population and the limited farmland, meeting the challenge of improving rural incomes will require some form of transformation of the subsistence, low-input and low-productivity farming systems to agricultural commercialization. Many literatures have concentrated on exploring the determinant and extent of agricultural commercialization to smallholder farmers but leaving the gap to conduct researches on the impact of agricultural commercialization that are growing food crops especially pulse production. Thus, this study was initiated to analyze production efficiency, commercialization and its impact on food security status of smallholder pulse producers in the study areas. In radiance of these big issues, the study was designed and executed to answer the following key research questions

1. What are the levels of technical, allocative and economic efficiencies and which factors were responsible for the inefficiency differentials among smallholder pulse producers?
2. What are the factors that determined market orientation and commercialization level of pulse producers?
3. What is the status of food security for smallholder pulse crops producers and what were the factors that determine food security?
4. What interdependences exist among production efficiencies, commercialization and food security status of smallholder pulse producers?
5. Did pulse commercialization improve the food security status of smallholder producers?

1.3. Objectives of the Study

The general objective of this study was to analyze and generate information on the important factors influencing efficiency, commercialization and its impact on food security status of smallholder pulse crops producers in East Gojjam zone, Amhara National Regional State.

The specific objectives of the study are to:

1. Measure the level of technical, allocative and economic inefficiencies and identify Sources of inefficiencies of pulse producers;
2. Identify the factors determining market orientation and commercialization of pulse producers;
3. Measure the status of food security and identify the factors affecting it;
4. Examine the interdependence of households' food security status with their crop production efficiencies and commercialization level and
5. Analyze the impacts of pulse commercialization on food security status of smallholder producers in the study areas.

1.4. Significance of the Study

The measurement of efficiencies (technical, allocative and economic) had remained an area of important research both in developing and developed countries. This was especially important in developing countries, where resources were insufficient and opportunities for developing and adopting better technologies are diminishing. Given the current technological conditions and the structure of production in Ethiopia, pushing the production area further is difficult due to the already existing pressures on the land (ADB, 2011).

An understanding of the relationships between efficiency, commercialization and farm-specific practices would provide policy makers with information to design programs that can increase the food production potential of smallholder farmers (Msuya *et al.*, 2008). The efficiency measurement is very important in any area of production because it is a factor

for productivity growth. It would help to indicate a possibility of increasing production without increasing the consumption of inputs/factors of production or decreasing the level of inputs and hence reduce total production cost without decreasing the level of output. Low productivity is mainly due to inefficient use of resources and low level of agricultural technology adoption. Low productivity also leads to low income and low level of living standard. In order to restrain this situation, knowing the causes of inefficiency in production and the reasons for low level of market oriented production system in the area through empirical studies was too essential. Understanding efficiency measurements also gave evidence on proper managerial activities in terms of efficient use of scarce resources.

Estimating the level of production efficiency among smallholder farmers was a crucial factor that helps much to improve efficiency in production. In addition to this, identifying the different factors contributing to the inefficiency were very important in order to formulate a better policy for intervention in order to bring a desired change in agricultural production system. Especially in the areas where resources were scarce, making such measurements and identifying their determinants were highly important to improve production and productivity without incurring additional investment.

Moreover, this study would be used as an input for researchers, extension workers and policy makers and for other stakeholders where policy recommendations were drawn for the improvement of production and productivity of pulse crops and commercialization decision to make interventions in areas of various agricultural policies for enhancing food security.

1.5. Scope and Limitations of the Study

This study was carried out in highland pulse crops-based farming systems of selected woredas of East Gojjam zone, Amhara National Regional State. The study was also limited only giving due attention to deal with smallholders' production efficiency, commercialization and its impact on food security status of pulse crop producers at the study woredas. Moreover, this study investigated the existing pulse crops production and commercialization decisions which were mainly based on a cross sectional survey data

obtained through household interviews in the selected kebeles of the study woredas based on the information generated from the sample households' survey during a single cropping season. The other limitation of this study was completely depended on people's perception to identify the food security level of households. Furtherly, the possible limitation of this study was the non-representativeness of the selected sample households to other farming systems, elsewhere in Ethiopia.

1.6. Organization of the Dissertation

This dissertation was organized into five parts. Chapter one was the introduction of the thesis that sets out the background information, research questions, objectives, problem statement and highlighting the significance of the study. Chapter two reviewed theoretical, analytical and empirical works related to economic efficiency, commercialization, food security and impact of commercialization on food security. Chapter three discussed the estimation procedures, descriptive and econometric techniques employed. Results and discussions were presented in part Four. Finally, chapter five summarized the findings and recommendations of this study.

2. LITERATURE REVIEW

This chapter reviews the definitions, theoretical, methodological, analytical frameworks and empirical studies conducted on production efficiency, commercialization and food security status on smallholder pulse producers. The theoretical review provides the background that supports investigation and offers justification of the research problem and used to construct theoretical framework used in the study. The empirical literature provides evidence from past studies related to the subject and the gaps to be filled by this study. The review also provides insights on key variables and analytical models used in examining and identifying the factors affecting production efficiency, commercialization and food security of smallholder pulse producers.

2.1. Definition of Basic Terms and Concepts

2.1.1. Efficiency

It is defined in terms of optimum production possibilities that comparing between observed and optimal values of its output and input. The comparison can take the form of the ratio of observed to maximum potential output obtainable from the given input, or the ratio of minimum potential to observed input required to produce the given output, and this efficiency is said to be technical (Lovell, 1993).

Efficiency of a farm is an indicator to its success in producing as large amount of output as possible given a set of inputs. Moreover, for determination of efficiency of a particular firm, there is a need for efficiency measurement through the production factor inputs and processes (Omonona *et al.*, 2010).

Technical efficiency (TE): Refers to the achievement of the maximum potential output from given amounts of inputs, taking into account physical production relationships. Koopmans (1951) and Farrell (1957) put forth that TE is measured within two main frameworks: input and output-oriented. In an input-oriented framework, TE gives the potential input reduction that a farm could apply without reducing its output level. In an output-oriented framework, TE gives information about the potential output increase that a

farm could implement without increasing its use of inputs. In the case of constant returns to scale, both orientations give close results.

According to Koopmans (1951), a producer is technically efficient if an increase in any output requires a reduction in at least one other output or an increase in at least one input, and if a reduction in any input requires an increase in at least one other input or a reduction in at least one output. Thus, a technically inefficient producer could produce the same outputs with less of at least one input, or could use the same inputs to produce more of at least one output.

Allocative Efficiency (AE): Refers to the ability to combine inputs and outputs in optimal proportions in the light of prevailing prices. Hence, AE shows whether the use of different proportions of production factors guarantees the attainment of maximum production with a particular market price (Koopmans, 1951; Farrell, 1957). Unlike TE concept that only considers the process of production, AE concept pertains to the idea that society is concerned with not only how an output is produced, but also with what outputs and balance of output are produced (Hensher, 2001).

Allocative efficiency in economic theory measures a firm's success in choosing an optimal set of inputs with a given set of input prices; this is distinguished from the technical efficiency concept associated with the production frontier, which measures the firm's success in producing maximum output from a given set of inputs (Lovell, 1993).

Economic Efficiency (EE): It is the product of technical and allocative efficiencies. It can be interpreted as the potential reduction in production costs (cost efficiency) or the potential increase in revenue (revenue efficiency) that a farm could apply in order to operate at the point of TE and AE. EE enables conclusions to be drawn on whether the farm operates at optimal or suboptimal size.

In economic analysis, efficiency is generally defined in a number of related ways including: the use of resources in such a way as to maximize the production of goods and services; or comparison of what is actually produced or performed with what can be achieved with the same level of resources (land, capital, labor, time, etc...). In fact, the concept of efficiency is relative and differs from productivity. Productivity is the ratio of

what was produced and what was spent to produce while efficiency compares what has been produced, given the resources available, with what could have been produced with the same resources (Fellipe *et al.*, 2012).

2.1.2. Commercialization

Commercialization refers to the progressive shift from household production for auto-consumption to production for sale in the market. This shift entails that production and input decisions are based on profit maximization, reinforcing vertical linkages between input and output markets (Olwande *et al.*, 2015).

Agricultural commercialization: defined as a shift from household production for home-consumption to production for sale in the market. This shift entails that production and input use decisions are based on profit maximization, reinforcing vertical linkages between input and output markets (Olwande *et al.*, 2015). Agricultural commercialization is a process involving transformation of subsistence agriculture to market-oriented production that tends to impact income, consumption and nutritional setup of the farm households (von Braun, 1995).

Agricultural commercialization is a process involving transformation of agriculture to market oriented production which tends to impacts income, consumption and nutritional setup of the farm households (von Braun, 1995). Importantly, it is more than producing surplus output to the market and thus includes household's decision behavior on product choice and input use based on the principle of profit maximization (Pingali and Rosegrant, 1995).

Agricultural commercialization involves the transition from subsistence farming to increased market-oriented production. It is commonly measured as the ratio of percentage value of marketed output to total farm production (Haddad and Bouis, 1990). Market-oriented production entails modernization of systems, which depends heavily on the intensification of production processes, adoption of new technology and farm mechanization. As the marketed share of agricultural output increases, input utilization decisions and output combinations are progressively guided by profit maximization objectives. This process leads to the systematic substitution of non-traded inputs with

purchased inputs, the gradual decline of integrated farming systems, and the emergence of specialized high-value farm enterprises (Omiti *et al.*, 2006).

Sokoni (2007) defined commercialization of smallholder production as a process involving the transformation from production for household subsistence to production for the market. Hazell *et al.* (2007) found out that most definitions refer to agricultural commercialization as the degree of participation in the output markets with the focus very much on cash incomes.

Smallholder commercialization occurs when a farmer participates in agricultural markets either as a seller or buyer. This can be achieved when a portion of the agricultural produce from the farmers is marketed and/or when part of the inputs are acquired from the agricultural markets (Pingali, 1997; Osmani and Hossain, 2015).

Market Orientation: A smallholder is market oriented if his production plan follows market signals and produce commodities that are more marketable. Under a semi-commercial system, where both market and home consumption are playing a central role in production decision, all crops produced by a household may not be marketable in the same proportion. Market orientation in agriculture is basically a production decision issue. Thus, market orientation is defined as the degree of allocation of resources (land, labor and capital) to the production of agricultural produce that are meant for exchange or sale (Berhanu and Moti, 2012).

Market orientation of smallholder agriculture leads to a gradual decline in real food prices due to increased competition and lower costs in food marketing and processing (Jayne *et al.*, 1995). These changes improve the welfare of smallholder farmers in two ways: for consumers, low food prices increase the purchasing power for food, while for producers a decline in food prices enables the reallocation of limited household incomes to high-value non-food agribusiness sectors and more profitable non-farm enterprises. Promoting investments in agricultural commercialization could reduce poverty but requires great shifts in priority setting in the rural and peri-urban areas of Kenya (Alemayehu *et al.*, 2008).

Market participation: Refers to any market related activity which promotes the sale of produces (Key et al., 2000).

Output Market Participation: It refers to household participation in output markets as the proportion of the value of sold crop to total crop harvested, expressed in percentage (Birhanu and Moti, 2010).

2.1.3. Food Security

Food security is defined by different agencies and organizations differently without much change in the basic concept. UN (1990) defines household food security as the ability of household members to assure themselves sustained access to sufficient quantity and quality of food to live active healthy life. Food security can be described as status in which production, markets and social systems work in such a way that food consumption need of a country and its people a real ways met.

FAO (2008) defines food security not only in terms of access to and availability of food, but also in terms of resource distribution to produce food and purchasing power to buy food, where it is produced. It has the same concept with the four dimension of food security: availability, accessibility, utilization and food system stability.

USAID (2005) defined food security as: when all people at all times have both physical and economic access to sufficient food to meet their dietary needs for a productive and healthy life. Here food security includes at a minimum the availability of nutritionally adequate and safe food and assured ability to acquire acceptable foods in socially acceptable ways (e.g. without resorting to emergency food supplies, scavenging, stealing, or other coping strategies).

2.1.4. Impact Evaluation

Impact evaluation is a particular evaluation which is structured around one particular type of question: What is the impact (or causal effect) of an intervention on an outcome of interest? (Gertler *et al.*, 2011). Ezemenari *et al.* (1999) put the same question as what would have been the welfare levels of particular communities, groups, households and

individuals in the absence of an intervention? Therefore, an impact evaluation looks for the changes in outcome that are directly attributable to a given intervention is answering particular cause-and-effect question (Gertler *et al.*, 2011). It is concerned with the net impact of an intervention on households and institutions, attributable only and exclusively to that intervention (Khandker *et al.*, 2010; Ezemenari *et al.*, 1999).

2.2. Theoretical Framework

2.2.1. Efficiency Theory

According to Greene (1997) the frontier production function defined as an extension of the familiar regression model based on the microeconomic premise that a production function represents some sort of ideal, the maximum output attainable given a set of inputs. In practice, the frontier production function is a regression where the estimation of the production function is implemented with the recognition of the theoretical constraint that all observations lay below it, and it is generally a means to another end, the analysis of efficiency. A measure of efficiency emerges naturally after the computation of the frontier production function, since it corresponds to the distance between an observation and the empirical estimate of the theoretical ideal. The estimated models provide a means of comparing individual agents, either with the ideal production frontier or with each other, and also provide point estimates of variables' effect on efficiency which a measure of efficiency of a firm consisting two components: technical efficiency which measures the ability of the firm to obtain the maximum output from given inputs; and allocative efficiency, which measures the ability of the firm to use inputs in optimal proportions given their prices. Computing these efficiency measures involves estimating the unknown production frontier (Coelli and Rao, 2005).

Farrell (1957) assumed that observed input per unit of output values for firms would be above the so-called unit isoquant. The unit isoquant defines the input-per-unit-of-output ratios associated with the most efficient use of the inputs to produce the output involved. The deviation of observed input-per-unit-of-output ratios from the unit isoquant is considered to be associated with technical inefficiency of the firms involved.

A more general presentation of Farrell's concept of the production function (or frontier) is depicted in Figure 1 involving the original input and output values. The horizontal axis represents the vector of inputs X , associated with producing the output, Y . The observed input-output values are below the production frontier, given that firms do not attain the maximum output possible for the inputs involved, given the technology available. A measure of the technical efficiency of the firm which produces output, Y , with inputs, X , denoted by point A, is given by y/y^* , where y^* is the frontier output associated with the level of inputs, X (see point B). This is an input-specific measure of technical efficiency.

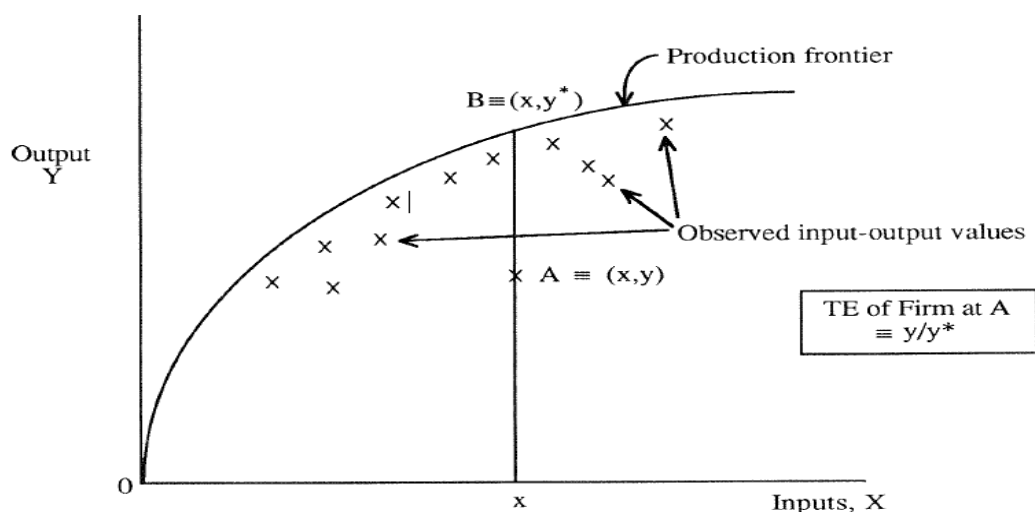


Figure 1: Technical efficiency of firms in input-output space

Source: Battese (1991)

Farm households operating at any point along the production frontier are technically efficient or it is an efficient subset of this feasible production set, whereas farm households operating at point A are inefficient because they could increase output to the level of frontier line without requiring more input. Then, points below the frontier are not technically efficient, and technical efficiency shows the physical relationship of input and output. More generally, if the actual production point lies on the production frontier, it is perfectly efficient. If it lies beneath the frontier then it is technically inefficient.

According to Coelli *et al.* (2005) if information on prices is available, and a behavioral assumption, such as cost minimization or profit maximization, is appropriate, then performance measures can be devised which incorporate this information. In such cases it is possible to consider allocative efficiency, in addition to technical efficiency. Allocative

efficiency in input selection involves selecting that mix of inputs (e.g., labor and capital) that produces a given quantity of output at minimum cost (given the input prices which prevail). Allocative and technical efficiency combine to provide an overall economic efficiency measure. Both can be measured by input or output approach. In the input approach, we evaluate the ability to minimize inputs keeping outputs fixed, whereas in output approach we evaluate the ability to maximize outputs keeping inputs fixed (Farrell, 1957).

To illustrate the distinction between technical efficiency and productivity, let us take one input and one output case by considering a production frontier described by the curve of (Figure 2) and the slope of the ray y/x that provides a measure of productivity. The farmer operating at point A is technically inefficient because he/she could increase the output to the level of the farmer that is operating at point B without requiring more input, indicating higher productivity at point B. However, by moving to the point C, where the ray is tangent to the production frontier defines the point of maximum possible productivity which is a productivity increase attained by scale economies. This is an example of exploiting scale economies which is the point technically optimal scale, while operation at any other point of the production frontier results in lower productivity.

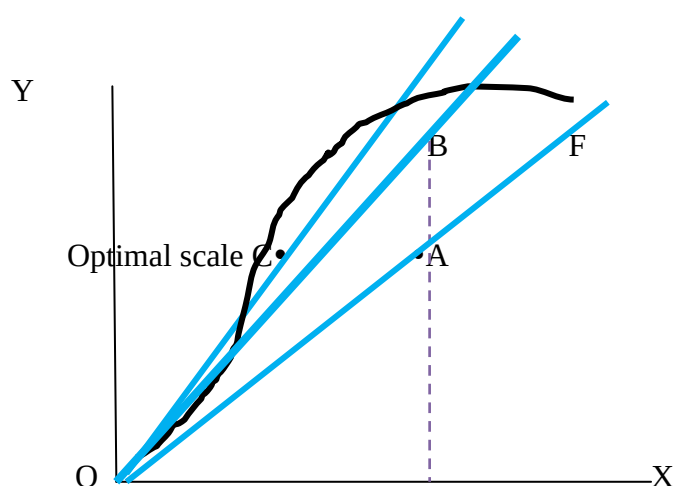


Figure 2: Productivity, technical efficiency and scale economies

Source: Coelli (2005)

Economic theory assumes that producers optimize both from a technical and economic perspective: (1) from a technical perspective, producers optimize by not wasting productive resources and (2) from an economic perspective producers optimize by solving

allocation problem involving prices (Kokkinou, 2010). According to Singh (1986) productive efficiency constitutes three components: technical, allocative, and over all individual production (economic) efficiencies. Other economists like Färe *et al.* (1985) and Antle and Capalabo (1988), have tried to include scale efficiency in addition to technical and allocative as components of production efficiency. Scale inefficiency is the situation where the firm is unable to operate at its constant returns to scale (CRS), at a long-run competitive equilibrium. AE reflects the ability of a firm to use the inputs in optimal proportions, given their respective prices and the production technology.

For economists, the critical criterion applied to evaluations of policies and programs is economic efficiency. Essentially, overall EE is attained when individuals in society maximize their utility, given the resources available in the economy. This is called achieving ‘Pareto efficiency,’ or ‘reaching the utility frontier’. With this allocation of resources no one can be made better off without making someone else worse off, nor could the winners from a reallocation compensate the losers (Kaldor’s extension of Pareto efficiency). This criterion takes the initial distribution of resources (and utility) as given, and only considers changes from this state (Productivity Commission, 2013).

2.2.2. Commercialization Theory

2.2.2.1. Theoretical foundation of agricultural commercialization

Majority of developing countries’ population live in rural areas and mainly dependents on subsistent agriculture as a source of livelihood. Transformation of the agricultural sector through commercialization has been seen as the most viable way to address the pervasive high levels of rural poverty and food insecurity. This view dates back to theoretical work of Johnston and Mellor (1961) that closely analyzed the role of agriculture in economic development in the context of William Arthur Lewis’ Dual Economy growth model. Johnston and Mellor (1961) argued that increased agricultural productivity (especially agricultural labor productivity) is necessary in order to free rural labor that is needed in the industrial sector. Increased agricultural productivity is also necessary to enlarge the size of the market for industrial outputs because rural farming households often constitute the bulk of the market for a wide range of consumer goods produced by the industrial sector. This increased productivity can be achieved through commercialization where households

specialize in production of goods for which they have comparative advantage (Johnston and Mellor, 1961).

The other theorists synthesized agricultural commercialization as a sequence of a transformation process going through three stages that can be seen in the lens of Rostow's theoretical model of economic development stages (Wharton, 1963; Timmer, 1988; Todaro, 1989 and Pingali and Rosegrant, 1995). These authors identified three stages of agricultural transformation from a low productivity traditional agriculture to a high productivity commercial sector. The first and most primitive is the low-productivity, purely subsistence peasant farming (Todaro, 1989) characterized by use of mainly non-traded and household generated inputs with the main production objective being food self-sufficiency (Pingali and Rosegrant, 1995). The second stage is what Todaro (1989) called "diversified" or "mixed" family agriculture, where part of the crop is grown for self-consumption and part of it is sold. This second stage is what Pingali and Rosegrant called semi-subsistence production that employed both traded and non-traded farm inputs with focus to production for both household consumption and surpluses for the market (similar to transition stage of Wharton, 1963). Finally, the third stage was identified as that representing the "modern" farm, exclusively engaged in high productivity, "specialized" agriculture geared to the commercial market what can qualify as commercial agriculture (Todaro, 1989) or a fully commercialized agricultural system where inputs are mainly bought and profit maximization is the main objective (Pingali and Rosegrant, 1995; Pingali, 1997). Therefore, these theoretical works suggest that rural economic growth and development policies should focus more on moving the agricultural sector rapidly from first stage through the second stage and ultimately to third stage.

Pingali *et al.* (2005) have cautioned that although agricultural commercialization is theoretically believed to emphasize specialization, it is not just restricted to production of the so called "cash crops". Production of marketable surplus of staple food crops is usually the most common initial form of commercialization among smallholder peasant farmers (Moti *et al.*, 2009). Due to pervasive market failures in most developing countries, commercialization can only offer the possibility of some level of diversification into non-staple cash crops but not total specialization. Therefore, smallholder farmers can commercialize either in main staple crops and/or cash crops depending on their agro-ecological and market circumstances. However, this does not preclude the theoretical

argument that these farmers will tend to be more specialized in the long run. It therefore follows that in modeling agricultural commercialization in developing countries with pervasive market failures, the most appropriate model to adopt is the non-separable household utility maximization (Ellis, 1993; Vance and Goeghegan, 2004). This non-separable household utility maximization follows the standard consumer theory with a caveat that there exists imperfect market information (de Janvry *et al.*, 1991).

2.2.2.2. Farm households' crop production decision and commercialization

A farm household is assumed to be commercialized if it is producing a significant amount of cash commodities, allocating a proportion of its resources to marketable commodities, or selling a considerable proportion of its agricultural outputs (Immink and Alarcon, 1993). However, the meaning of commercialization goes beyond supplying surplus products to markets. It has to consider both the input and output sides of production, and the decision-making behavior of farm households in production and marketing simultaneously (Pingali, 1997).

The commonly accepted concept of commercialization is that commercialized households are targeting markets in their production decisions rather than being related simply to the amount of product they would likely sell due to surplus production (Pingali and Rosegrant, 1995). Production decisions of commercialized farmers are based on market signals and comparative advantages, whereas those of subsistence farmers are based on production feasibility and subsistence requirements, and selling only whatever surplus product is left after household consumption requirements are met (Birhanu *et al.*, 2007).

Accordingly, three types of commercialization indices at household level can be specified. These are output and input side commercialization, commercialization of the rural economy and degree of household's integration into the cash economy (von Braun *et al.*, 1994). Output and input side agricultural commercialization indices of a household, respectively, measure proportion of agricultural output sold to the market and input acquired from market to the total value of agricultural production. Commercialization of the rural economy, on the other hand, is defined as the ratio of the value of goods and services acquired through market (including in kind exchange) transactions to total household income. Finally, the degree of household integration to the cash economy or

market is measured as the ratio of the value of goods and services acquired by cash transaction (not kind) to the total household income (Pingali and Rosegrant, 1995).

Household crop commercialization index as defined by Strasberg *et al.* (1999) is the total gross value of all crops sold as a percentage of total gross value of all crops produced. The household crop commercialization index measures the extent to which household crop production is oriented toward the market. A value of zero would signify a totally subsistence-oriented household; the closer the index is to 100, the higher the degree of commercialization. As commonly used in literature, household commercialization level can be categorized into three as low (less than 30%), medium or semi commercial (between 30% and 65%) and high or commercial (65% and above). It is also possible to categorize commercialization levels into two or four depending on the observed household differences or distribution of the commercialization scale. However, for binary choice modeling, it is necessary to determine a cutoff point between commercial and noncommercial (subsistence), semi commercial and commercial, or semi commercial and noncommercial (Leavy and Poulton, 2007).

2.2.3. Food Security Theories

Concern with food security can be traced back to the world food crisis of 1972-1974 and beyond that at least to the Universal Declaration of Human Rights in 1948, which recognized the right to food as a core element of an adequate level of living. Food security as a concept emerged at the United Nations Food and Agriculture Organization (FAO) World Food Conference in 1974. It is centered on two sub-concepts; food availability and food entitlement. The first, food availability refers to the supply of food available at local, national or international levels. The second, food entitlement refers to the capability of individuals and households to obtain food (Majda, 1999).

The focus on household food security is on the household as the most basic social unit in a society. The distinction between food security and household food security is important because activities directed towards improving household food security may be quite different from those aimed at improving national level food security. The latter often is more related to macro level production, marketing, distribution and acquisition of food by the population as a whole (FAO, 2003).

As a result of the famine that became rampant globally, the concept of food security was elaborated by a number of scholars. For example, while operationalizing food insecurity, the Food and Agricultural Organization (FAO) focused on securing access to food, necessary for an active, healthy life by the most vulnerable people. Around, 1994, a broader perspective of food security was adopted by the United Nations Development Program to include food security as a necessary element of human rights. Starting in 2001, the concept of food security was further expanded to include food and nutrition status (food availability, food access, food utilization) and stability (vulnerability and resilience), and food security was expected to exist “when all people, at all times, have physical, social and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life” (FAO, 1996; DFID, 2003).

The Rome Declaration of World Food Summit (1996) described three major dimensions of food security as availability, accessibility and utilization. The implications of these three dimensions at national, household and within household level are different. Sustainability is the outcome of availability and accessibility. At all three levels it measures the standard of living and economic and social standing of the country in the world; the household within the country and the individual within a household (Hina, 2001).

2.3. Methodological Frameworks

2.3.1. Measurement of Efficiency

Many different approaches have been applied by many researchers to measure efficiency changes in various types of institutions, and levels of decision-making units as well. Further, different approaches to efficiency measurements give different numeric answers. Therefore, it is essential to select appropriate measurements for efficiency to avoid measurement bias in results (Bozec *et al.*, 2006).

There are two approaches that can be used to measure efficiency in production: non-parametric and parametric frontier approaches. A parametric approach is exemplified by stochastic frontier, while Data Envelopment Analysis (DEA) for non-parametric approach.

Parametric frontier approaches: The Stochastic frontier Approach (SFA) was developed independently by Aigner *et al.* (1977) and Meeusen and Van den Broeck (1977). SFA is a parametric method where the error term is decomposed in a regression model into inefficiency component and measurement error component; $\varepsilon_{ij} = v_{ij} - u_{ij}$ where ε_{ij} is the error term, v_{ij} the measurement error, and u_{ij} the inefficiency component. The model is recommended when analyzing farm level data where measurement error, some missing information and presence of risks factors are likely to have a significant impact (Coelli, 1996). SFA approach can be extended to measure inefficiencies in individual production units based on some distributional assumptions for the u_{ij} on the technical and economic inefficiency scores. These assumptions are based on functional forms used in the analysis; half normal distribution for Cobb-Douglas forms, truncated normal for Trans-logarithmic forms and exponential distribution for generalized Leontief models (Mbagha *et al.*, 2003).

The models for SFA allow for estimation of standard errors and tests of hypotheses using maximum likelihood methods which cannot be possible with deterministic models because they violate certain maximum likelihood assumptions (Jondraw *et al.*, 1982; Ali and Flinn, 1989). However, a serious shortcoming with SFA is that there is no priori justification for the selection of any particular functional form for the inefficiency component. In parametric frontier methodology the selection of specific functional form may not represent the reality (Mersha, 2004). Moreover, Coelli *et al.* (1998) indicated that the SFA is appropriate for single-output technologies; unless cost-minimizing objective is assumed.

To solve the limitation of deterministic approach of Aigner and Chu (1968) and Timmer (1971) designed a method that involves dropping a percentage of firms closest to the estimated frontier, and re-estimating the frontier using the reduced sample. The arbitrary nature of the selection of some percentage of observation to omit has meant, however, that Timmer's probabilistic approach has not been widely followed (Coelli, 1995). Finally, Aigner *et al.* (1977) and Meeusen and Van den Broeck (1977) independently come up with the estimation of Stochastic Frontier Production (SFP) function, where the disturbance term has two components; the error component (v) and the stochastic noise (u). The principal advantage of SFA is the introduction of stochastic random noises that are beyond the control of the farmers. A second advantage of the approach is that it allows statistical test of hypothesis pertaining the goodness of fit of the model and test the degree of inefficiency. However, the major disadvantages of this approach are that it imposes explicit

restriction on functional form and requires specification of the technology, which may be restricted in most cases (Coelli and Battese, 1996; Coelli *et al.*, 2005).

Non-parametric frontier models: Data Envelopment Analysis (DEA): Data Envelopment Analysis (DEA) was developed mainly based on Farrell's work (Farrell, 1957). In DEA the production of an efficiency frontier is based on the concept of Pareto optimum. The Decision Making Units (DMUs) that lie on the efficient frontier are non-dominated and thus called Pareto optimal units or efficient DMUs. They are assigned an efficient index of one, while those that do not lie on the efficiency frontier are regarded as relatively inefficient with positive efficiency indices of less than one.

Data Envelopment Analysis (DEA) is flexible and can accommodate multiple inputs and outputs with different units. It doesn't require an assumption of a functional form relating inputs to outputs. It uses a non-parametric piecewise linear production frontier in estimating efficiency. A DEA, which is both non-parametric and non-stochastic model, may be either input-oriented or output-oriented. Both output-oriented and input-oriented DEA models produce the same efficiency estimate for a farm under the assumption of constant returns to scale in production. Under the variable returns to scale the estimates of efficiency will differ (Mohammad and Erandi, 2003).

According to Coelli *et al.* (1998), it is necessary to select orientation from input oriented DEA model or output oriented DEA model according to which quantities the decision maker has more control over. Smallholder farmers in the study areas have more control over inputs than outputs. Accordingly, input oriented DEA model was used in the study. Besides, it is pointed out that constant return to scale DEA model is only appropriated when all firms are operating at optimal scale. However, it is not possible to hold this assumption in agriculture in the study areas since smallholder farmers face constraints. As a result the constant returns to scale DEA model was applied for this study.

The outcomes of DEA of this study were efficiency scores which represent performance indicators as 1= best performance and 0= worst performance. The best of efficient DMUs lie on the frontier while the inefficient ones lie below the frontier. The efficient DMUs can be considered as benchmark of the inefficient DMUs. The inefficient DMUs can improve

their performances to reach the efficient frontier by decreasing their current input levels (Cooper *et al.*, 2006).

Coelli *et al.* (1998) summarized the following advantages of DEA: it can handle multiple inputs and multiple outputs, it doesn't require an assumption of a functional form relating input to outputs, it doesn't require a priori assumption with regard to the distribution of inefficiency parameter as in the case of parametric frontier models and it is unit invariant. Furthermore, according to Ajibefun (2008), the major advantage of the non-parametric frontier analysis is that it does not require the specification of a particular functional form for the technology.

The major advantage of the non-parametric approach to efficiency measurement is that it does not require the specification of a particular functional relationship between inputs and outputs. The production frontier is primarily estimated using field data and measure efficiency relative to the constructed frontier using linear programming approaches. However, the main disadvantage is that it is deterministic rather than stochastic, meaning that all deviations from the frontier are attributed to inefficiency only so it takes no account of the possible influence such as random shocks like measurement errors and other noises in the data and hence the approach is sensitive to outliers (extreme observations) and data measurement errors. A second disadvantage of the approach is that it is not possible to estimate parameters of the model and hence impossible to test hypothesis concerning the performance of the model. A third disadvantage of the approach is that the estimated function has no statistical properties, and hence the estimated production frontier has no statistical properties to be evaluated upon (i.e. Mathematical programming procedure produces estimates without standard error, t-ratio, and so forth) (Coelli and Battese, 1996).

Despite of there are limitations, this study used the data envelopment analysis (DEA). This is due to the fact that besides those drawbacks the approach has its own advantages as well. DEA permits one to assess the relative efficiency of a given producer using series of inputs and outputs. Moreover, the technique does not require an assumption for a specific production function to be used. More importantly, the decision maker does not need prior information about weights of inputs and outputs which reflect the relative importance of the different inputs and outputs. In addition, for each decision making unit (DMU),

efficiency is compared to that of an ideal operating unit rather than to the average performance.

2.3.2. Measurement of Market Orientation and Commercialization

Measuring Market Orientation Index (MOI): The market orientation and commercial scale of farm households can usually be divided into two binary values or three ordinal scales (as non-commercial, semi-commercial, and commercial), depending on the distribution of the commercialization scale (Samuel and Ludi, 2007; Samuel and Sharp, 2007; Bedaso et al., 2012).

This study assesses the commercialization of smallholder production from the output side. This was achieved by employing the household commercialization index (HCI) to determine household specific intensity of commercialization (von Braun, 1994; Strasberg *et al.*, 1999, Martey *et al.*, 2012).

The most widely adopted measurements of agricultural commercialization are the three household level indices developed by von Braun, *et al.*, (1994), that is, output and input side commercialization; rural economy commercialization; and degree of a household integration into the cash economy. For each type of commercialization, the authors formulated indices that can be used to measure the extent of household commercialization. First, the household commercialization index (HCI) measured the proportion of the value of agricultural output sold in the market and purchased inputs to the total value of agricultural production (eqn. 1 and eqn. 2). The two indices basically measured household participation in output and input markets respectively. The focus of this study is agricultural commercialization measured by the proportion of the value of agricultural output sold in the market to total value of agricultural production (Eqn. 1).

$$HCI_o = \frac{\text{Total Value of Agricultural Sales in the Market}}{\text{Total Agricultural Production Value}} \quad (1)$$

$$HCI_i = \frac{\text{Total Value of Inputs Acquired from the Market}}{\text{Agricultural Production Value of all inputs}} \quad (2)$$

Then, household's market orientation index in land allocation is derived from equation (1) as

$$MOI_i = \sum_{k=1}^{k=k} \alpha_k \frac{L_{ik}}{tL_i}; tL_i > 0 \text{ and } 0 \leq MOI_i \leq 1 \quad (3)$$

Where MOI is market orientation index of the household i , L_{ki} is amount of land allocated to crop k , and tL_i is the total crop land cultivated by the household i .

2.3.3. Measuring Household Food Security Status

There are different methods of measuring food security situation. These are individual food intake data, household calorie acquisition, household dietary intake method and the USD 18-item core module.

2.3.3.1. Individual and household food intake data

Individual food intake data is a measure of the amount of calories, or nutrients, consumed by an individual in a given time period, usually 24 hours. As summarized by Hoddinott (1999), there are two basic approaches used to collect these data: observational and recall. An enumerator resides in the household throughout the entire day, measuring the amount of food served to each person, and the amount of food prepared but not consumed is also measured. In the recall method, the enumerator interviews each household member regarding the food they consumed in the previous 24-hour period. Data collected on quantities of foods are expressed in terms of their calorie content, using factors that convert quantities of edible portions into calories. These intake data are compared against a definition of food needs. Individual calorie requirements reflect individual characteristics such as age, sex, weight, body composition, disease states, genetic traits, pregnancy and lactation status, and activity levels, as well as other factors such as climate.

A typical approach to measure individual food intake data is to begin with a reference person, say a 60-kilogram man somewhere between 30 and 60 years undertaking moderate activity. This yields a calorie requirement of approximately 2900 kilocalories per day. Individual requirements for children are made on the basis of their age and sex to yield ‘adult equivalents’. A minimum requirement for a low-activity existence 8 hours sleeping, one hour walking, 15 hours standing or sitting quietly is 2050 kilocalories or 70 percent of that required in order to undertake light activity. For this reason, this lower

figure is often used as a cutoff to determine whether an individual is consuming enough to meet his food needs. However, it should be stressed again that there is no universal agreement on these figures, and estimates of “basic requirements to meet food needs” range from 1885 to 2500 kcal (FAO, 1996; Hoddinott, 1999; Smith and Subandoro, 2007).

This method has two principal advantages: implemented correctly, it produces the most accurate measures of individual calorie intake (and other nutrients) and therefore the most accurate measure of food security status of an individual. Second, because the data are collected on an individual basis, it is possible to determine whether food security status differs within the household. The disadvantages are that these measures of intakes need to be made repeatedly in order to account for within person and within household day-to-day variations in nutrient intake. It requires highly skilled enumerators who can observe and measure quantities quickly and accurately.

2.3.3.2. Dietary intake method

In this method of food security analysis, one or more persons within the household are asked about different items that they have consumed in a specified period. These questions can be asked to different household members where it is suspected that there may be differences in food consumption among household members. Determining which items should appear on comprehensive lists can be done via rapid appraisal exercises, discussions with key informants, and references to previous survey work. The responses on all types of food items for the same question can be summarized in a table (Kennedy *et al.*, 2011).

For ease of analysis, the number of different seven or 12 food groups consumed, depending on the guideline and methodology used, should be calculated, rather than the number of different foods. Knowing that households consume more of an average number of food groups implies that their diets offer more diversity in both macro and micronutrients. This is a more meaningful indicator than knowing that households consume specific number of different foods, which might all be cereals. These food groups as reported in the FAO food balance sheet are cereals, roots/tubers, legumes, milk/milk products, eggs, meat/offal, fish/sea food, oil/fat, sugar/honey, fruits, vegetables, and others (Swindale and Ohri-Vachaspati, 2005).

A diverse diet is a valid welfare outcome in its own right for the fact that consuming a wide variety of foods so as to enhance dietary quality, in addition to longer-standing concerns regarding quantities of consumption, is important. The disadvantage of this measure is that the simple form of this measure does not record quantities. If it is not possible to ask about frequency of consumption of particular quantities, it is not possible to estimate the extent to which diets are inadequate in terms of calorie availability. The attractive features of this measure are that it is easy to implement, it directly captures notions of adequacy and vulnerability, and the questions asked are easy to understand. The disadvantage is that it is a subjective measure and comparison across households or localities is problematic which may lead to misreporting (Bickel *et al.*, 2000; Kennedy *et al.*, 2011).

The other method of measuring dietary diversity developed by Smith and Subandoro (2007) considers seven food groups: (1) cereals, roots, and tubers; (2) pulses and legumes; (3) dairy products; (4) meats, fish and seafood, and eggs; (5) oils and fats; (6) fruits; and (7) vegetables. The household-level measure underlying household diet diversity is calculated by counting the number of foods or food groups from which each household acquired food over the survey reference period. The steps for doing so when food groups are used as the basis for calculation include (1) bringing in the data containing the cleaned metric food quantities acquired by each household, (2) assigning a food group to each food, (3) creating a new data containing the mean of the food group variable for each household, (4) creating a variable with all cases equal to one, and (5) counting the number of food groups by creating a new data containing the sum of the variable with all cases equal to one.

A variant of this method of measuring dietary diversity at household and individual level developed by Kennedy *et al.* (2011) has improved the shortcoming of many methods. The dietary diversity questionnaire has the same question on consumption of 16 food subgroups and yes or no answers are recorded. Responses on the 16 food subgroups are aggregated into 12 major food groups in order to calculate the household dietary diversity scores. Some food groups in the dietary diversity questionnaire are combined into a single food group to create the dietary diversity scores. The responses can also be used to compute women's dietary diversity scores in the same manner. The potential score range is 0-12 for household dietary diversity scores and 0-9 for women. There are, however, no established

cut-off points in terms of number of food groups to indicate adequate or inadequate dietary diversity scores. Because of this, it is recommended to use the mean score or distribution of scores for analytical purposes and to set program targets or goals.

2.3.3.3. Household calorie acquisition

Households' calorie intake or acquisition is the number of calories, or nutrients, available for consumption by household members over a defined period of time. The principal person responsible for preparing meals is asked how much food is prepared over a period of time. After accounting for processing, this is turned into a measure of the calories available for consumption by the household. A set of questions regarding food prepared for meals over a specified period of time, usually either 7 or 14 days is asked to the person in the household most knowledgeable about this activity (Smith and Subandoro, 2007; Kennedy *et al.*, 2011).

Taking data on one-week period may have an advantage over two weeks in that it is easier for households to remember what has happened since the same day last week. The day of the week can help set up a specific memory post of the beginning of the recall period in respondents' minds, bounding the period (Smith and Ali, 2007). After the data is collected using seven days recall, the data will be converted to kilocalorie using the food composition table manual (Ethiopian Health and Nutrition Research Institute/EHNRI, 1997). Then the converted data will be divided to household Adult Equivalent (AE) to identify whether the household is food secure or insecure. Then the results will be compared with the minimum subsistence requirement per AE per day (*i.e.* 2100 kcal). Households who consume below this minimum requirement (2100 kcal per AE per day) will be categorized as food insecure and those households who consume above the threshold will be considered as food secure.

Measurements undertaken as part of the survey work should determine the equivalent standard measures based on the unit of measurement used in the survey. The number of calories available in a type of food will be computed by taking the converted standard quantity and multiplying it by the number of calories available in one kilogram of the food type (based on the content of 100 grams). The per capita calorie availability can be estimated by dividing the household calorie availability by the number of household

members with the appropriate weights given to age, gender, and type of activity (WHO and FAO, 1985; Kennedy *et al.*, 2011). Therefore, for this study Household caloric acquisition was used to analyze the food security status of the households.

2.4. Analytical Framework

2.4.1. Analyzing Determinants of Production Efficiency

The literature also suggests two analytical approaches for analyzing the determinants of efficiencies of crop production. The first approach advocates a one stage simultaneous estimation approach in which the inefficiency effects are expressed as an explicit function of a vector of various independent variables. This approach is best suited to estimate only determinants of technical inefficiency as in Coelli and Battese (1995) but, the procedure has been criticized due to inability of estimating determinants of allocative and economic inefficiencies (Bravo-Ureta and Rieger, 1991). Various studies such as Ephraim (2007), Elibariki *et al.* (2008), Otitoju and Arene (2010) and Shumet (2011) employed this approach to identify the determinants of technical inefficiency of crop production.

The second approach is two-stage estimation procedure in which first efficiency scores are derived employing either parametric and/or non-parametric approaches. In the next step the derived efficiency score is taken as dependent variable and is then regressed on explanatory variables using either OLS or two-limit Tobit models. Following the latter approaches, studies by Endrias *et al.* (2010) and Aye and Mungatana (2010) used two-limit Tobit model, whereas Arega and Reshid (2005) applied OLS method to identify the determinants of efficiencies of maize production. The use of OLS model in such types of dependent variables which takes values between 0 and 1 leads to the problem of heteroskedasticity so that parameter estimates obtained are inefficient, thus classical hypothesis tests, such as t-ratios are inappropriate (Gujarati, 1995). On the other hand, two-limit Tobit model is best suited for such types of dependent variable (efficiency scores) and yield the efficient estimates for unknown parameter vector (Maddala, 1999). The rationale behind using a Tobit model was that there were bounded natures of efficiency between 0 and 1 (Hussein, 1989; Greene, 1991).

Thus, in this study, two-limit Tobit model was applied to identify determinants of technical, allocative and economic efficiencies of pulses producers.

2.4.2. Determinants of Market Orientation

In analyzing the decision for and the level of market orientation past studies used different analytical models such as, ordinary least squares, simultaneous regression, double-hurdle, Logit, Cobb-Douglas, Probit and Tobit models. Such studies generally used either independent or simultaneous decision making as per their area of interest.

In analyzing the decision for and the level of market orientation, past studies used the double-hurdle model since it has the implicit advantage of being flexible to accommodate either sequential or simultaneous decision making of households and provides for the possibility of using same or different determinants in each one of the two commercial orientation hurdles (Key *et al.*, 2000; Holloway *et al.*, 2005; Bellmare and Barrett, 2006; Adam, 2009).

The Tobit model proposed first by Tobin (1958) describes the relationship between non-negative dependent variable and a set of independent explanatory variables. The weakness of the Tobit model in this kind of analysis is the assumption that a given set of explanatory variables have the same effects on both the probability of market participation and intensity of market participation (Wooldridge, 2010). This assumption also means that the partial effect of a given explanatory variable on the binary decision and the continuous decision is of the same sign. The model also assumes that zero traded volumes for non-market participating households are due to rational choice of the households (corner solution), though it may be due to a market entry barrier as noted by Komarek (2010). Another limitation of the tobit model is that it is only estimated when the dependent variable is above or below some cut off level (censored from left or right), hence it could underestimate the intercept and overestimate the slope (Sigei *et al.*, 2014).

Heckman sample selection and double hurdle are two-step models that relax these Tobit assumptions by allowing different mechanisms to determine the discrete probability of participation and the intensity of participation. In these two-step models (Heckman and Double Hurdle), the first step involves estimation of a probit model while the second step

can take different functional distributions (lognormal or truncated normal). In the Heckman sample selection models developed by Heckman (1979), a probit analysis is employed first to estimate the probability of participation (selection model) and then compute the inverse mills ratio (IMR) from the estimated probit regression. The computed IMR is used thereafter in the second step with other explanatory variables to explain the variation in the continuous (non-zero) outcome variable. These Heckman sample selection models correct for the fact that non-market participating group is not a random sub-sample of the population but one that self-selected itself into non-participating group due to both observed and unobserved covariates. In other words, as indicated by Wooldridge (2010), this self-selection bias is viewed as an omitted variable in the selected sample which is corrected by including IMR in the second step estimation.

On the other hand, the two step double hurdle model nests the Tobit model and therefore allows to test the restrictions implied in the Tobit hypothesis (Wooldridge, 2010; Mather *et al.*, 2011). Also, unlike the Heckman sample selection models where households that do not sell output or buy inputs are treated as missing observations in the second step (Goetz, 1992), the double hurdle model treats such households as corner solutions (modeled as a tobit). The rationale for a corner solution model is that non-market participating households are treated as valid and rational economic choices to be explained in the model and not a reflection of missing data (Reyes *et al.*, 2012).

The two-tier/double-hurdle model was developed by Cragg (1971). According to Lijia *et al.* (2011), Cragg first proposed the double-hurdle model as a generalization of the Tobit model by allowing the possibility that a factor might have different effects on the probability of acquisition and the magnitude of acquisition. The application of the model to any empirical study divides the study into two stages: an initial discrete probability of participation model and condition on participation, a second decision is made on the intensity of participation (Olwande and Mathenge, 2012). The first step in a two-tier model involves a Probit estimation while the second stage can take different functional distributions. While the simplest two step models assume lognormal distribution in the second stage, Cragg's double-hurdle assumes a truncated normal distribution.

The main advantage of the truncated normal distribution over the lognormal is that it nests the usual Tobit model thus allowing the testing of the restrictions implied by the Tobit

hypothesis against the two step model (Olwande and Mathenge, 2012). This makes the double-hurdle model theoretically more applicable than other two-tier models. The difference between the Heckman model and the double-hurdle model is in the second stage where the Heckman estimates an Ordinary Least Squares (OLS) equation while the double-hurdle model estimates a censored regression usually a truncated regression (cited by Alelign *et al.*, 2016). Thus due to this advantage, this study used double-hurdle model to analyze market orientation decisions and intensity.

2.4.3. Analyzing Determinants of Commercialization

In analyzing determinants of commercialization, studies used different analytical models including double-hurdle, Heckman and Tobit models as well as their various combinations. Such studies generally used either independent or simultaneous decision making as per their area of interest. Most of the authors such as Strasberg *et al.* (1999) and von Braun and Kennedy (1994) attempted to develop commercialization indices as dependent variables from the point of view of outputs to regress them on different explanatory variables.

Crag's double hurdle model as adopted by Mathenge and Olwande (2012) was considered for estimating the factors that influence farmers as economic agents to participate in agricultural commercialization. The double-hurdle model is the type of corner solution outcomes, as they define an initial discrete probability of participation model, first it involve conditional on participation ($Y > 0$), a second decision is made on the intensity of participation. Double-hurdle model of Craig (1971) is commonly used two tier model. The first step in two-tier model involves probit estimation while the second stage can take different functional form distribution. The simplest two step model for a corner solution outcome assumes that conditional on $Y > 0$, $Y | X$ follows a second stage which is defined by a truncated normal distribution instead of log normal distribution.

Following Maddala (1992), the Tobit model for the continuous variable market orientation index was employed. Unlike logit and probit which is used when dependent variables of interest take only two values (a dichotomous variable), denoting an event or non-event, tobit model handle limited response dependent variable like market orientation which range between 0 and 1.

The Tobit model is the most common censored regression model appropriate for analyzing dependent variables with upper or lower limits (Liu *et al.*, 2013; Abu, 2015 and Tobin, 1958). The model parameters are estimated by maximizing the Tobit likelihood function of the following form (Maddala, 1997; Amemiya, 1985).

The two-limit Tobit regression model was employed for this analysis since data generated about household commercialization index was in proportions. The dependent variable in this case has an upper limit of one in all cases and a lower limit of zero. The rationale for this is to match farmers' decision to fit the Tobit model which cannot take dependent variables greater than one or a negative and target policy interventions at farmer levels appropriately. According to Sindi (2008), it is assumed that both the decision to commercialize and the degree of commercialization are influenced by the same variables that increase the probability of commercialization and also increase the intensity of commercialization.

2.4.4. Analyzing Determinants of Food Security

It is commonly argued that logit and probit models are usually used to establish the relationship between household characteristics and dichotomous response variable. The advantages of these models over the linear probability model are that the probabilities are bound between zero and one. Moreover, they best fit the non-linear relationships between the response and the explanatory variables (Gujirati, 1995).

In principle, one can substitute the probit model for logistic model, as their formulations are quite comparable; the main difference is that the logistic model has slightly flatter tails than the cumulative normal distribution, i.e., the probit curve approaches the axes more quickly than the logistic curve (Gujirati, 1995). The choice between the two is one of (mathematical) convenience and availability of computer programs. On this score, the logit model is generally used in preference to probit. It is also noted that the logistic distribution has got an advantage over the others in the analysis of dichotomous outcome variables, because it is extremely flexible and easily used model from the mathematical point of view and results in meaningful interpretations (Hosmer *et al.*, 1989). It is less sensitive to outliers and easy to correct a bias (Collet, 1991). In instances where the independent variables are a categorical or a mix of continuous and categorical, logistic is preferred to

discriminant analysis. The assumptions required for statistical tests in logistic regression are far less restrictive than those for ordinary least squares regression. In general, logistic regression model has a peculiar property of easiness to estimate logit differences for data collected both retrospectively and prospectively (Collet, 1991).

Logistic regression identifies the effect of numerous independent variables which are defined simultaneously for estimating the existence of one of the other two dependent variables (Menard, 2010). The logistic regression model is also known as a logit model. Quinn and Keough (2002) allude that the logistic regression model caters for a non-continuous dependent variable. Baddeley and Barrowclough (2009) emphasize that a logistic regression model is used when the dependent variable is not continuous but instead has only two possible outcomes, zero or one. Allison (2012) explains that in a logit regression model the generalization of multiple and unordered categories of the dependent variable can be allowed efficiently. A logistic analysis for a binary outcome aims to estimate the odds of an occurrence of an event and to predict the effects of the explanatory variable on these odds. The event of the odds is a denotation that involves the probability that an event will be a success and the probability that an event will be a failure (O'Connell, 2006).

Therefore, in this study, binary logistic regression model was used to determine the factors affecting the sampled household food security.

2.5. Empirical Studies on Efficiency, Commercialization and Food Security

2.5.1. Estimation of Efficiency Scores

Jema (2008) used both parametric and non parametric approaches to study EE and marketing performance of vegetable production. The mean TE, AE and EE, estimated by the non parametric DEA, were 91%, 60% and 56% respectively indicating that farmers have attained a relatively high level of TE but lower AE and EEs. These results indicated that there was existence of a considerable potential to increase agricultural output without using additional inputs, given the existing technology. His results also indicated that if

these farmers operated at full efficiency levels, they could, on average reduce their costs of production by 44% and still produce the same level of output.

The study by Essa (2011) showed that most of the households had a higher technical efficiency levels. About 33% of maize farmers in the study area were operating above the efficiency level of 90% and 44.93% of them were operating in the range of 80-90% of technical efficiency levels. He identified that none of the farmers was operating below 50% of technical efficiency level. His result also indicated that the potential to improve maize productivity for individual farmers through improvement in the level of technical efficiency was the smallest as compared to that of the allocative efficiency and economic efficiency.

Endrias (2013) found that the average technical efficiency of the sampled household was 0.72 and the mean allocative efficiency was 0.70, with a minimum of 0.17 and a maximum of 0.98. The higher proportion of economically efficient farmers were found in classes ranges from 0.71 to 0.80 and 0.81 to 0.90 with each category representing 19.61% and 28.92% of the total sample households, respectively. The average economic efficiency level for the sample farmers was 0.53, with a minimum of 0.10 and a maximum of 0.91. His finding indicated that if the average farmer in the sample was to reach the economic efficiency level of his most efficient counterpart, then the average farmer could realize 41% of total production cost savings. Similarly the most economically inefficient farmer could realize 89% total production cost savings. In addition, to his finding, technical efficiency could be improved substantially and the economic efficiency constituted a more serious problem than allocative efficiency.

The study by Mussa (2013) also indicated that farmers in his study area were relatively good in technical efficiency than allocative efficiency or economic efficiency. The mean technical efficiency was found to be 84.87%. According to his finding, in the short run there were opportunities for reducing maize production inputs by 15.13% through adopting technologies used by the best practice of maize farmers. His study showed that the mean allocative efficiency of farmers in the study area was 37.47% indicating there is a need to improve the present level of allocative efficiency. To his finding, sample farmers with average level of allocative efficiency would enjoy a cost saving of about 32.24% to attain the level of the most efficient farmers and the most allocatively inefficient farmers would

have an efficiency gain of 66.18% to attain the level of the most technically efficient farmers.

Ermiyas *et al.* (2015) used a stochastic frontier production function to estimate farm household efficiency and its determinants among sesame producer farmers in south Omo zone, Southern Ethiopia. The average technical efficiency (TE), allocative efficiency (AE) and economic efficiency (EE) were 67.11%, 67.25% and 45.14%, respectively. This implies that farmers can increase their sesame production on average by 32.9% if they were technically efficient. Similarly, sesame producers can reduce current cost of inputs, on average, by 32.75% if they were allocatively efficient. The result also indicated that if these farmers operate at full efficiency levels, they on average could reduce their costs of production by 54.85%.

Sisay *et al.* (2016) in his study found that the average technical efficiency of the sample farmers was 0.62, with a minimum of 0.21 and the maximum of 0.94. According to his finding, if the average farmer in the sample was to achieve the technically efficient level of its most efficient counterpart, then the average farmer could realize 34% increase in output by improving only technical efficiency with existing input and technology. The mean allocative efficiency of the sample farmers was 0.57, with a minimum of 0.18 and a maximum of 0.89. A similar calculation for the allocative efficiency of the sample farmers reveals 36% increase in output by improving allocative efficiency, with the existing inputs and technology. Based on their study, the combined effect of technical and allocative efficiencies showed that the average economic efficiency level was only 0.39, with a minimum of 0.04 and a maximum of 0.84. Their result indicated that if the a farmer in the sample were to reach the economic efficiency level of his/her most efficient counterpart, then the average farmer could experience a 53% increase in output by improving efficiencies with the existing inputs and technology.

2.5.2. Determinants of Production Efficiency

Factors such as high cost of inputs including chemical fertilizers and herbicides, the size of farms negatively affected levels of efficiency of smallholders' farmers in crop production (Akinola and Adeyemo, 2008). The use of limited capital, land fragmentation and

unavailability and high input prices are reported as having a negative effect on efficiency of farmers in maize production (Elibariki *et al.*, 2008).

Krasachat (2009) investigated factors affecting technical inefficiency of white shrimp farms in Thailand. The DEA approach to estimate TE scores and a Tobit regression model to determine factors that affect farm efficiency were employed. The author found that the producers who experienced in tiger prawn production are likely to achieve higher levels of overall technical and scale efficiencies. Moreover, the difference in producers' participation in farm management training, producers' education level have a positive and significant impacts on the overall technical, pure technical and scale efficiencies.

Factors such as age, years of farming, and farm size that have found both positive and negative impact on efficiency depending on the specific socioeconomic circumstances. For instance, studies such as Idiong *et al.* (2009) and Otitoju and Arene (2010) found that the relationship between land holding, age, and years of farming experience with efficiency of crop production have found positive, while other studies such as Idiong *et al.* (2009), Otitoju and Arene (2010) and Endrias *et al.* (2010) have found a negative impact on efficiency and hence there is no clear-cut relationship between these variables and hence they have an ambiguous impact on efficiency of crop production.

Bifarin *et al.* (2010) showed that technical, allocative and economic efficiency indices varied widely and the estimated coefficients indicated that age is significant and positively correlated to technical and economic efficiencies, while extension services contributed significantly to technical efficiencies. In addition, the results of the inefficiency models revealed that farmer education and access to credit contributed significantly and positively to technical inefficiency, while extension visit had a significant impact but had an inverse relationship with technical inefficiency. In terms of allocative efficiency only access to credit was significant. This contributed positively to allocative inefficiency. The coefficient of age was negative for technical and economic inefficiencies, which implied that the older the farmer was, the more efficient he became.

Kaleab (2010) showed that education, gender, extension, cooperative membership, weeding and organic fertilizer use had positively determined TE of wheat production in the study area. On the contrary, land fragmentation, distance of the plot from homestead and

illness of the household members had a significant negative effect on TE. In addition, for commercial farms experience of the manager, distance of the farm from the main road, current value of farm machineries and provision of mechanization service by the farms had positive and significant impact on TE.

The availability of land, amount of seeds and labor (both family and hired) have strong impact on the productivity of a given land. The quantity of and the amount spent on fertilizer and agro-chemicals like pesticides and herbicides and mechanization (the use of a tractor) are all important predictors of productivity (Otitoju and Arene, 2010). Uses of oxen, labor, chemical fertilizer in maize production has a positive effect on productivity of maize production (Endrias *et al.*, 2010)

Hassen *et al.* (2012) found that the EE of mixed crop-livestock production system was determined by farm size, livestock ownership, labor availability, off/non-farm income participation, total household asset, total household consumption expenditure and improved technology adoption.

Ogisi *et al.* (2012) conducted technical and scale efficiency analysis in rice production using data envelopment analysis in Nigeria. They found out that most rice farmers operated with increasing returns to scale; education level, farmers experience and extension agents visit significantly and positively influenced the efficiency level of farmers in rice production whereas farm size was found to be negatively influenced the efficiency of rice smallholder producers.

Musa (2013) in his finding showed that DAP fertilizer, area, labor, oxen power and seed were influenced efficiency positively and statistically significant. He applied Tobit regression techniques to examine the relationships between TE, AE, and EE and various variables that were expected to have effect on farm efficiency. His results showed that soil fertility, frequency of extension contact, credit and distance to market were found to be statistically significant to affect the level of TE. Moreover, education, credit and frequency of extension contact were important factors that affect EE of farmers in the study area.

Gashaw *et al.* (2014) showed that agricultural cooperatives are effective in providing support services that significantly contribute to members' technical efficiency. These

results were found to be insensitive to hidden bias and consistent with the idea that agricultural cooperatives enhance members' efficiency by easing access to productive inputs and facilitating extension linkages. According to their findings, increased participation in agricultural cooperatives should further enhance efficiency gains among smallholder farmers.

Samuel *et al.* (2014) indicated that education, production experience and pesticide application were affecting efficiency of tomato production positively and significantly. In addition, Shettima *et al.* (2015) in their study found that numbers of laborers and amount of seed used positively and significantly affected production efficiency of vegetables whereas costs of labor, fertilizer and seed significantly affected the economic efficiency of tomato.

Ahmed *et al.* (2015) measured TE, AE and EE of maize production in the Central Rift Valley of Ethiopia. They showed that the mean TE, AE and EE were 84.87%, 37.47% and 31.62% respectively. They also identified education, frequency of extension contact, access to credit, distance to market and soil fertility as significant variables determining maize production efficiency in the study area.

Debebe *et al.* (2015) estimated TE, AE and EE in the southern part of Ethiopia using SFA. They found that the mean TE, AE and EE were 62.3%, 57.1% and 39%, respectively. They found that family size, level of education, extension service, cooperative membership, farm size, livestock holding and use of mobile phones as the main determinates of maize production efficiency.

Mango *et al.* (2015) showed that about 90% of farmers in the study area operated their maize farms at the efficiency level of between 60% and 75%, with an average efficiency level of 65%. They also identified gender of the household head, household size, frequency of extension visits, farm size and the farming region as the main factors determining TE of maize production in the study area.

Sisay *et al.* (2016) found that technical, allocative and economic efficiencies are positively and significantly influenced by size of household, education level, the size of livestock holding (TLU), extension service, cooperative membership and use of mobile cell-phone,

while total landholding size of the household head was negatively and significantly influencing efficiencies of maize production.

2.5.3. Empirical Studies on Determinants of Commercialization

Agricultural commercialization is mainly influenced by agro climatic conditions and risk; access to infrastructure and market; resource endowment of community and household; factor and input markets; institution and law; social and cultural factors affecting consumption preferences, production and market opportunities and constraints (Moti *et al.*, 2009). In addition, commercialization was influenced by commodity price, availability of family labor and geographic location of the household (Jagwe and Ouma, 2010).

Bedaso *et al.* (2012) estimated a multinomial logit representation of commercialization status of smallholder farmers in Ethiopia and the results showed that asset ownership, access to extension service and market information, quantity of inputs used, labor cost, total production and improved storage methods tend to increase the probability to be commercial farmer while labor size, seed rate, distance from market, and traditional storage methods tend to decrease the probability of commercialization.

Ele *et al.* (2013) showed that the degree of commercialization in the study area is moderately high (about 60.40%). Tobit regression analysis showed that total quantities of food crops produced, farming experience, access to agricultural extension service, size of land used for cultivation, membership in cooperatives and household family size as important factors determining the level of commercialization of smallholder farms.

Akinlade *et al.* (2014) analyzed using their data by using Tobit regression model and the model result showed that age, farm size, membership in associations, years of education, distance to market, heterogeneity index, cost of fertilizer, cost of chemicals, and decision-making index influenced the extent of commercialization.

Wonduwossen (2014) found that sex, distance to the nearest market and size of cultivated land played significant role in smallholders' commercialization decision as well as the result of truncated regression revealed that household education status, household size,

access to irrigation, cultivated land size, livestock and distance to the nearest market were the key determinants of the level of commercialization.

Gebreslassie *et al.* (2015) identified that age of household head, size of farm land, quantity of crop harvested, and livestock holding, were some of the factors that had very low but significant positive marginal effect on extent of marketing. Access to training in crop marketing and production had a significant effect on intensity of commercialization whereas Distance to nearest local market, as measured by time taken to reach the local market from homestead, family size, and price fertilizers lack of access to market information had significant and negative impact on intensity agricultural commercialization.

Dube and Guveya (2016) used household commercialization index to assess the degree of commercialization and Tobit model to identify factors associated with agricultural commercialization. Results of the regression model showed that size of the household, availability of draft power, livestock ownership, access to irrigation, agricultural training, distance of homestead to town and household income were significantly and positively influenced commercialization. On the other hand, number of household members attended secondary education; communal tenure and location in agro-ecological zone were significantly and negatively influenced commercialization.

Kabiti *et al.* (2016) used Tobit model to identify the factors that determine the level of commercialization from the input and output side. The input side commercialization was influenced by area under cultivation, irrigation availability, distance to input market and gross production value whereas output commercialization was by determined by household labor size, irrigation availability, gross agricultural production value, farming experience of the household head and non-farm income.

Kumilachew (2016) in his study found that commercial behavior of smallholder potato producers in Kombolcha woreda, Eastern Ethiopia and the production system was semi-commercialized in which about 59.5% of the potato produce was sold. The two limit-Tobit regression model result also indicated that non/off farm income, access to information, access to improved seed and access to irrigation influenced potato commercialization

positively and significantly but number of plots influenced potato commercialization negatively.

Asfaw (2018) used Double-hurdle model to analyze potato commercialization and the model result showed that livestock holding, land for potato production, frequency of extension contact, access to market information and participation in social organization influenced the decision to potato commercialize whereas the truncated model result also revealed that land allocated for potato production and participation in social organization influenced the intensity potato commercialization positively but family size and distance to market center influenced it negatively.

2.5.4. Impacts of Commercialization on Household Food Security

Commercialization of smallholder agriculture has a direct and usually positive impact on value chain actors such as input suppliers, output traders, transporters, processors, financiers and others. The positive impacts could be due to economies of scale created from increased demand and supply that tend to decrease average cost per unit of operation. Similarly, findings by Kowagoe (1994) in upland Java, Indonesia, suggested that a high contribution of marketing and processing to rural household income and employment is expected when commercialized farm products are processed in the village and then marketed. Kowagoe (1994) argued that the processing and marketing of commercial products at a village level contributed up to 70% of total household labor income and employment.

Moti *et al.* (2009) explained impacts of commercialization by categorizing as first, second and third orders. The first-order is mainly income and employment effects that are directly reflected in household welfare. The second-order effects include health and nutrition aspects usually contingent on the level of income attained through the existing level of commercialization. The third-order (or usually known as higher order) effects are the macro-economic and environmental effects that go beyond household level.

Agricultural commercialization would foster a sustained market-based growth of the agriculture sector. Growth in agriculture must be the centerpiece of pro-poor economic growth as majority of the poorest depends on agriculture for their livelihoods. Over the

recent decade, agricultural growth has leveled to around 3% per year. A sustained growth rate of at least 6% is required for the agriculture sector to help in fast-tracking the development targets of poverty reduction and food security (URT, 2010). Agricultural commercialization refers to the process in which farmers increase their productivity by producing more output per unit of land (and labor), produce greater surpluses which can be sold in the market and thus increase their market participation with a beneficial outcome of higher incomes and living standards (Jayne *et al.*, 2011).

The net effects of commercialization on household's food consumption expenditure can be analyzed by considering the effect of price level as lower income households may not guarantee an improvement in welfare aspects if they face higher market price. Rather, those households with higher income may have better tendency to enjoy from commercialization mainly in those countries like Ethiopia where the share of food consumption expenditure accounts a significant part of income. However, evidences from Malawi suggested that food security status of small scale farmers are less likely to be affected than large scale farmers during price shock time as food is mainly supplied from home production (Wood *et al.*, 2012). Furthermore, Baylis *et al.* (2012) also showed that commercialization increased nutrition, particularly for food insecure households.

Commercialization of the crop sub-sector correlated strongly and positively with household income. Commercialization and income would enhance each other. It could be that the household income is either invested in commercial farm activities or the income earned from such activities adds to the household income. Nevertheless, there is a potential of income enhancement through commercialization (Khamaldin *et al.*, 2013).

2.5.5. Empirical Studies on Determinants of Food Security

Another study by Ayalneh and Shimelis (2009) identified that household food insecurity is determined by family size, annual income, amount of credit received, access to irrigation, age of household head, farm size, and livestock owned. The findings imply that improvement in food security situation need to build assets, improve the functioning of rural financial markets and promote family planning.

A study by Orewa and Iyangbe (2009) revealed that there was a significant positive relationship between daily per capita calorie intake and household size, age, education level, sex and salary income earners. On the other hand, daily per capita calorie intake was adversely affected by dependency ratio and non-engagement in farming.

The study conducted by Ayalneh and Shimelis (2009) using binary logit model revealed that age of the household head, cultivated land size, livestock ownership, total income of the household, irrigation and amount of credit received have negative and significant effect on household food insecurity; on the other hand, family size has positive and significant effect. Similarly, As studied by Beyene and Muche (2010) using binary logit model showed that age of the household head, size of land cultivated, use of fertilizer, livestock ownership, soil and water conservation practices and oxen ownership have positive and significant relationship with household food security; whereas, education of household head, household size (AE) and off-farm/non-farm income have a negative and significant influence on household food security.

The estimation of food grain consumption and calorie intake patterns in Ethiopia by Guush *et al.* (2011) using nonparametric regression estimates and other descriptive and distributional measures verifies that there is much variation in Ethiopia's consumption patterns, depending on specific geographical and socio-cultural characteristics. Calorie consumption in Ethiopia is low, a high percentage of this consumption coming from cereals, and per capita intake of calories is relatively higher in rural than in urban areas.

Regassa (2011) and Bedeke (2012) in their studies found ownership of livestock, farmland size, family labor, off farm income, market access, use of improved technology, education, health, amount of rainfall and distribution, crop diseases, number of livestock and family size were identified as major determinants of household food security.

Zegeye and Hussein (2011), in their study at Eastern Ethiopia in 2008 using a Tobit model estimation of kilocalorie suggested that 80% of the sample households were food insecure and their food insecurity gap was 30%. The estimated intensity of food insecurity indicated that household food security was determined by livestock holding, farm income, family size, land cultivated, soil fertility, irrigated land size, off-farm and non-farm income.

The study by Gebre (2012) by using binary logit model indicated that household size and age of the household head have positive and significant effect on household food insecurity whereas educational status of the household head, asset possession, credit access and access to employment have negative effect.

WFP (2013) stated that food energy deficient household in Ethiopia is about two in every five households. Thus, in any development effort in the country, food or nutrition security must be one of the first considerations as it is at the top of efforts to bring resilience to poor harvests and future droughts. Since the launch of the first National Nutrition Program (NNP) in 2009, Ethiopia has shown marked walks towards achieving its goals.

Kahsay and Mulugeta (2014) by using multiple linear regression indicated that age of the household head, use of improved seed and adult equivalent have negative effect and statistically significant factor for calorie intake whereas, land size in hectare and number of livestock in TLU positively affect calorie intake of households.

Hussein and Janekarnkij (2018) in their study identified that use of fertilizer by farming households, total household income, access to veterinary services and access to extension services affected household food security positively and significantly whereas the agro-ecology stratum in which the household's farmland was located found to have a negative and statistically significant impact on food security.

2.6. Conceptual Framework

von Braun *et al.* (1994) developed a comprehensive theoretical framework of determinants of agricultural commercialization and how this process is linked to agricultural commercialization and household food security (Figure 3). In this theoretical conceptual framework, it can be seen that the welfare impacts of agricultural commercialization is mediated through a complex intra-household relationships

It also considers the production factor, socio-economic factor and institutional factors that influence production efficiencies as well as commercialization on pulse crops and finally it also shows the relationship of dependent variables towards producer's food security status.

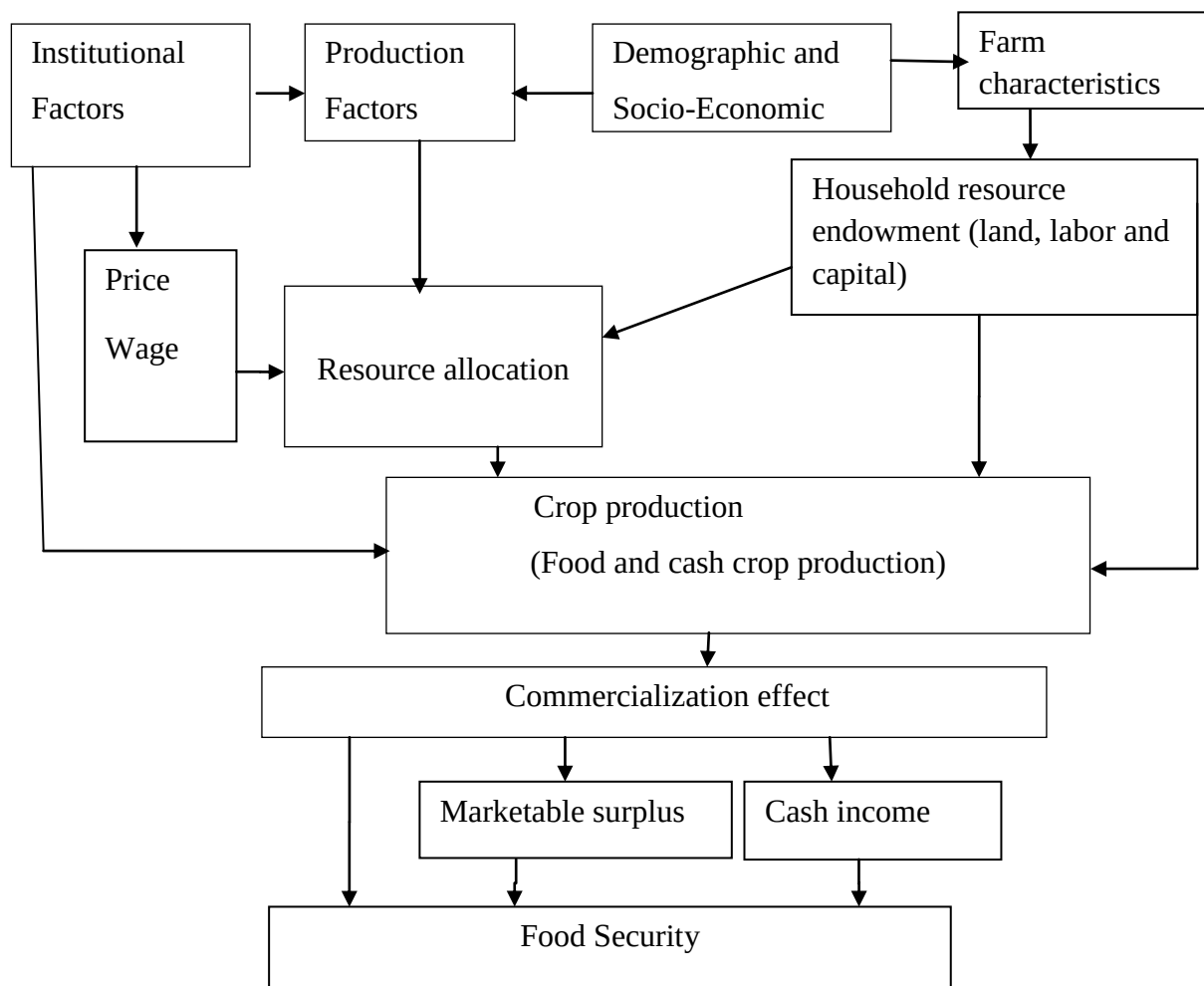


Figure 3: Conceptual framework of the study

Source: Adapted from Von Braun *et al.* (1994) and from literature reviewed

3. RESEARCH METHODOLOGY

This chapter discusses description of the study areas, data requirements, sources and methods of data collection, sample size and sampling techniques, methods of data analysis and definitions of variables and working hypothesis.

3.1. Description of the Study Areas

3.1.1. Amhara Region

Amhara Region is one of the nine ethnic divisions of Ethiopia. Its capital is Bahir Dar. Amhara is bordered by the state of Sudan to the west and northwest, and in other directions by other regions of Ethiopia: Tigray to the north, Afar to the east, Benishangul-Gumuz to the west and southwest, and Oromia to the south (UNECA,1996). The region is divided into 11 administrative zones, including the capital city of the region, Bahir Dar. The other 10 Administrative zones are: East Gojjam, West Gojjam, Awi, North Gonder, South Gonder, Wag Himra, North Wollo, South Wollo, North Shewa, and Oromia (BOPED 2002).

Amhara is topographically divided into two main parts, namely the highlands and lowlands. The highlands are above 1500 meters above sea level and comprise the largest part of the northern and eastern parts of the region. The highlands are also characterized by chains of mountains and plateaus. Ras Dejen (4620 m), the highest peak in the country, Guna (4236 m), Choke (4184m) and Abune Yousef (4190m) are among the mountain peaks that are located in the highland parts of the region. The lowland part covers mainly the western and eastern parts with an altitude between 500-1500 meters above sea level. Areas beyond 2,300 meters above sea level fall within the Dega climatic Zone, and areas between the 1,500-2,300 meter above sea level contour fall within the Woina Dega climatic zone; and areas below 1,500 contour fall within the Kolla or hot climatic zones. The Dega, Woina Dega and Kolla parts of the region constitute 25%, 44% and 31% of the total area of the region, respectively (UNECA, 1996).

The census conducted by the Central Statistical Agency of Ethiopia (CSA, 2007), the Amhara Region has a population of 17,221,976 (8,641,580 men and 8,580,396 women) urban inhabitants number 2,112,595 or 12.27% of the population. With an estimated area of 159,173.66 square kilometers, this region has an estimated density of 108.2 people per square kilometer. At 91.47% of the local population, the region is predominantly inhabited by people from the Semitic-speaking Amhara ethnic group. Most other residents hail from other Afro-Asiatic language communities, including the Agaw/Awi, Oromo, Agaw/Kamyr and Argobba.

About 85% of the people are engaged in agriculture. The region is one of the major Teff (staple food) producing areas in the country. Barely, wheat, oil seeds, sorghum, maize, wheat, oats, beans and peas are major crops produced in large quantities. Cash crops such as cotton, sesame, sunflower, and sugarcane grow in the vast and virgin tract of the region's lowlands. The water resources from Lake Tana and all the rivers found in the region provide immense potential for irrigation development. About 450,000 hectares of arable land is irrigable and suitable, especially for horticultural development. The estimated livestock population of the region is 9.1 million cattle, 8.4 million sheep and goats, 1.6 million equines, and 8.5 million poultry. About 40% of the livestock populations of the country are found in this region. The huge livestock potential of this region gives ample opportunity for meat and milk production, food processing as well as leather and wool production (CSA, 2012).

3.1.2. East Gojjam Zone

The study was conducted in three woredas namely Sinan, Debay Tilat Gin and Enarji Eawuga in East Gojjam zone of Amhara National Regional State of Ethiopia. East Gojjam zone lies at 10° 20' North latitude and 37° 43' East longitudes, and at an altitude range of 500-4154 m.a.s.l. The study zone is bordered in the South by the Oromia region, on the West by West Gojjam zone, in the north by South Gondar zone, and in the east by South Wollo zone. The bend of the Abay River defines the zone's northern, eastern and southern boundaries. The zone has 18 woredas and its zonal town is Debre Markos (DPPA, 2003). The annual rainfall of the area ranges from 900-1800mm and mean minimum and maximum temperature of 7.5°C and 25°C, respectively. The annual rainfall of the area

ranges from 900-1800mm and mean minimum and maximum temperature of 7.5⁰C and 25⁰C, respectively (Dereje *et al.*, 2012).

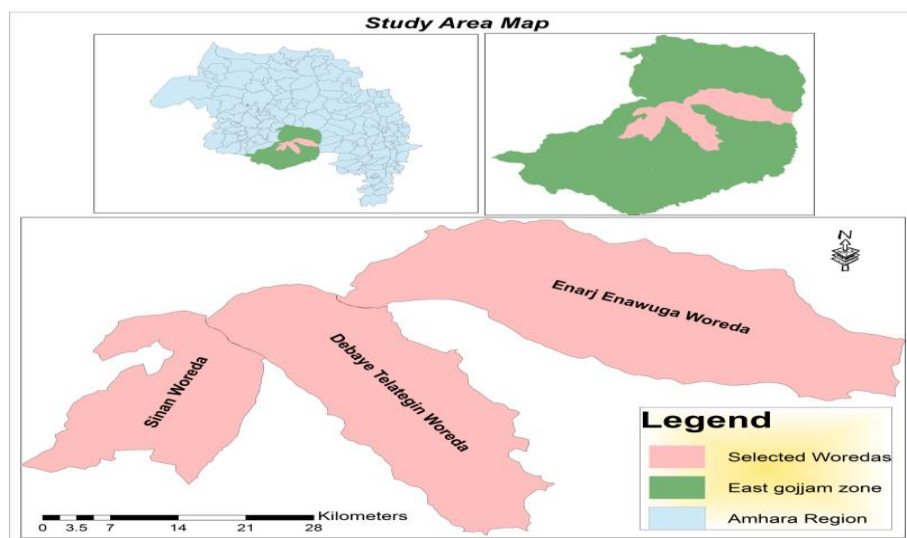


Figure 4. Map of the study area

Population characteristics

Based on the Population projection value (2018) report, East Gojjam zone has a total population of 3,105,422 of whom 1,625,089 are men and 1,480,333 women); with an area of 14,004.47 square kilometers. From the total population, 316,151 are urban inhabitants and 2,169,523 are rural inhabitants. The largest ethnic group reported in East Gojjam was the Amhara (99.82%); all other ethnic groups made up 0.12% of the population. Amharic is spoken as a first language by 99.81%; the remaining 0.19% spoke all other primary languages reported. About 97.42% of the populations are Ethiopian Orthodox Christianity, and 2.49% are Muslim (CSA, 2007).

According to World Bank memorandum, 8% of the inhabitants of East Gojjam have access to electricity, this zone has a road density of 24.2 kilometers per 1000 square kilometers (compared to the national average of 30 kilometers), the average rural household has 1.1 hectare of land (compared to the national average of 1.01 hectare of land and an average of 0.75 for the Amhara Region) and the equivalent of 0.6 heads of livestock. Around 11% of the population is in non-farm related jobs, compared to the national average of 25% and a Regional average of 21%. About 66% of all eligible children are enrolled in primary school, and 13% in secondary schools (World Bank, 2006).

Economically, farmers in East Gojjam depend on plough-based, labor intensive agriculture. *Meher* rain season (June–September) and *belg* rainy season (March–May) are the two rainy seasons for crop production. About 94.2 % of crop production in 2009/10 was produced in the *meher* (the main rainy season) season, while the remaining 5.8 percent was produced during the *belg* (short rainy season) and through small-scale irrigation systems. Average crop productivity of the area is 5.82 quintals per hectare (East Gojjam Zone Agricultural and Rural Development report, 2011).

3.2. Data Requirement and Sources

Both primary and secondary data were used. Cross-sectional primary data were collected from sample respondents using structured and pre-tested questionnaire format from 2017 production season. The questionnaire was pre-tested in each selected Woreda and revised according to the feedback obtained. Then, the final semi-structured questionnaire was employed to collect data from the smallholder pulse producing samples. Both quantitative and qualitative information were collected through face-to-face interview with individuals, key informants and then focus groups discussions using enumerators from recruited agricultural extension staff with prior experience in survey work. Key informant interview was used to collect more information from some key informants on related issues in which data were collected. This helps to understand better the issues that were raised and to triangulate the answers provided by the respondents. In addition, focus group discussion (8-11men/group) helps to strengthen or argue against some answers through checklists/unstructured question discussions of farmers based on the results obtained. Secondary data were collected from government and non-governmental offices from published and unpublished materials, central statistics Authority (CSA), Food and Agriculture Organization (FAO) data base and Ethiopian commodity exchange authority (ECX).

3.3. Sample Size and Sampling Technique

3.3.1. Sample Size Determination

To obtain a representative sample size, for cross-sectional household survey the study employed the sample size determination formula given by Kothari (2004):

$$N = \frac{Z^2 p q}{e^2} = \frac{(1.96)^2 (0.5)(0.5)}{(0.05)^2} = 385 \quad (3)$$

Where n is the sample size needed, Z is the inverse of the standard cumulative distribution that corresponds to the level of confidence, e is the desired level of precision, p is the estimated proportion of an attribute that is present in the population and q = 1-p. The value of Z is found from statistical table which contains the area under the normal curve of 95% confidence level.

3.3.2. Sampling Techniques

The study was mainly based on the data that were obtained through a farm household survey administered to sample farm households drawn through multi-stage sampling techniques. Multi-stage sampling techniques were employed to select smallholder pulse producers. In the first stage, three woredas, namely Enarg Enawuga, Sinan and Debay Tilat Gin were randomly selected from the 14 pulse crops producing woredas of East Gojjam zone. In the second stage, a total of nine pulse producing kebeles (3 kebeles from Enarg Enawuga, 3 kebeles from Debay Tilat Gin and 3 Kebeles from Sinan) were selected by using simple random sampling method from the sampled woredas. In the third stage, 385 farm households were randomly selected based on the probability proportional to their total sizes/numbers (Table 1.)

Table 1: Distribution of the sample in woredas, kebeles and households

Woreda	Kebele	Total number of households	Sample size
Debay	Assendabo	8,419	39
	Wedebeyesus	9,436	44
	Debreeyesus	10,644	50
	Abazash	7,246	34

Sinan	Dangule	9,759	45
	Sinan	6,875	32
		<hr/>	
Enarji Enawuga	Teguma	9,202	42
	Titar	10,059	47
	Yisar	11,117	52
Grand Total		82,757	385

Source: Own computation (2019)

3.4. Methods of Data Analysis

3.4.1. Descriptive Statistics

Descriptive statistics was used to analyze demographic and socio-economic characteristics of the farm households. From the descriptive statistics such as means, proportions and standard deviation was carried on to describe economic and physical characteristics associated with respondents. Independent sample t-test and chi-square tests were implemented to make comparisons between the categories with respect to key variables specified.

3.4.2. Econometric Analysis

3.4.2.1. Estimation of technical efficiency

Data Envelopment Analysis (DEA) was developed mainly based on Farrell's work (Farrell, 1957). In DEA the production of an efficiency frontier is based on the concept of Pareto optimum. The Decision Making Units (DMUs) that lie on the efficient frontier are non-dominated and thus called Pareto optimal units or efficient DMUs. They are assigned an efficient index of one, while those that do not lie on the efficiency frontier are regarded as relatively inefficient with positive efficiency indices of less than one.

DEA has the advantage of determining efficiency in multiple input-multiple output scenarios. Its first task is to determine which of the DMUs, as represented by observed data, form an empirical production function envelopment surface which is referred to as the efficiency frontier (Ajibefun, 2008). Thereafter, DEA provides a comprehensive

analysis of relative efficiency by evaluating each DMU and measuring its performance relative to the envelopment surface.

$$TE_j = \frac{u_1 y_{1j} + u_2 y_{2j} + \dots + u_k y_{kj}}{v_1 x_{1j} + v_2 x_{2j} + \dots + v_m x_{mj}} = \frac{\sum_{r=1}^k u_r y_{rj}}{\sum_{s=1}^m v_s x_{sj}} \quad (5)$$

where X_i and Y_i are inputs used and outputs produced; V_i and U_i are input and output weights, respectively; s is number of inputs ($s = 1, 2, \dots, m$), r is number of outputs ($r = 1, 2, \dots, k$) and j represents j^{th} DMUs ($j = 1, 2, \dots, n$).

Therefore, taking the output orientated approach the producer maximizes the output level given fixed inputs. Mathematically, it is written as:

$$Max: \frac{\sum_{r=1}^k u_r y_{rj}}{\sum_{s=1}^m v_s x_{sj}} \quad (6)$$

S.t.:

$$\frac{\sum_{r=1}^k u_r y_{rj}}{\sum_{s=1}^m v_s x_{sj}} \leq 1, \forall u_r, v_s \geq 0 \quad (7)$$

where r is number of outputs produced ($r=1,2,3,\dots,k$), s is number of inputs utilized ($s=1,2,3,\dots,m$), i is the DMU considered ($i=1,2,3,\dots,n$), X_{si} is amount of input s utilized by DMU i , Y_{ri} is amount of output r produced by DMU i , U_r is weight given to output r , and V_s is weight given to input s . Weights reflect the relative importance of inputs and outputs for efficient firms and weights assigned to peers for inefficient firms. They are used to linearly aggregated inputs and outputs. They will be calculated by solving the linear programming problem.

In order to solve equations (6 and 7), the following equation developed by Charnes, Cooper and Rhodes (CCR) (1978) was used.

$$Max: \theta = u_1 y_{1i} + u_2 y_{2i} + \dots + u_r y_{ri} \quad (8)$$

S.t.:

$$v_i y_{1i} + v_2 y_{2i} + \dots + v_s y_{si} = 1 \quad (9)$$

$$u_i y_{ij} + v_2 y_{2j} + \dots + u_r y_{rj} \leq v_1 y_{1j} + v_2 y_{2j} + \dots + v_s y_{sj} \quad (10)$$

$$u_1, u_2, \dots, u_r \geq 0 \quad (11)$$

$$v_1, v_2, \dots, v_s \geq 0 \text{ and } (i \text{ and } j = 1, 2, \dots, k) \quad (12)$$

Where θ is the technical efficiency and i represents i^{th} DMU. The CCR model assumes Constant Returns to Scale (CRS). According to Coelli *et al.* (2005), there will always be financial limitations or imperfect competitive markets where increased amounts of inputs do not proportionally increase the amount of outputs obtained. In order to account for this effect, the DEA model for Variable Returns to Scale (VRS) was developed by Banker, Charnes and Cooper (BCC) (1984) approach (Banker *et al.*, 1984). The VRS model allows an increase in input values to result in a non-proportional increase of output levels. The VRS surface envelops the population by connecting the outermost DMUs, including the one approached by the CRS surface. Hence the BCC model envelops more data and efficiency scores are bigger than or equal to scores of CCR.

To estimate technical efficiency the BCC approach for output orientated can be written as:

$$Max_{\phi, \lambda} \phi, \quad (13)$$

S.t.:

$$x_i - x\lambda \quad (14)$$

$$-\phi y_i + y\lambda \geq 0 \quad (15)$$

$$\lambda \geq 0 \quad (16)$$

$$N_1' \lambda = 1 \quad (17)$$

In the restriction $N_1' \lambda = 1$, N_1' is convexity constraint which is an $N \times 1$ vector of ones and λ is an $N \times 1$ vector of weights which defines the linear combination of the peers of the i^{th} farm. $1 \leq \phi \leq \infty$ and $\phi - 1$ is the proportional increase in outputs that could be achieved by the i^{th} DMU with the input quantities held constant. Note that $1/\phi$ defines a TE score which varies between zero and one. If $\phi = 1$ then the farm is on the frontier and is technically efficient and if $\phi < 1$ the farm lies below the frontier and is technically inefficient.

3.4.2.2. Estimation of allocative and economic efficiencies

Using the BCC approach, in order to investigate the economic efficiency or cost efficiency, the input orientated cost minimization DEA is specified as:

$$\text{Min } \lambda, \omega_i^* \chi_i^* \quad (18)$$

S.t.:

$$-y_i + y\lambda \geq 0 \quad (19)$$

$$\chi_i^* - \chi\lambda \geq 0 \quad (20)$$

$$N_1' \lambda = 1 \quad (21)$$

$$\lambda \geq 0 \quad (22)$$

Where, W_i' is a transpose vector of input prices for the i^{th} DMU and X_i^* is the cost-minimizing vector of input quantities for the i^{th} farm given the input prices. Economic efficiency is the ratio of potential minimum cost of production $W_i' X_i^*$ and the actual cost of production $W_i' X_i$ as:

$$EE = \frac{\omega_i^* \chi_i^*}{W_i X_i} \quad (23)$$

One important problem of DEA model is that it assumes all DMUs are homogenous and identical in their operations. If the heterogeneous DMUs are assessed by DEA without any modifications, the DEA yields a biased performance scores and inaccurate analyses. Therefore, this study applied a new algorithm called clustering based technique provided to perform the DEA computation in non-homogenous DMUs. Clustering is the process of organizing a data set into useful set of mutually exclusive clusters such that the similarity of the objects within a cluster is maximized while the similarity of the objects between different clusters is minimized (Okazaki, 2006 and Rai *et al.*, 2006).

3.4.2.3. Production inefficiency analysis

To deal with the factors of inefficiencies of farm households in crops production, different socio-economic and institutional variables will be regressed on inefficiency estimates using a two limit Tobit regression model. The Tobit model is deployed because the efficiency scores are double truncated at 0 and 1 as the scores lie within the range of 0 to 1.

The functional form of the Tobit model is:

$$y^* = \beta_o + \sum \beta_m + x_{jm} + \mu \quad (24)$$

Where y_i^* = latent variable representing the efficiency scores of farm j, β = a vector of unknown parameters, X_{jm} = a vector of explanatory variables m ($m = 1, 2, \dots, k$) for farm j and μ_j = an error term that is independently and normally distributed with mean zero and variance σ^2 .

Denoting y_i as the observed variable, the two limit Tobit model is specified as:

$$y_i = \begin{cases} 1 & \text{if } y_i^* \geq 1 \\ y_i^* & \text{if } 0 < y_i^* < 1 \\ 0 & \text{if } y_i^* \leq 0 \end{cases} \quad (25)$$

In this equation, the distribution of the dependent variable is not normally distributed rather its value varies between 0 and 1. If the data to be analyzed contain values of the dependent variable that is truncated or censored, the OLS is no longer applicable to the concept of estimated regression coefficients. If OLS is directly used it will lead to biased and inconsistent parameter estimation. However, Tobit model that follows the concept of maximum likelihood becomes a better choice to estimate regression coefficients (Maddala, 1999).

3.4.2.4. Market orientation analysis

Double-hurdle model is applied for the analysis of farm household market orientations decisions and intensity. The first hurdle involves factors determining crop market orientation decisions and assessed against a discrete choice dependent variable by market orientation decisions equation. The second hurdle concerns the relationships between market orientations indices for the level of indices with their determinants using the equation defined for level of market orientations. Thus, the double-hurdle model specification for both cases follow the same syntax is presented below:

$$a) \quad y_1^* = \omega \alpha + v_i \quad (26)$$

$$y_i = \begin{cases} 1, & \text{if } y_{i1}^* > 0 \\ 0, & \text{Otherwise} \end{cases} \quad (27)$$

$$b) Y_{i2}^* = X_i' \beta + v_i \quad (28)$$

$$\begin{cases} y_i = y_{i2}^* = x_i' \beta + u_i, \text{ if } y_{i2}^* > 0 \text{ and } y_{i1}^* > 0 \\ y_i = 0, \text{ Otherwise} \end{cases} \quad (29)$$

Where, y_{i1}^* is the latent variable describing the household's market orientation decisions; y_{i2}^* is the latent variable describing the level of market orientation defined by crop market orientation indices; y_i is observed level of market orientation; w_i is a vector of variables explaining household internal and external factors influencing initial market orientation decisions; x_i is a vector of variables influencing how much the household involved; and v_i and u_i are error terms and are assumed to have independence between them.

The truncated regression fits a regression model of dependent variables on explanatory variables from a sample drawn from a restricted part of the population. Under the normality assumption for the whole population, the error terms in the truncated regression model have a truncated normal distribution, which is a normal distribution that has been scaled upward so that the distribution integrates to one over the restricted range.

Let the truncated regression model be specified as follows:

$$y = X \beta + \varepsilon \quad (30)$$

Here y represents continuous outcomes either observed or not observed. The model assumes that the errors are normally and independently distributed.

The log-likelihood function for the double-hurdle model that nests a univariate probit model and a truncated regression model is given following Cragg (1971) by:

$$\log L = \sum_0 \ln \left[1 - \Phi(\omega_i' \alpha) \left(\frac{x_i}{\sigma} \right) \right] + \sum \ln \left[\Phi(\omega_i' \alpha) \frac{1}{\sigma} \varphi \left(\frac{y_i - x_i' \beta}{\sigma} \right) \right] \quad (31)$$

Where, “0” indicates summation over the zero observations in the sample; “+” indicates summation over positive observations; Φ (.) and φ (.) refer to the standard normal probability and density functions respectively; ω_i and X_i represent independent variables

for the Probit model and the Truncated model respectively; and α , σ , and β are parameters to be estimated for each model.

3.4.2.5. Pulse output commercialization analysis

There are diverse methods for estimating the level of commercialization and indicators that are also used for measuring the level of commercialization (Randolph, 1992). Majority of earlier studies of smallholder commercialization measure the level of commercialization in terms of the proportion of output sold in markets. The degree of farmers' participation in output markets could be measured either in terms of the proportion of output sold by the commercialization index or the total value of output sold (Samuel and Sharp, 2008). In measuring household-specific level of commercialization, Govereh *et al.* (1999) and Strasberg *et al.* (1999) used a household commercialization index (HCI), which is a ratio of the gross value of all crop sales per household per year to the gross value of all crop production. The concept used in this study is also supported by other studies made on commercialization of agriculture (von Braun, 1994; Chukwukere *et al.*, 2012) that they define output commercialization of smallholder agriculture in terms of not only cash crop but also food crops sales.

Thus, to achieve the stated objectives, the present study tries to assess the level of commercialization by calculating the Household Commercialization Index following Govereh *et al.* (1999) and Strasberg *et al.* (1999). The advantage the HCI is that it provides the level of commercialization for every household separately. The commercialization index is censored because some of its values cluster at the limit (i.e., 0 for subsistence producers and 1 for fully commercialized). Hence, censored regression model is the option for handling this limited dependent variable.

The study used the Tobit /censored normal regression model to identify the factors that determine the level of output commercialization by smallholder farmers. The Tobit model is the most common censored regression model appropriate for analyzing dependent variables with upper or lower limits (Tobin, 1958, Liu *et al.*, 2013; Abu, 2015;). For this study the Tobit model was preferred because the dependent variables (output

commercialization index) are truncated as latent variables. Specifically, the output commercialization indices are the dependent variables and are lower censored at zero and upper censored at 1. Thus, since the value of the dependent variable, commercialization index, ranges between 0 and 1 inclusive, a two-limit Tobit model has been chosen as a more appropriate econometric model. The two-limit Tobit was originally presented by Rossett and Nelson (1975) and discussed in detail by Maddala (1992) and Long (1997). The two limit Tobit model can be specified as:

$$y_i^* = \beta' x_i + \varepsilon_i \quad (32)$$

where y_i^* is a latent variable (unobserved for values smaller than 0 and greater than 1) representing subsistence or fully commercial index; x_i is a vector of independent variables, which includes factors affecting output sold; β is a vector of unknown parameters; and ε_i is a disturbance term assumed to be independently and normally distributed with zero mean and constant variance σ^2 ; and $i = 1, 2, \dots, n$ (n =the number of observations).

Given the observed dependent variable-commercialization index (y_i), the two limit Tobit model can be specified as:

$$y_i = \begin{cases} 0 & \text{if } y_i^* \leq 0 \\ y_i^* & \text{if } 0 < y_i^* < 1 \\ 1 & \text{if } y_i^* \geq 1 \end{cases} \quad (33)$$

McDonald and Moffit (1980) approach was also followed to decompose marginal effects in order to assess the effect of a change in the explanatory variables on the dependant variable. Therefore, the three types considered in the analysis of the Tobit model are shown below. These are:

a) The marginal effect on the latent variable (unconditional expected value)

$$\frac{\partial E(Y/X)}{\partial x_k} = \beta_k \Phi\left(\frac{x\beta}{\sigma}\right) \quad (34)$$

b) The marginal effect on the expected value of observations conditional on being uncensored

$$\frac{\partial E\left(\frac{Y/X, y > 0}{\partial X_k}\right)}{\partial X_k} = \beta_k + \beta_k \frac{\partial \lambda(c)}{\partial c} = \beta_k \{1 - \lambda(c)[c + \lambda(c)]\} < \beta_k \quad (35)$$

Where, $\lambda(c)$ is called the inverse mill's ratio. It captures the change in the dependent variable (conditioned on $y > 0$) when changing x .

c) The marginal effect on the probability that the observations are uncensored

$$\frac{\partial \Pr(y > 0/x)}{\partial X_k} = \phi\left(\frac{x\beta}{\sigma}\right) \frac{\beta_k}{\sigma} \quad (36)$$

3.4.2.6. Food security analysis

A food energy intake approach was used to determine the food security status of households. On the basis of this a household will be classified as food insecure household if the calorie intake per adult equivalent per day is below the minimum daily subsistence level (2100 kcal). The binary logistic regression model was used to identify the determinants of food security status of sample households. Following Pindyck and Rubinfeld (1981) the cumulative logistic probability function is specified as:

$$P_i = F[\beta_0 + \sum(\beta_i x_i)] = \left[\frac{1}{1 + e^{-\beta_0 - \sum(\beta_i x_i)}} \right] \quad (37)$$

Where, e is base of natural logarithms, x_i is i^{th} explanatory variable, p_i is the probability that a household is being food secure given x_i , β_0 and β_i are regression parameters to be estimated.

Similarly, it can be also written as:

$$p_i = \frac{1}{1 + e^{-Z_i}} \quad (38)$$

Where Z_i = function of explanatory variables X_n which is expressed as:

$$Z_i = \beta_0 + \beta_1 x_1 + \dots + \beta_n x_n \quad (39)$$

Similarly, the probability of households being food insecure specified as:

$$1 - p_i = \frac{1}{1 + e^{Z_i}} \quad (40)$$

Where $1 - P_i$ represents the probability that a households being food insecure given X_i

Therefore, it is written as:

$$\frac{p_i}{1 - p_i} = \frac{1 + e^{Z_i}}{1 + e^{-Z_i}} = e^{Z_i} \quad (41)$$

Here $P_i / 1 - P_i$ simply the odds ratio in favor of food security. The ratio of the probability that a household will be food secure to the probability of that it will be food insecure.

Finally, taking the natural log of equation (41) the following equation is obtained:

$$Z_i = \ln \left(\frac{p_i}{1 - p_i} \right) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_n X_n \quad (42)$$

Where, Z_i represents a function of explanatory variables X_n

β_0 represent the intercept of the model and

$\beta_1, \beta_2, \dots, \beta_n$ are the slope of parameters in the model.

The interpretation of the coefficients will be understandable if the logistic model can be written in terms of the odds and log of odds (Hosmer and Lemeshow, 1989). The odds ratio is the probability that a household being food secure (P_i) to the probability that household being food insecure ($1 - P_i$) which is Z_i in the model.

3.4.2.7. Interdependence of efficiency, commercialization and food security

This section discusses the interdependence of the results among the levels of efficiencies, commercialization and food security. To capture this multivariate interdependence of food security indicators with other household decision variables, the indicators of food security situations are simulated with the interdependent variables. Accordingly, the commercialization status of households is assumed to be interdependent with crop production efficiency and food security status. Thus, their interdependence was simulated by the multiple equations (Seemingly Unrelated Regression model)

$$Effi_1 = x_1 \beta_{1i} + \varepsilon_{1i} \quad (43)$$

$$Comm_2 = x_2 \beta_{2i} + \varepsilon_{2i} \quad (44)$$

$$Foodstat_3 = x_3 \beta_{3i} + \varepsilon_{3i} \quad (45)$$

$$\begin{pmatrix} \varepsilon_{1i} \\ \varepsilon_{2i} \\ \varepsilon_{3i} \\ \varepsilon_{4i} \\ \varepsilon_{5i} \end{pmatrix} \sim \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix} \begin{pmatrix} 1 & \rho_{12} & \rho_{13} & \rho_{14} & \rho_{15} \\ \rho_{21} & 1 & \rho_{23} & \rho_{24} & \rho_{25} \\ \rho_{31} & \rho_{32} & 1 & \rho_{34} & \rho_{35} \\ \rho_{41} & \rho_{42} & \rho_{43} & 1 & \rho_{45} \\ \rho_{51} & \rho_{52} & \rho_{53} & \rho_{54} & 1 \end{pmatrix} \quad (46)$$

$$E(\varepsilon/x) = 0$$

$$\text{var}(\varepsilon/x) = 1 \quad (47)$$

$$\text{cov}(\varepsilon/x) = \rho$$

Where $Effi_{ji}$ is the level efficiency score of the j^{th} farmer ($i = 1, 2, 3$ are technical, allocative and economic efficiency, respectively), $Comm_i$ is the commercialization level of the j^{th} farmer, $Foodstat_{ji}$ is the food security level (Kcal) of the j^{th} farmer, x'_1 to x'_3 are the respective vectors of covariates that determine the endogenous variables and β_1 to β_3 represents a vector of unknown parameters and ε_1 to ε_5 are the error terms. The assumption of disturbances to be strictly exogenous, homoscedastic, non-zero correlation among equations, but zero correlation among observation are also considered

3.4.2.8. Impact of commercialization on households' food security analysis

Several econometric methods have been developed to address this problem and they include propensity score matching (PSM) in a binary treatment framework, generalized propensity score (GPS) matching in a continuous treatment framework; instrumental variable (IV) approaches and switching regressions. PSM, GPS and IV approaches have inherent limitations that switching regressions overcome. Thus, this study adopts Generalized propensity score (GPS) method.

Generalized propensity score (GPS) method

The econometric model base of GPS is the potential outcome approach developed by Rubin (1974) and now widely used in different interventions evaluation literature. Assuming a random sample of units from a large population and indexed by $i = 1, \dots, N$.

For each unit i under treatment level t , there is a set of potential outcomes $\{Y_i(t)\}$ $t \in T$ refers to as the unit-level dose-response function (DRF). In the binary treatment case $T = \{0, 1\}$. Usually, in impact studies, missing data problem is inherent so that the research question of interest is the identification of the curve of average potential outcomes ((Imai and van Dyk, 2004). In other words, the main objective in such case is to estimate the average potential outcomes or the entire average dose-response function, $\mu(t) = E[Y_i(t)]$. In this study, it represents the function of the average potential livelihood outcomes over all possible commercialization levels and $Y_i(t)$ is a livelihood indicator including household income and food security for a household that is due to commercialization effects.

The observable variables for each unit i are a vector of covariates X_i , the treatment level actually received by the unit is T_i with $T_i \in (t_0, t_1)$ and the potential outcome corresponding to the level of the treatment received is $Y_i = y_i(T_i)$. As the focus in GPS application is on average dose-response and marginal treatment functions for households who are pulse crop producers are considered but households who don't produce pulse crop are not included in the study.

Key assumption and property

Similar to binary treatment impact study, the functionality of the GPS approach requires the weak unconfoundedness assumption and the balancing property (Hirano and Imbens, 2004).

A. Weak unconfoundedness

This assumption is also called the assumption of selection on observables. It states that after controlling for observable characteristics X_i , any remaining difference in treatment intensity T_i across units is independent of the potential outcomes $Y_i(t)$, equation (48).

$$y_i(t) \perp T_i / X_i \text{ for all } t \in T \quad (48)$$

The reason of referring to it as weak unconfoundedness is that it does not require joint independence of all potential outcomes, but requires only pair wise conditional independence of treatment with each of the potential outcomes (each potential outcome conditional on the covariates) (Hirano and Imbens, 2004). The random variable treatment

T_i is assumed to be conditionally independent from the random variable outcome Y_i , measured at an arbitrarily chosen treatment level t . Therefore, under weak unconfoundedness assumption, the average dose–response function can be obtained by estimating average outcomes in subpopulations defined by covariates and different levels of treatment.

B. Balancing property

Calling $r(t, x) = f_{T|X}(t/x)$ the conditional density of the treatment given the covariates, the GPS is expressed in equation (49).

$$R_i = r(T_i, X_i) \quad (49)$$

The GPS has a balancing property similar to the balancing property of the propensity score for binary treatments. Within strata with the same value of $r(t, X)$ the probability that $T = t$ does not depend on the value of X , i.e. the GPS has the property that $X \perp I\{T=t\} | r(t, X)$. Hirano and Imbens (2004) emphasize that this is a mechanical implication of the definition of the GPS and does not require unconfoundedness. In combination with unconfoundedness, however, it implies that assignment to treatment is unconfounded given the GPS. That is, Hirano and Imbens (2004) prove that, if assignment to treatment is weakly unconfounded given covariates X , then it is also weakly unconfounded given the GPS. Therefore, GPS can be used to remove biases associated with differences in the observed covariates. Hirano and Imbens (2004) also proved that if assignment to the treatment is weakly unconfounded given pretreatment variables X , then

$\beta(t, r) = E[Y_i(t) | r(t, X_i)] = E[Y_i | T_i = t, R_i = r]$; and $\mu(t) = E[\beta(t, r) | (t, X_i)]$. Given this result, it is possible to use the GPS to remove bias associated with differences in covariates in two steps and estimate the dose–response function at a particular treatment level t by using a partial mean approach in the third step.

First, estimate the GPS- the conditional density of the treatment given the covariates. The second step is to estimate the conditional expectation of the outcome as a function of two scalar variables, the treatment level T and the GPS R , as expressed in equation (50).

$$\beta(t, r) = E(Y | T = t, R = r) \quad (50)$$

The third step is to estimate the DRF at each particular level of the treatment. This is implemented by averaging the conditional expectation function over the GPS at that particular level of the treatment, equation (51).

$$\mu(t) = E[\beta(t, r(t, x))], t \forall T \quad (51)$$

The procedure does not average over the GPS $R = r(T, X)$, but instead it averages over the score evaluated at the treatment level of interest $r(t, X)$. Hirano and Imbens (2004) also emphasize that the regression function $\beta(t, r)$ does not have a causal interpretation, but that $\mu(x)$ corresponds to the value of the DRF for treatment value t , which compared to another treatment level t' does have a causal interpretation.

GPS application procedures

In practical implementation of GPS in estimating commercialization effects at different intensities in the study areas, three main steps are followed (Hirano and Imbens, 2004). The first step is to estimate the GPS as a conditional density of treatment given the covariates by using a flexible parametric approach. Given the covariates, commercialization is assumed to be distributed normal. Thus, the parameters of the treatment function i.e. β_0 , β_1 and δ_2 (conditional distribution of treatment) are estimated using maximum likelihood according to equation (52).

$$T_i / X_i \approx N[\beta_0 + \beta_1 X_i, \rho^2] \quad (52)$$

Here note that the main purpose of estimating the GPS is to ensure that the covariates are balanced across treatment categories; so that as long as sufficient covariate balance is achieved, the exact procedure for estimating the GPS is of secondary importance (Kluve *et al.* 2012). That is, after GPS estimation, its balancing property is tested before proceeding to step two. Following the estimation of the parameters of the treatment function in equation (52), GPS can be estimated in equation (53).

$$\hat{R}_i = \frac{1}{\sqrt{2\pi\rho^2}} \exp\left[-\frac{1}{2\rho^2} \left(T_i - \beta_0 - \beta_1 X_i\right)^2\right] \quad (53)$$

In the second step, the conditional expectation of the outcome, in this study food security indicator (s), (Y_i) is modeled as a flexible function (polynomial approximation) of observed

treatment (T_i) and estimated GPS ($\hat{R}_i$), which might also involve some interactions between the two (Hirano and Imbens, 2004). For instance, if quadratic approximation is followed, equation (54) is in order.

$$\beta(t, r) = g\left(\left[y_i / T_i \hat{R}_i\right]\right) = \alpha_0 + \alpha_1 T_i + \alpha_2 T_i^2 + \alpha_3 \hat{R}_i + \alpha_4 \hat{R}_i^2 + \alpha_5 T_i \hat{R}_i \quad (54)$$

Here g represents a link function, which depends on the outcome variable. It is not unusual to use regression models for continuous rural livelihood outcome variables such as household income and food security. Therefore, the parameters will be estimated by OLS using the estimated GPS, $\hat{R}_i$. Note that the estimated coefficients in equation (54) do not have a causal interpretation, except that testing whether the joint significance of all coefficients associated with GPS are equal to zero can be used to assess whether the covariates introduce bias (Hirano and Imbens, 2004).

Hirano and Imbens (2004) further outlined that in empirical analysis using the estimated parameters ($\hat{\alpha}$) in step two, estimation of the average outcome for each level of treatment (t) and an entire dose-response function is possible. In other words, the average dose-response function at a particular value of the treatment t will be estimated averaging the (estimated) conditional expectation $\beta(t, r)$ over the GPS at that level of the treatment using equation (55).

$$\mu(t) = E[\hat{Y}(t)] = \frac{1}{N} \sum_{i=1}^N g^{-1}[\hat{\alpha}_0 + \hat{\alpha}_1 \cdot t + \hat{\alpha}_2 \cdot t^2 + \hat{\alpha}_3 \cdot \hat{r}(t, X_i) + \hat{\alpha}_4 \cdot \hat{r}(t, X_i)^2 + \hat{\alpha}_5 \cdot t \hat{r}(t, X_i)] \quad (55)$$

$\hat{\alpha}$, is the vector of parameters estimated in step two and $\hat{r}(t, X_i)$ is the predicted value of $r(t, X_i)$ at level t of the treatment. The entire dose-response function can then be obtained by estimating this average potential outcome for each level of the treatment. In addition to the specification in equation (55) several other specifications should be implemented in order to allow for sufficiently flexible functional forms (Kluve *et al.*, 2007).

3.5. Defination of Variables and Working Hypothesis

3.5.1. Variables for Production Efficiency Analysis (DEA)

Output: The amount of aggregated pulse (grasspea, chickpea, faba bean and field pea) produced in kilogram during 2017 production season.

Production inputs and costs: Input variables and input costs are presented as follows:

Land allocated for pulse crops: It refers to total land in hectare cultivated for the pulse crops during 2017 production season.

Labor required: It refers to family and/or hired labors measured in man-day are used by the sample households for different agronomic practices of pulse production.

Seeds: It refers to the amount of seed (either improved or local seed) used by the sample households and measured in kilogram.

Fertilizer (DAP): It refers to the amount of fertilizers used by the sample farmers for their crop production year (2017) measured in kilogram.

Pesticides: It refers to the amount of pesticide and/or insecticide used by the sample farmers for their crop 2017 production season used in liter.

Cost of fertilizers (Urea/DAP): Cost of fertilizers is recorded as the market price paid to purchase fertilizers during 2017 production season in birr/kg.

Cost of seed: The amount of birr per kilogram paid by farmers to purchase seeds

Cost of labor: The amount of wage paid to hired labor during the production season and also estimate the wage amount if only family labor is used per man-day.

Cost of land: Rental cost is taken as price of land since land does not have market price measured in cost per hectare.

Cost of field chemical: This is estimated as the amount of cash paid for purchasing litter of pesticide in pulse 2017 production season.

Table 2. Summary of variables used for efficiency scores

Variable description	Measurement (unit)
Faba bean output	Kilogram
Field pea output	Kilogram
Chickpea output	Kilogram
Grasspea output	Kilogram
Cultivated land for aggregated pulse	Hectare
Labor used for aggregated pulse	Man-days
Oxen used for aggregated pulse	Oxen power per day
Agro-chemicals used for aggregated pulses	Liter
DAP used for aggregated pulse	kilogram
Faba bean seed used	Kilogram
Field pea seed used	Kilogram
Chickpea seed used	Kilogram
Grasspea seed used	Kilogram
Cost of land	Birr/hectare
Cost of labor	Birr per man-equivalent
Cost of agro-chemicals	Birr/ liter
Cost of DAP	Birr/kilogram
Cost of oxen power	Birr per oxen-day
Cost of faba bean seed	Birr/kilogram
Cost of field pea seed	Birr/kilogram
Cost of chickpea seed	Birr/kilogram
Cost of grass pea seed	Birr/kilogram

Note that the two efficiency indices, the Technical efficiency (TE) and the Allocative efficiency (AE) can be combined to give the economic efficiency index.

$$EE = (TE) * (AE)$$

3.5.2. Variables for Determinants of Production Inefficiency

Dependent variables: Technical, allocative and economic inefficiency scores of smallholder pulse crops producers that take the values between 0 and 1.

Independent variables

Age of the household head: It affects farm households 'in farming processes. Older people usually have accumulated knowledge that helps them to improve their agricultural production. Older farmers are more experienced in farming activities and are better to assess the risks involved in farming than younger farmers (Rebecca, 2011). This implies that as age of the decision maker increases, their efficiency will increase. Therefore, age of the household head influenced inefficiency of production negatively.

Sex of the household head: It refers to sex of the household head (male=1, female=0). The study by Rebecca (2011) revealed that reducing inequalities in human and physical capital between male and female farmers will potentially increase output and efficiency. However, according to Mignouna *et al.* (2012) who assessed the technical efficiency of maize producers in Western Kenya, no significant difference was observable in the sex of the household head although the groups vary significantly in terms of their educational level. Therefore, in this study sex was expected to affect the inefficiency of producers positively or negatively.

Family size: Household members are sources of labor for agricultural activities, and it is assumed to affect production efficiency of pulse crops. Various farm operations such as plowing, planting, weeding, harvesting and threshing are usually performed by households. Women and children are mainly involved in weeding. Mignouna (2012) stated that the household size has an ambiguous effect. It is associated with the availability of timely labor and in this case, larger families are likely to be more efficient. On the other hand, a larger family with more dependents decreases efficiency in farming due to low supply of farming labor. Therefore, in this study family size was expected to affect the inefficiency of producers positively or negatively.

Education level of the household head: It enables farmers to have access to new information and idea as well as improved knowledge and skill to use resources in most efficient ways. It is hypothesized that the education of the household head, measured as a

continuous variable in terms of formal years of schooling has a positive effect on efficiency (Apata *et al.*, 2010). Studies conducted by Mariano *et al.* (2010) used the year of schooling completed by the farm head as the variable affecting technical efficiency. Year of schooling as a variable is known to be positively related to technical efficiency. This implies that farmers with more years of schooling are more efficient than those with less or no years of schooling. Khan and Saeed (2011) agreed that the higher the level of formal schooling by farmers, the higher the technical, allocative and economic efficiencies. This is because educated farmers are likely to access information easily, and use it to make well informed decisions. Therefore, in this study education was expected to affect the inefficiency of pulse crops producers negatively.

Amount of improved seeds used: It is a continuous variable measured in kilograms. There is a positive impact and significant relationship between seed and output (Oyewo, 2011). Seeds were divided into three categories: certified hybrid seed, open pollinated varieties and recycled hybrid and local varieties. Farmers who use certified hybrid seed are expected to have higher efficiency levels (Chiona, 2011). According to Rebecca (2011) most small-scale farmers who practice subsistence farming do not buy certified seeds, but they use recycled seeds that are stored after every harvest, while others buy recycled seeds from their fellow farmers. In this study, access of improved seed was expected to affect the inefficiency of pulse crops producers negatively.

Distance to main road: It is used as proxy for accessibility of transportation to markets. Farmers far away from main road might face difficulty to get transportation access and cost of transportation will be high. Households far away from the main road would have less chance to be efficient than those farmers nearer to the main road (Mungatana, 2011). Thus, it was hypothesized that long distance from main road has positive effect on inefficiencies in crop production.

Distance to development agents' office: It is used as proxy for assessing the accessibility of training services to farmer in crop production. Proximity to development agents' office has advantage of obtaining awareness of farmers and exposes to new ideas and information about productivity of inputs, opportunities, input and output management and prudent handling of cash. Farmers who received training were hypothesized to be more efficient than those who did not received training. Ismat *et al.* (2009) found that training is

negatively related to technical and economic inefficiencies. Therefore, it was hypothesized that long distance from development agents' office has positively effect on producers' inefficiencies.

Landholding size: It is one of the most important resources in agricultural production. The size of land holding hypothesized to have both positive and negative impact on the efficiencies of crop production (Idiong *et al.*, 2009; Otitoju and Arene, 2010). Some studies suggested that small farm size is expected to be more efficient than large frames because of its simplicity in management and transaction costs. But some others oppose to this, they argue that larger farmer is more likely to employ improved agricultural technologies, used as a capital base and enhances the risk bearing ability of farmers and hence could be more efficient than small farms due to its advantage of the economic scale and scope associated with larger sizes (Hussein, 2007). For this study, land holding size was hypothesized to influence inefficiency negatively.

Access to market information: Market information access by the household head is proxy to assess the market price and quantity to be sold. Access to market to input and output information by the household head enhance efficiencies of maize production (Sisay *et al.*, 2016). Thus it was expected that there was a negative relationship between market information access and inefficiencies of pulse production.

Frequency of extension contact: Refers the number of days to be contacted between the household head and extension agent within a given production year. Most of extension service is given to the farmers by the development agent at the grass root level. The provision of agricultural extension service will help farmers to be aware of the benefit and the existence of new technologies. Research result by Otitoju and Arene (2010) also confirmed that a positive relationship was hypothesized between the variable extension contacts and efficiencies of maize production. Therefore, it was expected that an increase in frequency of extension contact has a negative relation on the inefficiency of pulse crops producers.

Amount of credit used: It is a continuous independent variable representing the amount of credit that was obtained either in cash or in kind during the survey year. Ayinde *et al.* (2010) found that introduction of improved farm inputs with complementary practices require considerable amount of capital for purchase of inputs. However, in most cases

smallholder farmers cannot finance these improved farm inputs themselves. Then, the availability of farm credit especially from formal sources becomes a vital component of the modernization of agriculture and to improve the wealth status of farmers. Hence, it is hypothesized that credit will influence pulse crops producers' inefficiency negatively.

Livestock holding: It is measured as a continuous variable in terms of Tropical Livestock Unit (TLU). Farmers who have more livestock size are expected to be more efficient in pulse crops production than those who have no or few livestock size. This is because livestock provides a working power (oxen for draught power), manure fertilizer and is a source of income that can be used to purchase the necessary improved agricultural technologies (Beyene, 2004). Therefore, livestock holding was hypothesized to negatively affect technical, allocative and economic inefficiencies of pulse crops production.

Off/non-farm participation: Participation of the household in off/non-farm income generating activities can be the source of income which will help the households to generate additional income that can help to improve their agricultural practices. In this case such income may have positive impact on efficiency of production. However, participation in off-farm or non-farm (income from working out of agriculture) usually competes for labor that is used for own agricultural activities and in this case it may have negative effect on efficiency of production. Therefore, off/non-farm income was expected to affect pulse crops producers' inefficiency positively or negatively.

Cooperative membership: It refers to participating in any farmer's organization (cooperatives) as membership. Olwande (2010) on his study revealed that most farmers' cooperative associations engage in group marketing, bulk purchasing of inputs, credit provision for its members, and dividend pay and increases access to information which is important to production and marketing decisions. Therefore, in this study cooperative membership was expected to affect pulse crops producers' inefficiency negatively.

Table 3. Variables to influence technical, allocative and economic inefficiencies

Variable Description	Measurement (unit)	Expected sign
Age of household head	Continuous(Year)	-
Sex of household head	Dummy (Female=0, Male =1)	+/-
Household size/member	Adult equivalent	+/-
Education status of household head	Years of schooling	-
Access to improved seed	Dummy (0=No,1=Yes)	-
Landholding size	Continuous (ha)	-
Frequency of extension contact	Frequency contacts per month	-
Amount of credit used	Continuous(Birr)	-
Distance to development center	Continuous (walking hour)	+
Distance to main road	Continuous (walking hour)	+
Total livestock unit	Continuous (number)	+
Off/non-farm participation	Dummy Yes=1, Otherwise =0	+/-
Cooperative membership	Dummy (0=no, 1= yes)	-
Market information access	Dummy (Yes=1,otherwise =0)	-

3.5.3. Variables for Market Orientation Analysis

The dependent

Variables for the double-hurdle model are: a) the discrete binary choices of market orientation decision and b) the intensity of market orientation indices. The dependent variable for the first hurdle (Probit model) pertains the market orientation indices of less than 30% assumed to be zero value and market orientation indices greater than or equal to 30% obtained value of 1. Whereas for the second hurdle (truncated regression), the dependent variable is represented by the value of commercial orientation index calculated for individual observations.

Independent variables

Based on the reviews of literature, the following variables are hypothesized to affect market orientation decision and intensity.

Sex of the household head: It is a dummy variable that takes value of 1 if a household head is male and 0 if female. Since women play a key role in agricultural production, it is important to consider the role they played in the process of crop marketing. Female headed households are usually less likely commercialize in crop production since they are usually endowed with less resource and less exposed to new information due to their social position. Lewis *et al.* (2008) stated that gender difference and the marketing styles at Oklahoma wheat producers showed that men tend to sell more grain frequently than women. It was therefore, hypothesized negatively to influence market orientation decision and intensity.

Age of the household head: It is a continuous variable and measured in years. Age is a proxy measure of farming experience of household head. Aged households are believed to be wise in resource use, on the other hand young household heads have long investment horizon. It is a continuous variable measured in years. A farmer with longer period of experience in production was assumed to have a better knowledge than who has a lower experience in agriculture because through time producers acquire skill about marketing and supply better than those who are less experienced (Alene *et al.*, 2008). It was also assumed that as age increases the production capacity will decrease and amount produced and marketed supply decrease. Hence, it was expected to have either positive or negative sign effect on market orientation.

Education level of the household head: It is described as an essential element in any development process and is measured as years of schooling obtained by the household head. It is expected that the more years an individual is exposed to education, the more open he/she would be to new ideas. Literate households have better skills, and better access to information and ability to process information (Berhanu and Moti, 2012). Therefore education level of farm households was hypothesized to influence the decision and level of market orientation positively.

Distance to road: It is a continuous variable measured in walking hours. It was negatively and significantly influenced the decision and level of household's market orientation. The

reason was that households far away from main road may impose a negative bearing on the decision and level of crop market orientation and participation due to the high transaction cost that farm households perceive in terms of transportation and negotiation capacity.

Distance to market: It is a continuous variable measured in walking hours and included to capture the role of travel costs in influencing probability and intensity of market orientation. It is used as a proxy for market access and is expected to influence market orientation negatively as distant markets mean higher cost of transport and lesser likelihood of purchasing improved input that may lead to higher production for which market is not accessible (Barret, 2007; Alene *et al.*, 2008). Thus distance to market was expected negatively influence market orientation decision and intensity.

Landholding size: It is taken as a continuous variable measured as the total cropped area in hectares under the household management (own land, rented-in land or shared land). This means that as the cultivated land size increases, the probability of crop market orientation increases (Birhanu and Moti, 2010; Bedaso *et al.*, 2012). Thus, it was expected that landholding size affects market orientation decision and intensity positively.

Access to market information: It is measured as a dummy variable taking a value of one if the farmer had access to market information and zero otherwise. The better the market information the farmers have about the products marketing, the higher would be their crop market orientation decisions and market orientation intensity. Moreover, farmers marketing decisions are based on market price information, but poorly integrated markets may convey inaccurate price information, leading to inefficient product movement (Abraham, 2013). Thus, market information was expected to influence market orientation decision and level positively.

Access to extension service: Extension service is the major instrument through which new ideas and techniques are transmitted to farmers. It is a dummy variable whether the household head had got access to extension services or not. Agricultural extension services enhance farmer skills and knowledge, link farmers with modern technology and markets, and ease liquidity and input supply constraints (Berhanu and Moti, 2012). So farmers who have more contact with extension worker can improve their decision to adopt crop market orientation. This variable was expected to influence market orientation decision and intensity positively.

Access to chemical fertilizer: It is a dummy variable denoting the amount of fertilizer applied to crops in kilogram. Chemical fertilizer is used as a good indicator of whether or not a given farm household is interested to grow crops for market oriented purposes. Furthermore, chemical fertilizer is selected since the behavior of farm households thriving to pull together their effort and valuable inputs in the production of a given commodity symbolize households motive to increase return from the farming business (Adam, 2009). Therefore, this variable was expected to influence market orientation decision and intensity positively.

Pesticide/ herbicide use. It is a dummy variable taking a value 1 if a smallholder producer used chemical and 0 otherwise. Fungal and bacterial diseases are among the main production constraints in the major pulse growing areas of the country (Fininsa and Yuen, 2002). The effect of diseases may be restricted to certain production systems, locations, cropping seasons and market supply loses (Chilot, 2010). Among the listed pulses disease in Ethiopia are common bacterial blight, rust and angular leaf spot are economically important. Some of the control measures for pulse diseases are using chemicals, disease resistance varieties, clean seeds and intercropping (Fikre *et al.*, 2012). Therefore, this variable was hypothesized to influence the decision for market orientation positively.

Access to improved seed: It is a dummy variable taking value of 1, if a farmer used improved seeds and 0 otherwise. Seed is an essential agricultural input, which affects production. Improved seeds may withstand drought and erratic rainfall distribution when they are resistant to moisture stress. They can increase agricultural productivity by boosting overall production, which in turn contributes to participate in the market and supply more of his produce the intern obtain food security at the household level (Lipton, 2005). Therefore, this variable was expected to influence market orientation decision and intensity positively.

Credit amount: It is a continuous independent variable representing the amount of credit that was obtained either in cash or in kind during the survey year. Credits are expected to enhance farmers' financial capacity to purchase productivity enhancing inputs (like planting materials, fertilizer and crop protection), pay wages, invest in machinery, or to smooth consumption as well as markets, ease liquidity and input supply constraints, and

thus, leading to increase agricultural productivity, induce market orientation and thus greater commercialization (Martey *et al.*, 2012). Therefore, this variable was expected to influence market orientation decision and intensity positively.

Cooperative membership: It is used as proxy for assessing the role of association in market orientation and participation. Farmer cooperative facilitates information provision related to price, profitability, availabilities of new technology and the provision of credit services to its members. A positive relationship was therefore, hypothesized between the variable cooperative membership and market orientation decision and intensity.

Quantity of pulse produced: It is a continuous variable measured in quintals. A marginal increase in pulse yield in the 2017 production season was assumed to have significant effect in volume of pulse supplied to the market. Thus, the volume of pulse produced was expected to have positive relation to market participation and marketable surplus. Rehima (2006) found that the amount of pepper produced affected the marketed supply of pepper positively and significantly. Therefore, this variable was hypothesized to affect market orientation decision and intensity positively.

Table 4. Description of variables hypothesized to influence market orientations decision/level

Description of variables	Measurement	Expected sign
Age of household head	Continuous (years)	+/-
Sex of household head	Dummy (0=female, 1=male)	+/-
Education level	Continuous (years of school)	+
Distance to market	Continuous (Walking hours)	-
Distance to road	Continuous (Walking hours)	-
Landholding size	Continuous (ha)	+
Market information	Dummy (1=yes, 0= No)	+
Access to chemical fertilizer	Dummy (1=yes, 0= No)	+
Pesticide/herbicide used	Dummy (1=yes, 0= No)	+
Amount of credit use	Continuous (ETB)	+
Extension participation	Dummy (1=yes, 0= No)	+
Cooperatives member	Dummy (1=yes, 0= No)	+
Total livestock owned	TLU	+/-

Access to improved seed	Dummy (1=yes, 0= No)	+
Pulse quantity produced	Continuous (Qt)	+

3.5.4. Variables that Influences Output Commercialization

Dependent variable

Commercialization index (CI): It is measured as the ratio of the gross value of pulse sales to gross value of pulse produced by the household in 2017 production year.

Independent variables

Sex of the household head: This is a dummy variable that takes value of 1 if a household head is male and 0 if female. Since women play a key role in agricultural production, it is important to consider the role they played in the process of crop marketing. Male headed households have better access to information which would provide them better ability to manage their farms and produce more surpluses for market as compared to female headed households (Leykun and Jema, 2014). Male headed households have relatively better advantage to attend agricultural training, to produce more output and to supply more volume of pulse to the market than female headed households. Therefore, it was hypothesized to influence pulse commercialization positively.

Age of the household head: It is a continuous variable and measured in years. Age is a proxy measure of farming experience of household head. Aged households are believed to be wise in resource use, on the other hand young household heads have long investment horizon. It is a continuous variable measured in years. A farmer with longer period of experience in production was assumed to have a better knowledge than who has a lower experience in agriculture because through time producers acquire skill about marketing and supply better than those who are less experienced (Tadele *et al.* 2017). It was also assumed that as age increases the production capacity will decrease and amount produced and marketed supply decrease. Hence, it was expected to have either positive or negative sign effect on commercialization.

Education level of the household head: It is a continuous variable that refers to the number of years of formal schooling the household head attended. Educated household

heads are expected to have better skill, better access to information and make better use of their available resources. Educated household head was found to have a positive effect on the level of wheat commercialization (Tadele *et al.*, 2017). Literate households have better skills, and better access to information and ability to process information (Berhanu and Moti, 2012). Therefore education level of farm households was hypothesized to influence the decision to sell more crop output.

Household size: It is a continuous variable that refers to the total number of members of the household and measured in terms of adult equivalent. Having more household members reduces the proportion of output that going to the market because of households with large member tend to consume more of what they have produced and less is available for sales (Efa *et al.*, 2016). As the proportion of output consumed at home increased, the quantity of output sold decreased. Therefore, household size is expected to affect the quantity of pulse to be sold negatively.

Distance to road: It is a continuous variable measured in walking hours. Households far away from main road may impose a negative bearing on the decision and level of participation due to the high transaction cost that farm households perceive in terms of transportation and negotiation capacity. Pender and Dawit (2007) and Berhanu and Moti (2010) examined that marketing costs is completely hindering or limiting the level of smallholder market participation. Hence, this variable was hypothesized to affect volume of pulse sold negatively.

Distance to the market: It is a continuous variable measured in walking hours and included to capture the role of travel costs in influencing probability and intensity of market orientation. It is used as a proxy for market access and is expected to influence market orientation negatively as distant markets mean higher cost of transport and lesser likelihood of purchasing improved input that may lead to higher production for which market is not accessible (Barret, 2007; Alene *et al.*, 2008). Besides, Tadele *et al.* (2017) indicated that distance to market of selling wheat in minutes of walk from wheat producers homestead influence the level of commercialization negatively and significantly. Thus distance to market was expected negatively influence output sold.

Landholding size: It is taken as a continuous variable measured as the total cropped area in hectares under the household management (own land, rented-in land or shared land). Land size cultivated has a positive significant outcome on being transition and commercial farmer (Leykun and Jema, 2014). In addition, the study by Efa *et al.* (2016) showed that larger area allocated to *tef* production increases the quantity of produce available for sale. Thus, it was hypothesized that landholding size influenced commercialization intensity positively.

Access to market information: It is measured as a dummy variable taking a value of one if the farmer had access to market information and zero otherwise. The better the market information the farmers have about the products' marketing, the more output would be sold. Moreover, farmers marketing decisions are based on market price information, but poorly integrated markets may convey inaccurate price information, leading to inefficient product movement (Abraham, 2013). Thus, market information was expected to influence output sold positively.

Frequency of extension contact: It is the major instrument through which new ideas and techniques are transmitted to farmers. It is a continuous variable in which the household head had contacted extension services providers. Agricultural extension services enhance farmer skills and knowledge, link farmers with modern technology and markets, and ease liquidity and input supply constraints (Berhanu and Moti, 2012). Moreover, Tekalign (2014) and Girma (2015) found that extension contact and advice significantly and positively influenced crop commercialization and marketed surplus of teff. So this variable was hypothesized to influence pulse commercialization positively.

Access to chemical fertilizer: It is a dummy variable denoting the amount of fertilizer applied to crops in kilogram. Chemical fertilizer is used as a good indicator of whether or not a given farm household is interested to grow crops for market oriented purposes. Furthermore, chemical fertilizer is selected since the behavior of farm households thriving to pull together their effort and valuable inputs in the production of a given commodity symbolize households motive to increase return from the farming business (Adam, 2009). Therefore, this variable was expected to influence output sold positively.

Pesticide/herbicide use: It is a dummy variable taking a value 1 if a smallholder producer used chemical and 0 otherwise. Fungal and bacterial diseases are among the main production constraints in the major pulse growing areas of the country (Fininsa and Yuen, 2002). The effect of diseases may be restricted to certain production systems, locations, cropping seasons and market supply losses (Chilot, 2010). Among the listed pulses disease in Ethiopia are common bacterial blight, rust and angular leaf spot are economically important. Some of the control measures for pulse diseases are using chemicals, disease resistance varieties, clean seeds and intercropping (Fikre *et al.*, 2012). Therefore, this variable was hypothesized to influence crop output sold positively and significantly.

Livestock holding: It is measured as a continuous variable in terms of TLU. Farmers who have more livestock size are fewer tendencies to participate both for market orientation and participation than those who have no or few livestock size. This is because smallholder farmers who have livestock allocated large proportions of their land for grazing in which the land for crop production is being so small (Birhanu and Moti, 2010). On the other hand, livestock provides a working power (oxen for draught power), manure fertilizer and is a source of income that can be used to purchase the necessary improved agricultural technologies which fosters production and productivity that leads to more supply to the market (Habtamu, 2013). Therefore, livestock holding was expected to influence crop output sold either positively or negatively.

Access to improved seed: It is a dummy variable taking value of 1, if a farmer used improved seeds and 0 otherwise. Seed is an essential agricultural input, which affects production. Improved seeds may withstand drought and erratic rainfall distribution when they are resistant to moisture stress. They can increase agricultural productivity by boosting overall production, which in turn contributes to participate in the market and supply more of his produce the intern obtain food security at the household level (Lipton, 2005). Therefore, this variable was expected to influence crop output sold positively.

Cooperative membership: It is used as proxy for assessing the role of association in market orientation and participation. Farmer cooperative facilitates information provision related to price, profitability, availabilities of new technology and the provision of credit services to its members (Birhanu and Moti, 2010). A farmer who is member of farmer cooperative is more likely to participate at the market and hence sell more of his produce

than others. A positive relationship was, therefore, hypothesized between the variable cooperative membership and crop output commercialization.

Off/non-farm participation: It is a dummy variable that taking a value of 1 if a household head has access to credit service and 0 otherwise. Tekalign (2014) found that participation in off/non-farm activities negatively impacts the degree of crop commercialization. Receiving non/off farm income negatively affect the marketed surplus of haricot bean, farmers who had more cash from non/off farm sources were not able to encouraged by earning from sale of haricot bean and sold less output than those who did not have access (Shewaye, 2016). There for this variable influenced commercialization of pulses negatively.

Quantity of pulse produced: It is a continuous variable measured in quintals. A marginal increase in pulse yield in the 2017production season was assumed to have significant effect in volume of pulse supplied to the market. Thus, the volume of pulse produced was expected to have positive relation to marketable surplus. Rehima (2006) found that the amount of pepper produced affected the marketed supply of pepper positively and significantly. Therefore, this variable was hypothesized to affect output sold positively.

Table 5. Description of variables hypothesized to influence pulse commercialization

Description of variables	Measurement	Expected sign
Age of the household head	Continuous (years)	+/-
Sex of household head	Dummy(0=female, 1= male)	+
Education level	Continuous (years of school)	+
Family size	Continuous(Adult equivalent)	-
Distance to market	Continuous (Walking hours)	-
Distance to road	Continuous (Walking hours)	-
Landholding size	Continuous (ha)	+
Market information access	Dummy(1=yes, 0= No)	+
Access to chemical fertilizer	Dummy(1=yes, 0= No)	+
Pesticide/herbicide use	Dummy(1=yes, 0= No)	+
Off/non-farm participation	Dummy(1=yes, 0= No)	-
Frequency of extension contact	Continuous (count)	+

Cooperatives membership	Dummy(1=yes, 0= No)	+
Total livestock number	TLU	+/-
Access to improved seed	Dummy(1=yes, 0= No)	+
Pulse quantity produced	Continuous (Qt)	+

3.5.5. Variables that Determine Households Food Security

Dependant variable

Food security: Households' calorie intake or acquisition is the number of calories, or nutrients, available for consumption by household members over a defined period of time. Then the results would be compared with the minimum subsistence requirement per AE per day (*i.e.* 2100 kcal). Households who consume below this minimum requirement (2100 kcal per AE per day) was categorized as food insecure and those households who consume above the threshold was considered as food secure.

Independent variables

Age of the household head: Older people have relatively richer experiences of the social and physical environments as well as greater experience of farming activities (Haile *et al.*, 2005). That is, when household heads get older, they are expected to have stable economy in farming. Moreover, older household heads are expected to have better access to land than younger heads, because younger men either have to wait for land redistribution, or have to share land with their families. However, Babatunde (2007) and Taye (2014) stated that young household heads were stronger and expected to cultivate larger farm size than older household heads. Hence, the expected effect of age on household food security was positive or negative.

Sex of the household head: It is an important determinant of food security and it is represented in the model by dummy variable (*i.e.* 1 if the household head is male and 0 otherwise). Male-headed households have more access to agricultural technologies, more labor power and farmland as compared to female-headed households. Moreover, with regard to farming experience and access to technology males are better than female farmers. Women farmer may need a long adjustment period to diversify their income sources fully and become food secure (Fekadu and Mekuanint, 2010; Tewodros and

Fikadu, 2014). Therefore, it was hypothesized male headed households are more likely to be food secure than female headed households.

Educational level of the household head: It is a continuous variable measured in years of schooling. Educated household head has the capacity to innovate and to adopt timely technology and has better understanding of the cash crops that can help them to have a better income for purchasing food items than the non-educated households (Amaza et al., 2009; Misgina, 2014). Thus, education status was hypothesized to have a positive effect on household food security.

Landholding size: Ownership of the larger cultivated land, the higher the probability of being food secure to the farm households. This means, the farm households due to ownership of larger size of cultivated land would have higher the probability to produce more food and sources of cash products than households with smaller size of cultivated land. As a result of using this resource, the farm households would have probability of acquiring capital which might enable them to invest on other production resources and inputs that contributes to food security of the households (Shiferaw *et al.*, 2013). Therefore, it was hypothesized that households with large cultivated land would have less likelihood to be food insecure.

Family size: It refers to the total number of household members who lived and eat with household at least for six months. It is an important variable which determines the state of household food security and expected to have negative effect on household food security. Increasing family size tends to exert more pressure on consumption than contribution to production (Tsegay, 2009; Misgina, 2014). In this study, this variable was expected to influence food security status of households negatively.

Distance to the market: It is continuous variable indicating the distance from the farm household's residence to the local market center measured by average walking hour. Households nearer to market centers had better chances to be food secure than those who are away from market centers due to the reason that households nearer to market center have the probability of selling their produce and purchase food from market. As distance from market center becomes far and far the probability of households to sell their product and purchase supplementary materials becomes less which resulted in low probability of

household being food secure become (Fekadu *et al.*, 2015). Hence, market distance was hypothesized to have a negative relationship with food security status.

Access to improved seed: It is a dummy variable taking value of 1, if a farmer used improved seeds and 0 otherwise. Seed is an essential agricultural input, which affects production. Improved seeds may withstand drought and erratic rainfall distribution when they are resistant to moisture stress. Seed is an essential agricultural input, which affects production. Improved seeds may withstand drought and erratic rainfall distribution when they are resistant to moisture stress. They can increase agricultural productivity by boosting overall production, which in turn contributes to attaining food security at the household level (Tewodros and Fikadu, 2014). Thus, using improved seeds has positive association with household food security

Quantity of pulse produced: It is the annual pulse quantity produced by the household head. Thus, the amount of pulse produced was expected to have positive relation to food security status of the households. The lower the amount of food obtained from own production, the more likely the household to be food insecure (Tewodros and Fikadu, 2014). Therefore, as more quantity of pulse produced, food security status of the households was influenced significantly.

Access to chemical fertilizer: It has been perceived as a factor of improving productivity per unit area. Households who have access to chemical fertilizer was more likely to be food secure than those who have not accessed (Misgna, 2014). Therefore, chemical fertilizer utilization could increase agricultural productivity and influence the food security status of a household positively.

Off/non-farm participation: Participation in off/non-farm income generating activities is an important aspect to increase household income. This was measured by whether or not a household head involved in diversified income sources such as selling firewood, working on farms as daily laborers and running petty or small trade. The success of households and their members in managing food insecurity is largely dependent on their ability to get access to off farm job opportunities which could serve as livelihood diversification strategies (Beyene and Muche, 2010; Taye, 2014). Hence, it was hypothesized that the

availability of off-farm/non-farm income is positively associated with household food security.

Livestock ownership (TLU): The livestock holding of the household was measured by the number of Tropical Livestock Unit (TLU). Livestock contribute to household's economy in different ways, for instance, as a source of pulling power, source of cash income, source of supplementary food, and means of transport. Besides, livestock are considered as a means of security and means of coping during crop failure and other calamities (Fekadu *et al.*, 2105). Therefore this variable was hypothesized to influence food security positively.

Income from pulse: It is the amount of total income (measured in Birr) that a household had earned income from sales of pulse in the production year. It is obvious that income earned from any source improves the food security status of the household. High-income families are less likely to be food insecure (Taye, 2014). Hence it was expected that households who have large pulse income are better in their food security status.

Income from livestock: It is a continuous variable and it was the amount of total income (measured in Birr) that a household had earned income from sales of livestock. It is obvious that income earned from any source improves the food security status of the household. High-income families are less likely to be food insecure (Taye, 2014). Hence it was expected that households who have large income are better in their food security status.

Table 6. Description of variables hypothesized to influence food security status

Description of variables	Measurement	Expected sign
Sex of household head	Dummy (1female, 0 male)	+
Age of household head	Continuous (years)	+/-
Education level	Continuous (year of schooling)	+
Family size	Continuous (Adult equivalent)	-
Landholding size	Continuous (ha)	+
Distance to market	Continuous (walking hour)	-
Access to improved seed	Dummy (1=yes, 0=No)	+
Quantity of pulse produced	Continuous (quintal)	+

Access to chemical fertilizer	Dummy (1=yes, 0=no)	+
Off/non-farm participation	Dummy (1=yes, 0=no)	+
Livestock ownership	Continuous (TLU)	+
Income from pulse sold	Continuous (ETB)	+
Income from livestock sold	Continuous (birr)	+

3.5.6. Variables for Impact Analysis

Dependent variable

Commercialization index: It is continuous variable which is obtained from the sale of outputs

Outcome variable: Food security of the household head in kilocalorie (kcal) intake

Control variables (covariates)

In observational or non-experimental impact researches, covariates selection criteria are critical (Li and Fraser, 2015). This is because, from its very definition, propensity score is the probability that an agent takes treatment given covariates. It is about identifying and controlling confounding variables. The general rule-of-thumb guide is to include all covariates that have association with both treatment and outcome variables (Patorno *et al.*, 2013). However, Rubin (1997) and Brookhart *et al.* (2006) propose that inclusion of covariates that have association with outcome variable regardless of its association with treatment variable is useful in reducing variance of estimated treatment effect. This is because there is a chance that a variable related to the outcome is also related to treatment (Garrido *et al.*, 2014).

Table 7. Control variables (covariates)

Variable	Description/units of measurement
Sex of the household head	Male= 1, female=0
Education level of household head	Year of schooling
Family size	Measured in adult equivalent (AE)
Landholding size	Landholding size in ha
Distance to road	Distance to main road in walking minutes

Distance market	Distance to market in walking minutes
Participation in training	Participation in formal or informal training
Market information	Access to market information
Credit access	Amount of credit obtained (ETB)
Total livestock owned	Total livestock unit(TLU)
Quantity of pulse produce	Amount of pulse produced (QT)

4. RESULTS AND DISCUSSION

This chapter presents the results and discusses the main findings of the study in comparisons with the results of other similar studies. It starts with simple descriptive statistics results and moves on to econometric models results.

The descriptive analysis was used to describe the general socio-economic and demographic characteristics of the sample farm households, the characteristics of pulse crops production, commercialization and food security status in the study areas. Mean, percentage, standard deviations, t-test and chi square tests were employed. Econometric models were also employed to identify the factors affecting smallholder pulse producers' efficiency level, market orientation decision and levels, commercialization levels, food security status and impact of commercialization on food security in the study areas.

4.1. Descriptive Analysis

4.1.1. Demographic and Socio-Economic Characteristics of Sample Households

The number of sample respondents was 385. The age of the sample respondents ranges from 28 to 71 years with the average age of 50.06 years. The average family size per sample household was 5.8 which was larger than the national average household size of 4.6 persons per household (EDHS, 2012; CSA, 2014). In addition, the sampled households walked on average 50.19 minutes to arrive at the nearest market center and 33.35 minutes to reach the main road (Table 8).

The livestock species found in the study area are cattle, goat, sheep, donkey, mule, horse and poultry. Livestock is kept both for generating income and traction power. To assess the

livestock holding of each household, the Tropical Livestock unit (TLU) per household was calculated. As depicted from Table 8, the average livestock holding of the sample household heads was 6.5 TLU. Land is also one of the necessary factors of production for the households in the study area. The average landholding size in the sample study area was 1.04 hectares per household which was lower than the national average land holding size of 1.17 ha per household (CSA, 2014).

Table 8. Summary statistics of the sample households (continuous variables)

Variables	Min	Max	Mean	Std.Err
Age of household head	28	71	50.07	0.56
Educational level of household head	0	8	1.21	0.10
Family size in adult equivalent	3	9	5.8	0.06
Distance to main market	25	80	50.2	0.58
Distance to main road	15	45	33.4	0.33
Distance to development agents	10	45	30.1	0.35
Landholding size	0.50	1.75	1.16	0.02
Land allocated for pulse crops	0.06	0.63	0.33	0.01
Frequency of extension contact	3	14	7.52	1.64
Credit amount	0	5600.00	842.07	1198.07
Total number of livestock (TLU)	1	14	6.64	0.113

Source: Computed from survey data (2019)

Regarding sex of the sample farm household heads, about 79.5% were male-headed and the remaining 20.5% were female-headed. The result indicated that about 35.6% of the respondents have got credit services for their own pulse production. Extension services usually play a major role in disseminating new and improved farming techniques. Table 9 showed that about 71% of the farmers had contact with the development agents. Moreover, 68.1% of the sampled households have accessed market information for pulse marketing from different sources. Training received on the use of improved seed, technology adoption, agronomic practices and pre and postharvest losses will enhance agricultural productivity and in turn increases market supply of the product. Thus, the result in the study area indicated that 69.9% of the respondents have got training access on pulse production and marketing.

As displayed in Table 9, about 67.3% of the sampled household heads were members of farmers' cooperatives where participation at cooperatives was believed to enhance the information exchange and experience sharing among farm households on the use of improved agricultural technologies and recommended agronomic practices. In addition, about 87.8% of the sampled respondents also participated in social activities (*edir and equib*).

Table 9. Summary statistics of sample households (dummy variables)

Variable	Description	No. of respondents (n=385)	Percent
Sex of household head	Male	307	79.7
	Female	78	20.3
Credit access	Yes	137	35.6
Extension participation	Yes	273	70.9
Coops membership	Yes	259	67.3
Social participation	Yes	338	87.8
Training access	Yes	269	69.9
Market information	Yes	262	68.1
Off/non-farm participation	Yes	70	18.2
Access to improved seed	Yes	273	70.9
Access to chemical fertilizer	Yes	261	67.8
Access to field chemical/pesticides	Yes	238	61.9

Source: Computed from survey data (2019)

4.1.2. Income Sources of the Sampled Households

The annual income from crop production (pulse and cereal crops), livestock and income generated from non-farming activities was considered to enumerate the average income of household farmers. As it was indicated from Table 10, the highest income was generated from crop production followed by income from non-farming activities and livestock income. The households on average have got 6712.80 birr from pulse crop sales, 3542.80 birr from cereal crops sale, 1204.20 birr from livestock sales and 1514.90 birr from off/non-farm income in the production period of 2017. The Gini coefficient measurement of farm households' income indicated that the highest (0.87) income inequality distribution

was observed from non farming activities and there was also income inequality (0.62) distribution among the smallholder pulse producers. This showed that pulse producers had earned much more income by pulse production than those who did not produce pulse crops.

Table 10: Descriptive statistics of income indicator variables for sampled households

Description	Sampled households (n=385)		
	Mean	Std.Dev	Gini coeffi.
Pulse income	6712.80	4921.4	0.62
Cereal income	3542.80	2578.2	0.29
Livestock income	3258.30	1204.2	0.21
Off/non-farm income	638.40	1514.9	0.87

Source: Computed from survey data (2019)

4.2. Efficiency Analyses for Pulse Production

4.2.1. Inputs Used and Costs for Aggregated Pulse Production

The costs of production inputs are based on the quantity and quality of inputs used. These costs were obtained by adding the production costs of individual crops during 2017 farming season. The opportunity cost used to determine the cost of land was its rental value collected from individual farm households under study. The cost of other inputs was the market prices during the production period. The mean annual rental value of land used varies depending on the size and quality of the soil type. The cost of land was approximated by its rental value. Based on the result indicated in Table 11, on average a given household allocate a total of 0.36 hectare of land for grasspea, chickpea, faba bean and field pea production and its average cost was also computed as ETB 9959.93 per hectare.

Labor was used for agricultural production activities (includes ploughing, planting, weeding, harvesting and threshing) and it constitutes both family labor and hired ones. The major sources of labor inputs were household labor and non-cash exchange labor. In most cases, there arises a difficulty in quantifying the cost of household labor and non-cash exchange labors. Maximum effort was made to fully include the cost of these labors. Labor was aggregated for each farmer in a single unit in man/day. The cost of hired labor was estimated based on the daily average wage rate (85 ETB per day) of the nearby village. As a result, total cost of labor input was the sum of cost of hired labor and opportunity cost of family labor. The average labor cost was 1825.5 ETB with an average of 21.5 man-days per hectare for pulse production during the survey period (Table 11).

The survey result depicted that the smallholder pulse producers used 57.9 kg/ha of DAP and its average cost was 1041.79 ETB/ha. In addition, smallholder producers used 2.01 liter of chemicals (pesticides and insecticides) with the average cost of 287.23 ETB/ha.

Table 11. Inputs used and cost of inputs for pulse crops production

Aggregated pulse crops			
Variables	Unit	Mean	Std.Err
Land allocated for pulses	Ha	0.36	0.01
Cost of pulse land	ETB/ha	6494.03	20.21
Total pulse seed used	Kg/ha	122.64	2.23
Total pulse seed cost	ETB/ha	2578.74	37.16
Total oxen power	Oxen day/ha	10.85	0.17
Total oxen cost	ETB/ha	1639.60	32.21
Total labor day	Man –day/ha	21.5	0.17
Total labor cost	ETB/ha	1825.5	18.60
Total DAP used	Kg/ha	57.9	1.66
Total DAP cost	ETB/ha	1041.79	24.85
Total field chemical use	Kg/ha	25.85	0.05
Total field chemical cost	ETB/ha	1225.75	12.95

Note: Aggregated pulse crops (grasspea, chickpea, faba bean and field pea)

Source: Survey data (2019)

4.2.2. Pulse Output and amount of inputs used

Table 12. Descriptive statistics of output and production inputs for individual pulse crops

Variables Descriptions	Mean	Standard Error
Grasspea production (n=267)		
Grasspea output (kg)	465.49	6.939
Seed used (kg)	52.63	0.878
Land allocated (ha)	0.06	0.003
Number of labor used (man-days)	6.05	0.027
Chemical used (liter) (n=219)	8.27	0.090
Oxen used (Oxen-day)	4.23	0.062
Chickpea production (n=310)		
Chickpea output(kg)	492.77	6.596
Seed used (kg)	68.03	0.469
Land allocated	0.07	0.003
Number of labor used (man-days)	5.04	0.098
Chemical used (liter/kg) (n=231)	2.01	0.054
DAP used (n=205)	15.50	0.715
Oxen used (Oxen-day)	3.65	0.092
Faba bean Production (n=345)		
Faba bean output(kg)	598.71	8.663
Seed used (kg)	78.92	0.294
Land allocated (ha)	0.12	0.003
Number of labor used (man-days)	7.48	0.040
Chemical used (liter/kg) (n=304)	11.45	1.072

DAP used (kg) (n=291)	20.30	0.820
Oxen used (Oxen-day)	4.05	0.013
Field pea production (n=323)		
Field pea output(kg)	527.2	6.312
Seed used (kg)	95.74	1.024
Land allocated (ha)	0.13	0.003
Number of labor used (man-days)	7.27	0.049
Chemical used (liter/kg) (n=205)	4.12	0.057
DAP used (kg) (n=229)	21.20	0.817
Oxen used (Oxen-day)	3.34	0.024
Source: Survey data (2019)		

4.2.3. Costs of Inputs for Pulse Production

These costs were obtained by adding the production costs of individual crops during 2017 production season. The opportunity cost used to determine the cost of land was its rental value collected from individual farm households under study. The mean annual rental value of land used vary depend on the size and the land fertility/quality. Based on the result indicated in Table 13, there is a large deviation observed in the costs of land used for grasspea and chickpea crops. This is due to the variation in the size and quality of land allocated to individual crop by farm sample households.

The major sources of labor inputs for 2017 production year were household labor and non-cash exchange labor. In most cases, there arises a difficulty in quantifying the cost of household labor and non-cash exchange labors. However, the average daily wage for a laborer was used as the cost of household labor and non-cash exchange labors to determine the cost of labor.

One of the constraints that hinder productivity of pulse crops is the availability of improved seed (Gete *et al.*, 2015). Seeds are provided by informal and formal seed systems. The informal system is a self-saved seed or farmer to farmer seed exchange system and formally seeds are provided by government agencies and commercial organizations (Boere *et al.*, 2015). In the study areas, most of smallholder pulse producers

used their own seed for 2017 production year and purchased from the nearby local market. The cost of seed was determined by the quality and quantity of seed purchased per quintal for the production year.

The most prominent inorganic fertilizers which are widely used in the study areas are Diammonium Phosphate (DAP). During the survey period, smallholder pulse producers used chemical fertilizer for chickpea, faba bean and field pea production. But the amount of fertilizer application is below the recommended rate which means they didn't use sufficient amount of fertilizer. The costs of chemical fertilizers are almost similar except for few differences due to transportation and related costs.

Table 13. Descriptive statistics of production input costs for individual crops

Variables Descriptions	Mean	Standard Deviation
Grasspea production (n=267)		
Land cost	2666.85	561.63
Seed Cost	639.08	56.11
Labor cost	554.57	60.91
Oxen Cost	457.64	291.38
Chemical cost (n=219)	289.72	176.33
Chickpea production (n=310)		
Land cost	2421.87	254.27
Seed Cost	820.35	27.05
Labor cost	588.15	92.88
DAP cost (n=205)	245.66	112.65
Oxen Cost	423.94	235.71
Chemical cost (n=231)	194.55	80.36
Faba bean Production (n=345)		
Land cost	2447.10	90.57
Seed Cost	898.96	34.97
Labor cost	635.65	63.19
DAP cost (n=291)	394.57	228.55
Oxen Cost	472.35	308.12

Chemical cost (n=304)	468.94	274.96
Field pea production (n=323)		
Land cost	2424.46	95.98
Seed Cost	1007.74	118.96
Labor cost	616.26	80.28
DAP cost (n=229)	403.56	220.35
Oxen Cost	461.73	285.90
Chemical cost (n=205)	272.55	160.86

Source: Survey data (2019)

4.2.4. Description of Variables Used for DEA

One of the most critical steps in order to conduct a DEA analysis is careful examination of the output and input variables and establishing an appropriate level of aggregation. It is necessary to aggregate the data to form a smaller number of inputs and output variables. According to Coelli *et al.* (2005) there are important issues to be considered during input and output aggregation processes. Firstly, it is important to ensure that aggregates formed are meaningful. It is necessary to ensure that the aggregates are formed across variables that exhibit similar movements in relative prices or quantities. Secondly, prices data are integral part of the work when multiple outputs are aggregated. Therefore, value aggregation can be formed by the product of price and quantity and summing it over all the commodities included in the aggregate. Therefore, following Coelli *et al.* (2005), in this study aggregation of outputs (grass pea, chickpea, faba bean and field pea) and inputs (land, labor, field chemicals, fertilizer, seed and oxen power) was made keeping that values formed are meaningful and price values are incorporated in value aggregation.

Regarding the reconciliation of zero value data in the DEA analysis different, approaches for outputs and inputs were used. Accordingly, for DMUs producing any of outputs (single or multiple positive outputs) regardless of the type and quantity they produced zero level output was taken as zero for analysis. This is due to the fact that outputs can be zero in the DEA analysis. However, unlike zero outputs, zero inputs were treated differently. Battese (1997) suggested that it is possible to estimate production frontier by assigning very small value greater than zero. Fried *et al.* (2008) also indicated that zero inputs are more

problematic in DEA and they recommended that substituting a very small positive number which is near to zero.

4.2.5. Efficiency Scores

The model output presented in Table 14 indicated that farmers in the study area were relatively good in TE than AE or EE. The mean TE was found to be 0.72. It indicated that farmers on average could decrease inputs (land, labor and fertilizers) by 28% if they were technically efficient. AE was found to be 0.56, indicating the AE of farm households revealed 44% increase in output by improving AE, with the existing technology. In another form of analysis, the mean allocative efficiency of 56% means that there is a need to improve the present level of allocative efficiency. For instance, farmer with average level of allocative efficiency would enjoy a cost saving of about 44% derived from $(1 - 0.56/1) \times 100$ to attain the level of the most efficient farmer.

The combined effect of TE and AE factors showed that the average EE level to be 0.40. Moreover, the result also means that the farmer with average level of economic efficiency would enjoy a cost saving of about 60% derived from $(1 - 0.4/1) \times 100$ to attain the level of the most efficient farmer. Therefore, this result showed that the existence of significant technical, allocative and economic inefficiency in crop production among smallholder farmers in the study area.

Table 14. Summary statistics of efficiency measures

Type of efficiency	Mean	Std.Dev
Technical efficiency	0.72	0.176
Allocative efficiency	0.56	0.205
Economic efficiency	0.40	0.174

Source: model output, 2019

The majority of the sampled households have TE score in the range of 50-59.9% and 70-79.9% (Figure 5). There were also farmers whose TE levels were limited to the range 0.9 to 10% only. Farmer in this group has a room to enhance their pulse production at least by 90 percent on average. Out of the total samples, 21.6% was operating below 50% of

technical efficiency level and 9.8% of the farmers have TE greater than 90%. Technical efficiency estimate was low compared with the results obtained by Jema (2008), Essa (2011), Musa (2013), Mustefa (2014) but relatively higher than the results obtained by Fekadu (2004), Ali *et al.* (2012) and Wadi'ah (2012). According to Coelli *et al.* (1998), the high technical efficiency estimates might also be related to the higher number of input-output variables.

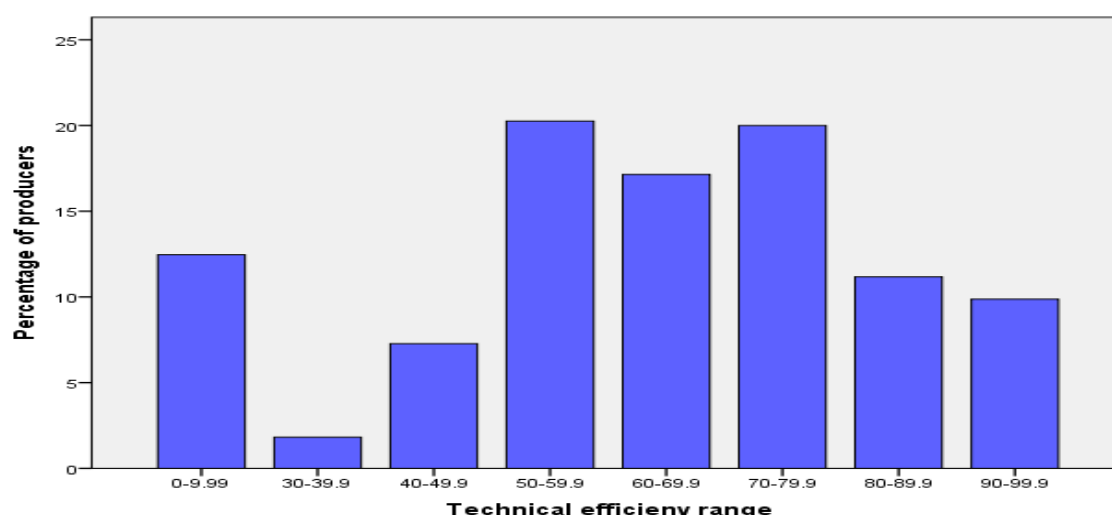


Figure 5. Distribution of technical efficiency scores

Source: Own computation (2019)

Allocative Efficiency (AE)

As shown from Figure 6, AE distribution scores indicate that the largest efficiency group of pulse producers (37.1%) operates between 0 and 49.99%. Only less than 2.3 % of the total pulse producers have an AE score of greater than 90%. This shows that there is a great opportunity to increase the efficiency of pulse producers by reallocation of resources in cost minimizing way.

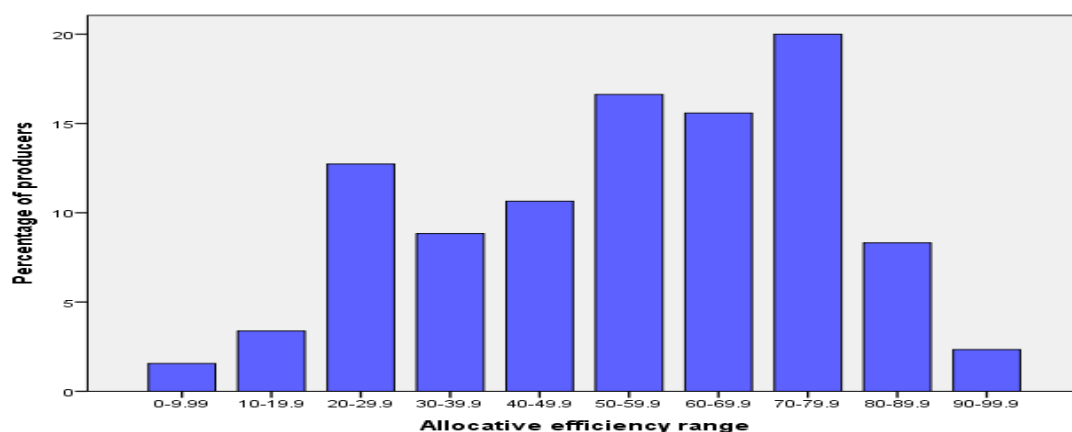


Figure 6. Distribution of allocative efficiency scores

Source: Own computation (2019)

Economic Efficiency (EE)

As indicated from Figure 7, the EE distribution scores indicate that the largest efficiency group of pulse producers (73.8%) operates between 0 and 49.99%. Only less than 0.3 % of the total pulse producers have an EE score of greater than 90%. This shows that there is a great opportunity to increase the efficiency of pulse producers by reallocation of resources in cost minimizing way.

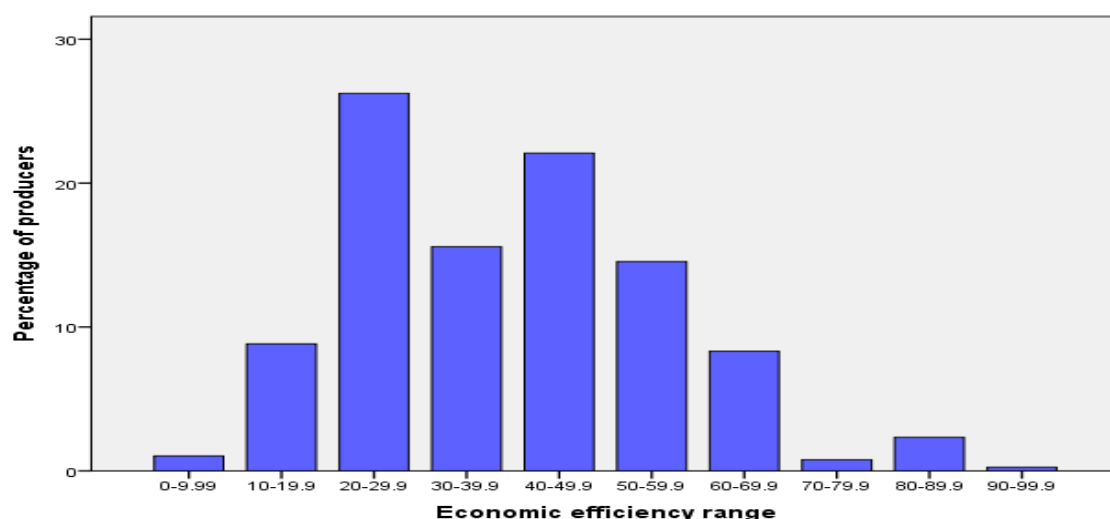
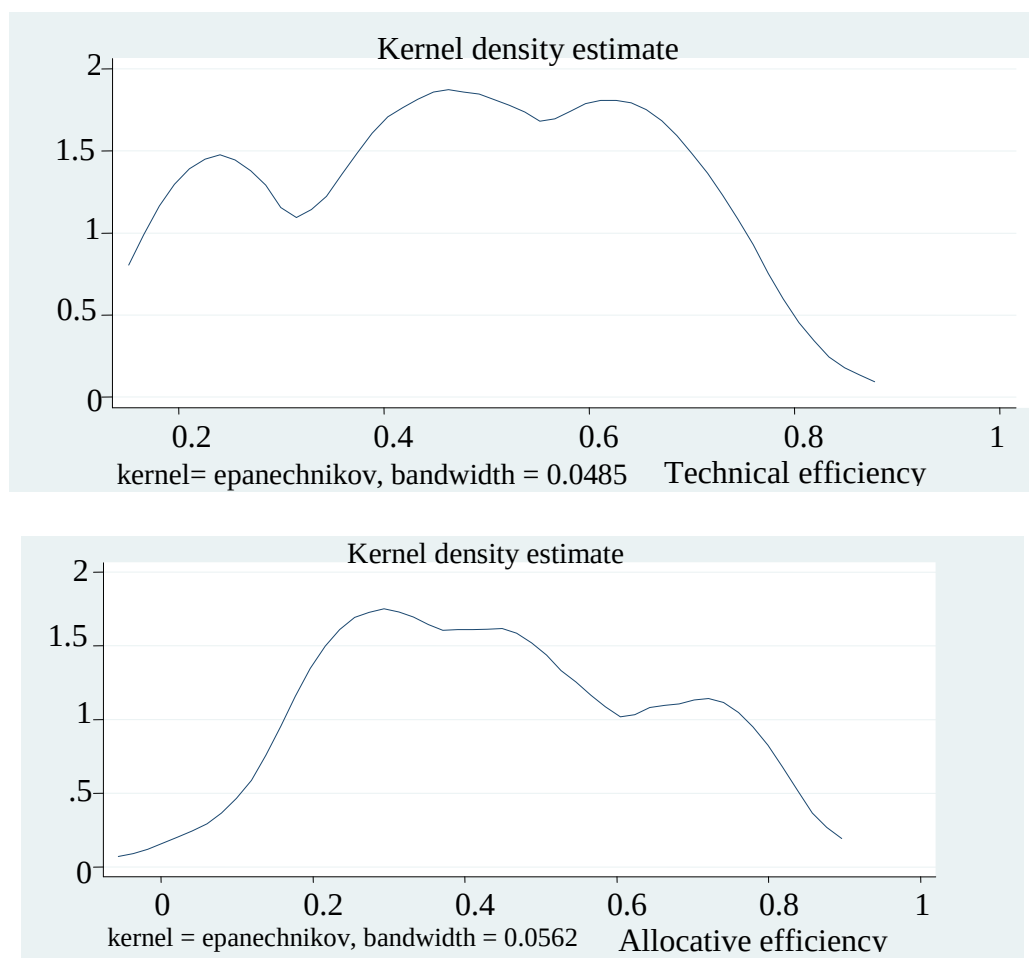


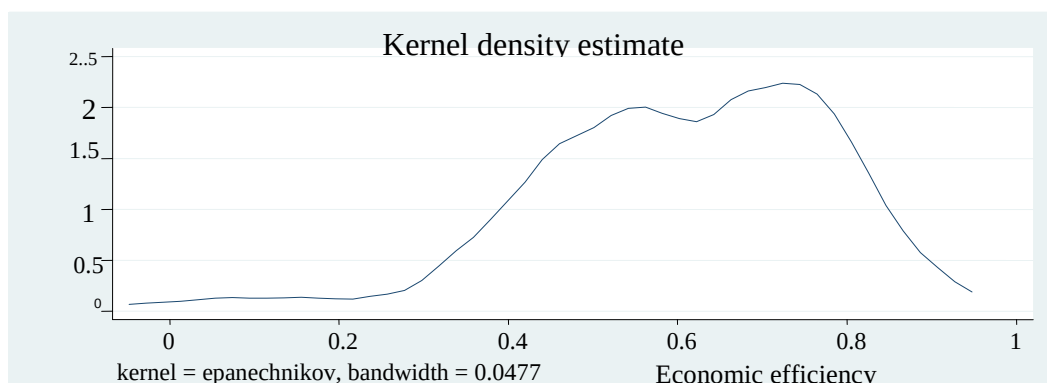
Figure 7. Distribution of technical efficiency scores

Source: Own computation (2019)

4.2.6. Determinants of Inefficiencies in Pulse Production

After measuring the level of technical, allocative and economic efficiency indices, it was necessary to identify which factors influenced the level of TE, AE and EE in pulse production. Before explaining the model, a test on multicollinearity and heteroskedasticity were made. The VIF was found to be low (a mean VIF of 1.43) (Appendix Table 3). This shows that there is no severe problem of multicollinearity in the data set. The Breusch-Pagan/Cook-Weisberg test for heteroskedasticity indicated a small chi-square value (0.02 for TE, 0.13 for AE and 0.04 for EE), implying there were no heteroskedasticity problems in the data. In addition, the Breusch Pagan test for heteroskedasticity indicated that the null of the constant variance variables is rejected implying the occurrence of heteroskedasticity problem. Also, the model specification was carried out using the Ramsey-reset test, and the results revealed that there were no omitted variables in the model. In addition, a test for normality TE, AE and EE of plot residuals was made using Kernel density plot residuals. The estimated graph resembles normally distributed curve that shows normality assumption is not violated (Figure 9).





Source: Computed from survey data, 2019

Figure 9: Kernel density estimate for efficiencies

The marginal effects of changes in explanatory variables from Tobit regression were computed for the purpose of interpretation. That is, the derived values for the significant explanatory variables indicated that the effects of a unit change in those variables on the unconditional expected value of TE, AE and EE expected value of TE, AE and EE conditional upon being between 0 and 1 and probability of being between 0 and 1.

The result of the Tobit model showed that TE was significantly influenced by distance to development office, landholding size, off/non-farm participation and livestock owned. AE was also significantly influenced by sex of household head, educational level, landholding size, access to improved seed, market information access and participation in extension. Moreover, sex of household head, landholding size, access to improved seed, market information and participation in extension were important factors influencing EE of crop producing households in the study area (Table 15).

Education level of the household head: It has a positive and significant effect on TE of pulse production at 5% level of significance. Smallholder farmers who were better educated can understand agricultural instructions easily, have higher tendency to adopt improved agricultural technologies, have better access to information and are able to apply technical skills imparted to them than uneducated ones (Dawang *et al.*, 2011). Thus, the level of education of household head emerges as an important factor in enhancing efficiencies of pulse production in the study areas. Moreover, a one year increase in educational level of the household head will increase AE by 5.4%. This result is similar with other studies such as Aye and Mungatana (2011), Khan and Saeed (2011) and Sisay *et*

al. (2016) who found that a farmer with greater years of schooling tends to be highly efficient in allocation of resources and crop production.

Sex of the household head: It was found to have positive and significant impact on AE and EE at 1% significance level. As hypothesized, the survey result showed that male headed households were more efficient than female headed households. The possible explanation is that male headed households might have better practical experiences in farming and one might argue that females are too much occupied with additional responsibilities within the household, such as caring for children and had little time for the management of their farm plots that led to low allocative efficiency levels. According to Chiona (2011), male headed households are likely to be wealthier and capable of adopting new and expensive agricultural technologies. On the other hand, female farmers aren't likely to attend meetings and adopt the best production practices. The survey result also indicated that being male headed farmer increases AE and EE by 12.6% and 11.5% respectively. This result resembles the finding of Aynelam (2006) and Mustefa (2014).

Landholding size: As hypothesized, it was found to have significant and positive impact on TE, AE and EE at 1% significance level. This might be farmers with larger area of cultivated land have the capacity to use compatible technologies that could increase the efficiency of the farmer and earn better economies of scale. The findings of Andreu (2008), who indicated that larger farms had a competitive advantage over smaller farms in terms of choosing and having access to more optimal input bundles for their operations is lending robust support to the hypothesis that farm size is associated with improved efficiency. In addition, Endrias *et al.* (2010) found a positive and statistically significant relationship between land size and efficiency because large land holding farmers are more likely to employ modern agricultural practices and hence could be more efficient due to its advantage of the economic scale and scope associated with large farm size. Table 15 indicated that an increase in land size by one ha increases TE, AE and EE by 11%, 11.1% and 12.8% respectively.

Distance to development agents' office: As it was hypothesized, farmers who were nearer to the development agents' office can easily get an opportunity for new production and market information, training, and demonstrations to encourage best farming practices at

farmers training center. The result indicated that there was a negative and significant relationship between distance to development office and technical efficiency at the study area. Table 15 showed that a 1km increase in the distance from farm household residents to development agents' office, there would have the probability of decreasing the level of TE by 0.3%.

Livestock owned (TLU): The coefficient of livestock ownership for technical efficiency is positive and statistically significant at 10%. Sisay *et al.* (2017) found that farmers who owned more number of livestock were technically, allocatively and economically more efficient than those who owned few number of livestock in the production of maize. His justification was that livestock provides a working power (oxen for draught power), manure fertilizer and is a source of income that can be used to purchase the necessary agricultural inputs. In similar manner, positive and significant impact of livestock ownership on AE and EE as in the case of Wondimu (2010), confirmed that the considerable contribution of livestock in reducing the current cost of inputs in barley production. The two limit tobit result showed that an increase in livestock by one TLU increases TE by 4.2%.

Access to market information: As hypothesized, it influenced AE and EE of smallholder pulse producers positively and significantly at less than 1 and 10% respectively. Farmers who received market information on how to sell, where to sell and how much to sell might have encouraged to produce more and to supply their product to the market and those who allocate their resource properly become efficient producers. As depicted from Table 15, a change in the dummy variable representing the access of market information by the household head ordered from 0 to 1 increase AE and EE by 18.3% and 9.9% respectively.

Access to improved seed: There was a significant and positive influence among AE and EE at less than 10 percent significance level. Oyewo (2011) in his study revealed that there was a positive impact and significant relationship between improved seed and efficiency. In addition, Chiona (2011) found that farmers who use certified hybrid seed had higher efficiency levels. Rebecca (2011) with the similar manner explained the relationship between improved seed utilization and smallholders efficiency and her study showed that most small-scale farmers who practice subsistence farming do not buy certified seeds but they use recycled seeds that are stored after every harvest while others buy recycled seeds

from their fellow farmers which in turn this practice affects the crop output every year in terms of quantity as well as quality. According to Endrias *et al.* (2013) the use of hybrid maize variety positively and significantly affected the technical efficiency of smallholder maize producers. Thus, smallholder farmers who used improved seed increase AE and EE by 11.2% and 12.3% respectively.

Frequency of extension contact: It is positively and significantly affected AE and EE at 1% significance level. A study by Aye and Mungatana (2011) indicated that a frequent contact facilitates the flow of new ideas between the extension agent and the farmer thereby giving a room for improvement in farm efficiency. Farmers who had more number of contacts with extension agents improved their access to improved inputs and farming management practices thereby increased their production efficiencies. Moreover, Jude *et al.* (2011) also pointed out that advisory service rendered to the farmers in general can help farmers to improve their average performance in the overall farming operation as the service widens the household's knowledge with regard to the use of improved agricultural inputs and agricultural technologies who found that extension agents provide farmers with new information on improved agricultural technologies and better farm management practices. As shown in Table 15, smallholder farmers who had more extension contacts increase AE and EE by 15.2% and 15.8% respectively.

Off/non-farm participation: As hypothesized, this variable influenced TE negatively and significantly at less than 10 percent significance level. There are arguments about this variable in which some studies revealed that off/non-farm activities have a systematic effect on the technical efficiency of the farmers on one hand it will have a negative relation with the technical efficiency if the farmer is always out of the farming activity for the search of additional income from these off/non-farm activities. On the other hand, it will affect the technical efficiency positively due to the income obtained from such off/non-farm activities could be used for the purchase of agricultural inputs and augment financing of household expenditures which would otherwise put pressure on on-farm income. As shown from Table 15, smallholder farmers who participated at off/non-farm activities decreased TE by 5.6%. This finding was also consistent with the findings of Dolisca and Jolly (2008) and Alemu *et al.* (2009).

Table 15. Tobit results on technical, allocative and economic inefficiency

Variable	Technical inefficiency		Allocative inefficiency		Economic inefficiency	
	Marginal effect	Std.Err	Marginal effect	Std.Err	Marginal effect	Std.Err
Sex of household head	0.036	0.032	-0.126***	0.031	-0.115***	0.028
Age of household head	0.001	0.001	0.000	0.001	0.001	0.001
Education level	0.020	0.024	-0.054**	0.024	-0.027	0.022
Distance to market	0.001	0.001	0.000	0.001	0.000	0.001
Distance Deve.office	0.003**	0.001	0.001	0.001	0.000	0.001
Distance to main road	0.001	0.002	0.001	0.002	0.001	0.001
Landholding size	-0.11***	0.042	-0.111***	0.041	-0.128***	0.037
Improved seed use	-0.068	0.056	-0.112*	0.053	-0.123*	0.048
Cooperative member	0.030	0.033	0.007	0.032	0.018	0.029
Market information	0.101	0.061	-0.183***	0.059	-0.099**	0.054
Extension contact	-0.076	0.051	-0.152***	0.049	-0.158***	0.046
Off-farm participation	0.056**	0.026	0.017	0.025	0.033	0.023
Livestock holding	-0.042*	0.035	-0.001	0.005	-0.002	0.005

Note: “*”, “**” and “***” represent statistical significance of factors at 10%, 5% and 1% levels, respectively.

Source: Own computation (2019).

4.3. Determinants of Market Orientation and Commercialization

4.3.1. Measurement of Pulse Commercialization and Market Orientation

Pulse commercialization index was expressed through sale of grass pea, chickpea, faba bean and field pea at different levels which ranges from 0 to 1. As indicated in Table 16, the mean of commercial indices was 0.345 which implies that on average sampled households sold 34.5% of his/her total pulse crop produce. This shows that the level of crop output commercialization in the study areas was very low as compared to the national average which is about 52% (ATA, 2016). Comparing the four pulse crops, the households commercial indices of faba bean and field pea are larger than the commercial indices of grass pea and chickpea. This indicated that households majorly sold much of their faba bean and field pea output than that of grass pea and chick pea. Moreover, the survey result shows that farm households' pulse commercialization fall in semi-commercial level. The survey result indicated, about 36.9%, 47.3% and 15.8% of the sampled households were categorized under low, medium and high commercial levels, respectively.

Table 16: Commercialization of smallholder pulse producers

Description	Min	Max	Mean	Std. Err.
Commercial index of grass pea	0.00	1.00	0.252	0.016
Commercial index of chickpea	0.00	1.00	0.288	0.016
Commercial index of faba bean	0.00	1.00	0.428	0.016
Commercial index of field pea	0.00	1.00	0.413	0.015
Aggregated commercial index	0.00	1.00	0.345	0.013
	Number		Percent	
Commercialization status	Low	142	36.9	
	Medium	182	47.3	
	High	61	15.8	

Note: Aggregated crops represent the four crops (grass pea, chickpea, faba bean and field pea) Source: Own computation (2019)

The average market orientation index of the four crops was 8.1% which indicates that on average a typical household is less commercialized. As the survey result indicated, smallholder pulse producers' market orientation was very small (Table, 17)

Table 17. Market orientation indices of sample households

Indices (percentage)	Mean	Standard deviation
Market orientation index of aggregated pulse crops	8.1	3.2
Grass pea market orientation index	4.1	5.3
Chick pea market orientation index	5.6	5.8
Faba bean market orientation index	12.1	5.4
Field pea market orientation index	10.5	4.9

Note: Aggregated crops represent the four crops (grass pea, chickpea, faba bean and field pea) Source: Own computation (2019)

4.3.2. Determinants of Market Orientation

The double-hurdle model is estimated by maximizing the log-likelihood function and the results are presented in Table 18. The coefficients in the first hurdle indicated how a given variable affects the likelihood (probability) of market orientation decision and the variables in the second hurdle designated the level of market orientation.

Determinants of household market orientation decision: The results of the first-hurdle shows that sex of household head, landholding size, access to improved seed, market information and quantity of pulse produced influenced households' decision of market orientation positively and significantly whereas distance to main road influenced it negatively.

Sex of the household head: It affected the households' market orientation decision positively and significantly at less than 10% significance level. The probable reason was that male-headed households have a better access to information who would provide them with better ability to manage their farms and produce more output for market as compared

to female headed households. This study result was similar to the findings of Leykun and Jema (2014) and Tekalign (2014).

Distance to main road: It influenced the decision of household's market orientation negatively and significantly at less than 10% significance level. The reason might be households far away from main road may impose a negative bearing on the decision of crop market orientation due to the high transaction cost that farm households perceive in terms of transportation access once they produced. This result was consistent with other similar studies such as Aye and Mungatana (2011) and Alelign (2018) who found that a farmer far away from the main road was not able to decide market oriented production. This was because the households' residences who were far from the main road visited the particular market rarely as there was extra transport cost or wastage of time.

Landholding size: As hypothesized, it has a positive and significant effect on households' market orientation decision at less than 1% significance level. A smallholder farmer who has large landholding size can reallocate his land for crop production mainly for market oriented crops. As it was observed from the descriptive statistics, the smallholder producers who allocated large proportions of land for pulse production earned more income from the sale of pulse produce which in turn put decisions for market oriented production. This result is similar with the findings of Mahelet (2007). If households allocated more land to pulse crop, the larger portion of their earnings would be from the sale of pulse crop and their tendency to produce and sell pulse crop would be high (Alemineh *et al.*, 2016).

Market information access: As expected, it influenced smallholder pulse producers positively and significantly to market orientated production system at less than 1% significance level. Farmers who have got market information can increase production and marketing decisions and this can help them make choices from the very first stages of the production planning process up until the moment when the product is actually sold. Access to market information through different sources like radio, telephone, personal observations, traders or from extension agents reduces risk perceptions and encourages smallholder producers to make decision of market oriented production (Tewodros, 2014).

Access to improved seed: This has been recognized by policy makers and development practitioners as one of the key components of inputs required to enhance crop productivity. In this study, the use of improved pulse seed positively influenced market orientation decision at less than 10% level of significance. Improved seed utilization is a major input to enhance pulse productivity which in turn increases the decision to produce market oriented crop outputs (Abafita *et al.*, 2015). This confirms that the use of improved pulse crops seed varieties were a major driver of gains as smallholder producers were engaged to produce for market. Therefore, the use of improved seed would result in increased the decision for market oriented production.

Quantity of pulse produce: It influenced the decision to produce market oriented production significantly and positively at less than 1% level of significance. When the production of pulse in a given year is better, the higher the market oriented production and the amount of pulse that can be sold to the market. As shown in the descriptive statistics, smallholder producers who were producing pulses potentially got much amount of income in which they decided to produce pulses for market oriented strategy. Hence, the amount of pulse produced was one of the major factors that determine the probability to make decisions in the tendency of market orientation (Table 18).

Determinants of the level of market orientation: The results of the second-hurdle indicates that level of crop market orientation of farm households was positively and significantly influenced by education level of household head, landholding size, extension contact, access to market information and quantity of pulse produced but it was also influenced by distance to market significantly and negatively.

Education level of the household head: It influenced the level of market orientation positively and significantly at less than 10% significance level. It is also evident that educated farmers tendency to accept different agricultural technologies is high, so that they can produce more surplus for market. The result is in conformity with the findings of Aman *et al.* (2014) that reveals education increases the ability of farmers to get and analyze relevant market information which would improve the managerial ability of the farmers in terms of better formulation and execution of farm plans, and acquiring better information to improve their level of market orientation. Thus, the level of education of household head emerges as an important factor in enhancing market oriented production in

the study areas. This would help them to produce more market oriented crops and increases their willingness to sell. This result resembles the research findings of Tadele *et al.* (2017) that found as the level of formal education of the household head increased the level of wheat commercialization.

Distance to market: This variable influenced the level of market orientation negatively and significantly at 10% significance level. This might be the farmers located in distant from the market was weakly accessible to the market and the closer to the market the lesser will be the transportation cost and time spent. In addition, Tadele *et al.* (2017) indicated that as the distance from wheat producers homestead is far, which in turn influenced the level of market orientation negatively and significantly.

Landholding size: Large farm size creates the possibility of expanding pulse production and exploiting economies of scale by increasing the competitive advantage of farmers in input usage over households with smaller farm size (Agwu *et al.*, 2012). Thus household who have large farm size had a significant and positive effect on the level of market orientation at less than 1% level of significance. The truncated regression result showed that smallholder farmers who have large land holding size also allocated their land for market oriented pulse crop production. This indicated that increased landholding size under pulse crops would lead to increased productivity and then increased the level of market orientation. This result was consistent with the findings of Efa *et al.* (2016) and Leykun and Jema (2014) indicated that large land size has a positive significant outcome on being transition and commercial farmer and the larger area allocated to production increases the quantity of produce available for sale.

Frequency of extension contact: This variable influenced the level of market orientation significantly and positively 10% significant level. This implies that when development agent, experts of agriculture and researchers provided technical advice on pulse production (on improved seed, fertilizer application, pre and post harvesting practices), smallholder producers encouraged produce market oriented production level. This result is consistent with the findings of Tekalign (2014) and Girma (2015) who found that extension contact and advice significantly and positively influence the level of market orientation.

Quantity of pulse produce: it influenced the level of household market orientation positively and significantly at 1% significance level. When the capacity of households improved to produce surplus production, then the households' market orientation level is also increased (Abdu *et al.*, 2016). Therefore, the amount of pulse produced was one of the most important factor that determine the level of market orientation.

Access to market information: As depicted from Table 18, it influenced the level of market orientation positively and significantly at less than 1% significance level. Abdu *et al.* (2016) indicated that smallholder producers who get market information can produce more based on the positive price signals and lately increase the level of market orientation. Market information was a crucial factor for producers to make decisions for setting prices for their produce and they were empowered to earn more return from what they sold (Abafita *et al.*, 2015). Therefore, market information plays a significant role to increase the level of market oriented production system.

Table 18. Factors influencing smallholder farmers' market orientation decision and levels

Variables	Probit Regression (1 st Hurdle)		Truncated Regression (2 nd Hurdle)	
	Coef.	Std.Err.	Coef.	Std.Err.
Sex of household head	0.892*	0.444	0.008	0.009
Farming experience	-0.009	0.019	0.000	0.000
Education level of household	0.109	0.101	0.003*	0.002
Distance to market	-0.018	0.012	-0.040*	0.020
Distance to road	-0.042*	0.020	0.001	0.003
Landholding size	4.588***	1.038	0.106***	0.023
Access to improved seed	1.889*	0.816	0.005	0.017
Access to chemical fertilizer	0.843	0.616	-0.015	0.012
Pesticide use	0.386	0.313	-0.005	0.009
Amount of credit	-0.252	0.263	0.008	0.006
Total livestock owned	-0.079	0.061	-0.001	0.002
Extension contacts	0.772	0.778	0.027*	0.016
Market information access	2.030***	0.601	0.082***	0.019
Quantity of pulse produced	1.187***	0.169	0.024***	0.003

Constant	7.462***	1.406	0.171***	0.026
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Note: “*”, “**” and “***” represent statistical significance of factors at 10, 5 and 1% levels respectively; Wald χ^2 (13) = 650.82, Log likelihood= 556.14; Prob.> χ^2 =0.000, number of observation= 385

Source: Own computation (2019).

4.3.3. Determinants of Pulse Outputs Commercialization

The variables included in the model were tested for the problems of multicollinearity and the result shows there was no problem of multicollinearity among the variables. The maximum value of VIF obtained for these variables was found to be low (1.5). Furthermore, all the variables were tested for the problem of heteroskedasticity using the Breuch-Pagan test and heteroskedasticity was not found. A test for normality of commercial index (CI) was made using Kernel density plot residuals. The Kernel density plot provided fairly smooth curve that closely resembles a normally distributed curve, indicating that the normality assumption was not violated (Figure 10). In addition, the model specification was carried out using the Ramsey-reset test and the results revealed that there were no omitted variables in the model.

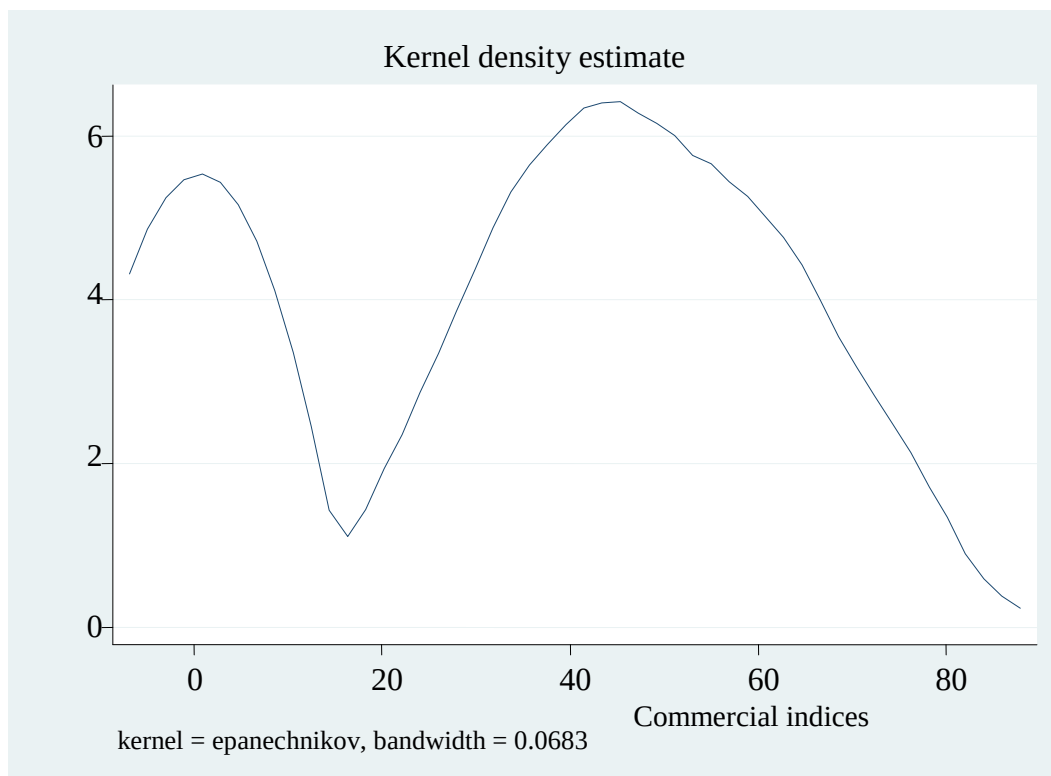


Figure 10: Kernel density estimate for commercial index

Source: Computed from survey data (2019)

Determinants of pulse output commercialization: As indicated in Table 19, farm households' pulse output commercialization was positively influenced by access to improved seed, cooperative membership, landholding size, market information access and quantity of pulse produce and it was also negatively influenced by family size and livestock owned.

Access to improved seed: The result from Table 19 showed that access to improved seed affected pulse output commercialization positively and significantly at less than 1%. Thus, access to improved seeds yields higher production and possibly higher selling price for the crop. The survey result indicated that smallholder producers who were accessed to improved pulse seeds increase the commercialization level by 17.4%. This study result resembles the findings of Kumilachew (2016).

Family size: This is measured in terms of the number of adult equivalent in a household. It influenced the level of household commercialization negatively and significantly at 1% significance level. The probable reason was that as the number of adult people increases, the level of consumption of adults will increase to the extent that it will have noticeable

negative impact on the available output with the consequences of limited produce available for sale due to increased consumption and diseconomies of scale (Adam and Dawit, 2015). The result from Table 19 indicated that for one additional adult equivalent family member, the level of output sale decreases by 1.5%. This result was consistent with the result of Benjamin *et al.* (2014) and Abdu *et al.* (2016) that households with large family sizes need to feed their family first and take the remaining small portion surplus to the market especially if the crop is consumable at home.

Cooperative membership: It influenced the level of pulse output commercialization positively and significantly at less than 10% significance level. This might be farmers' cooperatives contributed to the practice of crop output market participation via its advantage of obtaining better information access and procurement of credit services for member farmers. The marginal effect result revealed that the households being members of farmers' cooperatives increase the level of commercialization by 7.1%. This finding is consistent with the results of Rehima *et al.* (2013) and Stephen *et al.* (2017).

Landholding size: It affected the pulse output commercialization significantly and positively at 10% probability level. Large farms enjoy economies of scale and often produce surplus and easily become market oriented compared to small farms. This means that land plays a key role in promoting commercialization oriented production which will enable the farmers to produce more and increase the quantity to supply to the market (Martey *et al.*, 2012). The result from Table 18 indicated that households who have large farm size increase the level of commercialization by 7.6%.

Total livestock number: This variable significantly and negatively affected the level of commercialization at 5% significance level. The marginal effect result shows that an increase in livestock owned by one TLU, the probability to sell pulse crops decreases by 0.5%. The possible explanation was that households who have large number of livestock, the larger portion of their earnings would come from the sale of livestock and their decision to produce crops for participation in output market would be low. The other possible reason could be that smallholder farmers who have large number of livestock might allocate large proportion of their land for grazing rather than growing crops. This study result was consistent with the findings of Alelign *et al.* (2016).

Access to market information: It significantly influenced pulse output commercialization positively and significantly at 5% significance level. This might be farmers who accessed market information set prices and search for potential buyers thereby facilitating decisions on the quantity to sell. The survey result indicates smallholder producers who accessed market information increases output commercialization level by 7.1%. This result resembles the findings of Ochieng *et al.* (2015) and Chauke *et al.* (2016) who indicated that market information helps to increase utilization of yield enhancing farm inputs such as fertilizers and improved varieties which eventually increase commercialization levels.

Quantity of pulse produced: This influenced the level of pulse output commercialization positively and significantly at 1% significance level. The probable reason could be an increase in household gross production value will result in an increase in the household output commercialization level. An increase in household gross production value necessitates the producer to market the excess after taking away the portion for household consumption (Ochieng *et al.*, 2015). If farmers are specialized in the production of pulse crops, their emphasis to produce and sell output would be increased (Tadesse, 2019). Thus, the result from Table 19 indicates that smallholder farmers who produce more quantity of pulse increased the output commercialization by 5.9%.

Table 19: Parameter estimates of two-limit Tobit model for commercialization level

Variables	Marginal effect	Std.Err
Sex of household head	0.058	0.034

Age of household head	0.001	0.001
Education status	0.008	0.005
Family size	-0.015***	0.005
Distance to market	-0.000	0.001
Distance to road	-0.001	0.001
Landholding size	0.076*	0.048
Access to improved seed	0.174***	0.036
Chemical fertilizer use	0.006	0.024
Training access	0.027	0.037
Field chemical use	0.034	0.018
Cooperative membership	0.071*	0.038
Access to market information	0.075**	0.031
Off-farm participation	-0.008	0.028
Tropical livestock unit(TLU)	-0.005**	0.003
Quantity of pulse yield	0.058***	0.006
Constant	1.89*	
Sigma	0.791	
<hr/>		
LR χ^2 (16) = 850.56	Log likelihood =225.69	
Prob > χ^2 = 0.000	Pseudo R^2 = 0.831	

Number of observation =385

Note: ***, ** and * indicate significance at 1%, 5% and 10% levels, respectively. Source:
Model output based on survey data, 2019

4.4. Food Security Status Analysis

This section presents the measurement of food security status results and its determinants. The first sub-section presented the descriptive result of food security measurement and the second sub-section covers the model results of factors affecting food security of smallholder farmers in the study areas.

4.4.1. Food Security Status of the Households

The households' food security status was measured by direct survey of consumption. Data on the available food for consumption, from home production, purchase and /or gift/loan/wage in kind for the previous seven days before the survey day by the household was collected. Then the data were converted to kilocalorie and then divided by household size measured in AE. Following this, the amount of energy in kilocalorie available for the household is compared with the minimum subsistence requirement per adult per day (i.e. 2100 kcal). As a result, from all respondent households, 252 (65.5%) of households were found to be food insecure and 133 (35.5%) were food secure. In addition, the mean energy available per AE for the surveyed respondents was 1625.5 Kcal (Table 20).

Table 20: Energy available per AE per day among sample households

Energy available per AE in (Kcal)	Food secure (n=133)	Food insecure (n=252)	Total sample (n=385)
Minimum	2102.0	584.0	3101.0
Maximum	3101.0	1921.0	584.0
Mean	2283.4	1278.3	1625.5
Std.Err	14.9	18.2	27.6
Std.deviation	171.9	288.6	541.7

Source: survey result 2019

The result of descriptive statistics shows that there exists a significant mean difference between foods secure and insecure households. Continuous variables including age of household head, family size in adult equivalent, distance to market, livestock ownership, number of oxen owned, land holding size and income from pulse crops were significantly influence household food security status at various probability level (Table 21).

The mean age of sample households was 50.1. Similarly the mean age of food secure and insecure household heads was 55.5 and 47.2, respectively. The t-value shows that there is significance difference between the two groups associated with this variable at less than 1 % probability level. The mean family size (adult equivalent) for the sampled household was 5.8. The mean family size for food secured and insecure household was 5.7 and 5.9

respectively. The t-value result revealed that there is a significant family size difference between food secure and insecure households (Table 21).

The distance to the central market is on average 49.58 minutes. Table 21 indicates that the distance from the market for food secured households is 48.5 minutes whereas for food insecure households are 50.48 minutes. The t-value result revealed that there is no significant difference between food secure and insecure households with regard to the distance to central market.

The average landholding size for the sample households is 1.04 ha. The mean land size among food secured and insecure households was 1.2 ha and 0.95 ha respectively. The t-value showed that there was significantly difference between the two groups in relation to landholding size. In addition, sampled households have also on average 1.79 oxen in which food secured and insecure households owned 2.03 and 1.67 oxen respectively. The t-value revealed that there was significance difference between the two groups for this variable. Livestock is a key resource in farm households where the farming households support their livelihood. In addition, the survey result indicated that the sampled households have on average 6.64 livestock. Food secured and insecure households have on average 6.21 and 6.87 TLUs with a significance mean difference in relation to this variable (Table 21).

The survey result revealed that on average sampled households earned 6711.7 ETB from the sale of pulse. Food secured and insecure households earned 9891 and 5033.9 ETB respectively from pulse crops sales. There is significant mean difference in income earning from pulse crops sale between the two groups. In addition, the sampled households on average earn 3542.80 ETB from the sale of major crops. Food secure household on average earn 4418.33 ETB and food insecure sampled household earned on average 3050.68 ETB. There is a significant mean difference between these two groups. Likewise, on average sampled households earned 638.36 ETB from livestock sales. Food secure households earned 401.7 ETB whereas food insecure households earned 763.3 ETB from livestock sales with a significant mean difference related to this variable (Table 21).

Table 21. Descriptive summary of continuous variables.

	Food Security (n=133)		Food insecurity (n=252)		Total sample (n=385)		
Variable	Mean	Std.Err	Mean	Std.err	Mean	Std.err	t-value
Age of household head	55.5	0.74	47.2	0.69	50.07	0.56	-7.5***
Family size	5.36	0.11	7.05	0.06	6.12	0.05	2.1**
Distance to market	48.50	1.01	50.48	0.70	49.58	0.58	1.62
Landholding size	1.20	0.02	.95	0.02	1.04	0.02	-7.4***
Oxen number	2.03	0.04	1.67	0.05	1.79	0.04	-4.7***
Livestock ownership	6.21	0.18	6.87	0.14	6.64	0.11	2.9***
Income from pulse	9891.01	307.65	5033.86	297.14	6711.7	250.81	-9.8***
Income major crops	4418.33	311.92	3050.68	104.35	3542.7	131.4	-4.9***
Income from livestock	401.69	107.11	763.28	102.80	638.36	77.20	2.2**

***, ** and * are indicates significant at less than 1%, 5% and 10% probability levels, respectively

Source: Survey Result, 2019

Table 22 showed that the discrete variables such as sex of household head, educational status of household head, access to improved seed, access to chemical fertilizer (DAP), field chemical used, credit access and off-farm participation for sampled households.

The survey result indicated that 40.7% of male households were food secure and 59.3% of male households were also food insecure whereas 10.2 % of female households were foods secure and 89.8 % of female households were food insecure. The chi-square value for this variable showed that there was a significant difference between the two groups in terms of sex of the households.

Table 22 indicates that 48.5% of literate sampled households were food secure whereas 51.5% were food insecure. On the other hand 23.1% of illiterate households were food secure and 75.9% were also food insecure. As it is showed from the chi-square value, there was a significant difference between the food secured and insecure household interims of education status of households.

Access to improved seed was one of important agricultural input used by the farmers of the study area. The survey result indicated that about 46.2% of sampled smallholder producers

who accessed improved seed were food secured and 53.8% were food insecure whereas 6.2% of the sampled households who did not access improved seed were food secure and 93.8% were food insecure. The chi-square value also showed that that there was significant difference between the two groups in terms of access to improved seed (Table 22).

Survey result indicated that 44.9% of households who had access to chemical fertilizer were food secure whereas 55.1% of households were food insecure. On the other hand, 9.01% households who did not access to chemical fertilizer were food secure and 90.99% were food insecure. In addition, about 48.4% of households who had access to field chemical/pesticides were food secure and 51.6% of households were food insecure. Furthermore, 10.6% of households who did not use field chemical/pesticides were food secure and 89.4% were food insecure. As can be seen from the Table 22, the chi-square value shows that there was significant difference between the two groups in terms of access to improved seed and field chemical/pesticides used.

As depicted from Table 22, 43.1% of the sampled respondents who access to credit were food secured and 56.9% were food insecure whereas about 29.8% of smallholder producers who did not get credit access were food secure and 70.2% were food insecure. In addition, smallholder households who participated in off/non-farm activities showed that about 22.9% were food secure but 77.1% were food insecure. Moreover, about 37.1% sampled households who did not engage at any off/non-farm activities were food secured but 62.9 % were food insecure. The chi-square value also indicates that that there was significant difference between the two groups in terms of credit access and off/non-farm activities.

Table 22. Descriptive summary of dummy variables

Variable	Category	Food secure (n=133)		Food insecure (n=252)		Total sample (n=385)		χ^2 value
		No.	%	No.	%	no.	%	
Sex of HH head	Male	125	40.7	182	59.3	307	100	25.5***
	Female	8	10.2	70	89.8	78	100	
Education level	Literate	80	48.5	85	51.5	165	100	24.8***
	Illiterate	53	23.1	167	75.9	220	100	
Improved seed	Yes	126	46.1	147	53.9	273	100	55.9***
	No	7	6.2	105	93.8	112	100	
Chemical fertilizer	Yes	123	44.9	151	55.1	274	100	44.7***
	No	10	9.0	101	91.0	111	100	
Pesticide used	Yes	118	48.4	126	51.6	244	100	56.2***
	No	15	10.6	126	89.4	141	100	
Credit access	Yes	59	43.1	78	56.9	137	100	6.8**
	No	74	29.8	174	70.2	248	100	
Off-farm participat	Yes	16	22.9	54	77.1	70	100	5.2*
	No	117	37.1	198	62.9	315	100	

***, ** and * are indicates significant at less than 1%, 5% and 10% probability levels, respectively

Source: Survey Result (2019)

4.4.2. Determinants of Food Security

Empirical result from the model and model fitting ($-2\log$ likelihood =63.946) and goodness-of-fit statistics (χ^2 =123.7, $p= 0.000$) show that the likelihood ratio for all explanatory variables are different from zero and the model fits the data very well. In addition, the variables included in the model were tested for the problems of multicollinearity and the result shows there was no problem of multicollinearity among the variables. The maximum value of VIF obtained for these variables was found to be 1.43 (Appendix Table 4). Furthermore, all the variables were tested for the problem of heteroskedasticity using the Breuch-Pagan test and heteroskedasticity was not found. Moreover, the model specification was carried out using the Ramsey-reset test and the results revealed that there were no omitted variables in the model.

As indicated in Table 23, households food security was positively and significantly influenced by landholding size, credit amount, access to pesticide and income from pulse and it was negatively and significantly influenced by family size and distance to market.

Distance to market center: It has been found to be negatively related with food security and significant at less than 5% probability level. It was expected that households nearer to market centers had better chances to be food secure than those who are away from market centers due to the reason that households nearer to market center have the probability of selling their produce and purchase food from market. As distance from market center becomes far and far the probability of households to sell their product and purchase supplementary materials becomes less which resulted in low probability of household being food secure. The odds ratio in favor of food security decreases by 0.97, if distance in hours of walk increases by one hours keeping other factor unchanged. The result of this study is similar with study findings of Fekadu *et al.* (2015), Mekuanint (2015) and Abayneh and Belay (2017).

Family size: This is measured in adult equivalent and influenced food security of the household negatively and significantly at 10% significance level. This might be, households in rural areas with large family size mainly composed of nonproductive members could face difficulty in ensuring food security due to high burden levied on active labor and less food availability to each person within the household and ultimately end up with difficulty to achieve food security. This implies larger household sizes require increased food expenditure and competition for limited resources. The survey result indicated that as family size increases by one person, the probability of household to be food secure decreases by a factor of 0.81. This result resembles with the findings of Sisay (2012), Fekadu *et al.* (2015), Mekuanint (2015) and Abayneh and Belay (2017).

Landholding size: It has a significant and positive influence on household food security. It was hypothesized that farmers who have larger cultivated land are more likely to be food secure than those with a smaller area. This might be where households with large landholding produce more food for household consumption and for sale and have better chance to be food secure than those having relatively small size of land with the concept that the increase in agricultural output has been attained through the expansion of

cultivated land. A large size of cultivated land implies more production and availability of food grains and the possibility that the household gets more output is high as it remains the basic capital input in food production. The result reveals that the odds ratio in favor of food security increases by the factor 0.21 when the area under cultivation is increased by 1 ha. This study result was similar to the findings of Mekuanint (2015), Zelalem (2014) and Abayneh and Belay (2017).

Access to credit services: As hypothesized, it was positively related with food security and statically significant at less than 10% probability level. This is because farm households who have the opportunity of accessing farm credit would build their capacity to produce more through purchasing of agricultural inputs. The households with more access to farm credits have the possibility to produce the probability of being vulnerable to food insecure. The other possible reason might be that agricultural credit services give households an opportunity to be involved in alternative income generating activities that the derived revenue increases financial capacity and purchasing power of the households to escape from risk of food insecurity. The odds ratio in favor of food security increases by a factor of 0.62 as a household has access to agricultural credit services. This study result resembles the results obtained by Zemach (2013) and Zelalem (2014).

Pesticide/herbicides used: It was found to have significant positive effect with the food security status of households. Households access to field chemical are more likely to be food secure than those who did not access it. Smallholder farmers who used field chemicals can protect their field crops when plant diseases and pests occurred this in turn increase production and productivity that can support food security of the households. The odds ratio in favor of food security increases by a factor of 0.46 as a household has used field chemicals.

Income from pulse: This was found to have a significant influence and positive relationship with household food security at 1% probability level which implies that the likelihood of food security increases with producing cash crop. Cash crop production is positively and strongly associated with higher income, higher rate and intensity of use of purchased inputs and higher yield and hence improved food security status of households. Therefore, those households who produce cash crops become in a better position for food security than those who didn't produce cash crops. Holding other things constant, the odds

ratio in favor of food security increases by a factor of 1.02 as a household has produced and sold cash/pulse crops. This study result resembles the study by Fekadu *et al.* (2015).

Table 23. Logit regression estimates of factors affecting food security of the households

Variables	Coefficient	Wald stats	Sig.	Odds ratio
Sex of HH head	0.47	0.63	0.43	1.59
Education level of HH head	0.08	0.08	0.77	1.08
Family size (AE)	-0.21*	3.16	0.08	0.81
Distance to market(min)	-0.03**	5.87	0.02	0.97
Land holding size(ha)	1.58*	4.38	0.04	0.21
Pulse produce quantity	2.01*	7.02	0.92	1.89
Access to improved seed	0.45	0.29	0.59	0.64
Access to chemical fertilizer	0.34	0.35	0.56	0.71
Credit access	0.49*	3.38	0.07	0.62
Pesticide use	0.78**	3.82	0.05	0.46
Livestock in TLU	0.05	0.29	0.59	1.05
Income from pulse (ETB)	0.02****	7.41	0.00	1.02
Income from livestock	0.00	0.32	0.57	1.00
Off-farm participation	1.19	1.81	0.16	3.30
Constant	3.85****			
- 2 Log likelihood		72.74		
Chi-squared (χ^2)		123.8		
Pseudo R ²		81.3		

****, * * and * are significant at less than 1% and 5% probability levels, respectively.

Source: Own computation (2019)

4.5. Interdependence of Efficiencies, Commercialization and Food Security Analysis

This section discusses the interdependence among the levels of efficiencies, commercialization and food security.

Assuming that the levels of commercialization correlate with the level of technical, allocative, economic efficiency and food security status in pulse production, the underlying determinants were identified by simultaneous estimation of the SUR model. As outlined in Table 24, the key hypothesis that the correlation of the residuals among five equations is zero which is strongly rejected at 5% level of significance, implying that the use of the model is justified and level of commercialization, efficiencies and food security in pulse production are interdependent and influenced by similar underlying determinants among smallholder farmers. About 25%, 27% and 42% of the variation in the level of economic efficiency, commercialization and food security status was explained by SUR model, respectively.

In the simulation model, the level of technical, allocative and economic efficiency commercialization and food security status were commonly affected by landholding size, improved seed used and pulse quantity produced. In addition, the level of efficiencies and food security was positively affected by sex of the household. Chemical fertilizer (DAP use) has a positive effect on the level of efficiencies and chemical (pesticide and insecticide use) also influenced allocative efficiency, commercialization and food security status significantly. The result further indicated that age of the household head and extension services have positive effect on the level of commercialization and food security respectively in pulse production areas.

The lower section of Table 24 indicated the value of error term correlation between the level of technical, allocative and economic efficiency, commercialization and food security status. As it was showed from the result, the correlation between level of efficiencies, commercialization and food security was small in magnitude. This showed that there was interdependence between the level of efficiency, commercialization and food security status in pulse production.

Table 24. Interdependence of efficiency commercialization and food security

Coefficient(Equations)

Variables	Economic efficiency	Commercialization level	Food security
Sex	3.78***	0.62	2.12**
Age	0.98	2.24**	1.34
Education	0.94	1.15	0.50
Family size	0.75	0.03	-0.89
Distance market	-1.31	0.30	-0.31
Landholding size	2.18**	2.71**	2.29**
Oxen number	1.54	0.12	0.75
Improved seed	2.13**	2.91**	4.76***
Chemical fertilize	2.51**	0.18	0.55
Pesticide use	1.22	2.37**	1.88*
Extensioncontact	0.98	1.18	4.05***
Quantity of pulse	1.86*	2.15**	3.26***
Constant	5.77***	4.71***	5.31***
R ²	25	27	42
Correlation matrix of residuals			
Economic	1		
Commercialization	0.0029	1	
Food security(Kcal)	0.0036	0.0023	1
Breusch-Pagan test of independence: $Pr > \lambda^2(10) = 243.623***$			

***, ** and * indicate the level of significance at 1.5 and 10 percent , respectively

Source: Own computation (2019)

4.6. Impact of Commercialization on Rural Households' Food Security

4.6.1. Estimation of Generalized Propensity Scores (GPS)

The conditional distribution of commercialization index was estimated. Before estimating GPS, the goodness-of-fit test was conducted. Commercialization index which is the treatment variable, was assumed to be normally distributed and tested. The assumption of normality is statistically satisfied at 0.05 level with small values of Skewness (- 0.01) and Kurtosis (2.65). Table 25 shows the coefficients and robust standard errors estimation.

Table 25. Estimated GPS: Linear regression of covariates

Variable	Coefficients	Std.Err
Sex	0.042	0.158
Age	0.0046	0.004
Education	0.029**	0.012
Family size	0.003	0.021
Landholding size	0.869***	0.171
Distance to road	-0.005	0.003
Distance market	-0.004**	0.002
Training access	0.234*	0.135
Market information	0.397	0.2552
Credit access	0.049	0.048
Tropical livestock unit	-0.001	0.012
Quantity of pulse	0.124***	0.022
constant	0.007*	0.325

***, ** and * means significant at the 1, 5 and 10% probability levels, respectively

Source: Model results (2019)

4.6.2. Test for Covariate Balance

After estimation, the covariates balancing property of GPS was checked. Table 26 shows results of the balancing test within each commercialization interval. This was checked by testing the conditional mean of the pre-treatment variables or covariates since the GPS was not different between households that belong to a particular treatment group and between those that belong to other treatment groups. When the test fails to reject the hypothesis that the two sets of households are statistically indifferent, there is more confidence to believe that the treated and control groups matched by the GPS are balanced (Liu and Florax, 2014). Following Hirano and Imbens's (2004) procedure, the balancing property of GPS was assessed by cutting the distribution of commercialization index at 30th and 70th percentiles. Accordingly, covariate distribution was compared between three groups, i.e. group one (households with $\leq 50\%$ commercial index), group two ($50\% < \text{household commercial index} \leq 56\%$ commercial index) and group three ($56\% < \text{household commercial index level} \leq 75\%$ commercial index).

Table 26: Common support region

Treatment interval with GPS estimate	Dosage Group	Min	Max
GPS 1			
≤ 0.5	Commercial index ≤ 0.5	0.289	0.668
	Commercial index > 0.5	0.5	0.668
	Common support region [0.426, 0.668]		
GPS 2			
0.5 to 0.75	$0.5 < \text{commercial index} \leq 0.75$	0.529	0.668
	Commercial index ≤ 0.5 and Commercial index > 0.75	0.560	0.668
	Common support region [0.586, 0.668]		
GPS 3			
≥ 0.75	Commercial index > 0.75	0.569	0.668
	Commercial index ≤ 0.75	0.75	0.668
	Common support region [0.687, 0.668]		

Source: own computation (2019)

4.6.3. Impact of Commercialization on Households' Food Security (Dose-response function)

After confirming balancing property of the estimated GPS was used to estimate the conditional expectation of household food security as a function of two scalar variables (the commercialization level and the GPS) and their interaction (Table 27).

The final step of the GPS-based impact analysis was estimating the average DRF with causal inference. The average impact of commercialization index on household food security at particular commercial intensity was estimated. Following Hirano and Imbens

(2004), the average potential outcome was estimated based on ten values of commercialization level 0.1, 0.2, 0.3,..., 1. After this, the DRF at commercial index t was estimated as $E[HH \text{ food secure } (t)]$. The DRF was estimated within 95% confidence band obtained using 1000 bootstraps replications (the same bootstrap was used for estimating GPS).

Table 27: Estimated dose-response function for household food security

Calorie intake	Coef.	Std.Err.	Z-value
Commercial index	109.69	48.01	2.28**
Commercial index square	44.98	26.63	1.69*
GPS	153.39	133.98	1.14
GPS square	359.25	298.78	1.20
Commercial index*GPS	141.92	99.45	1.43
Intercept	99.43	37.08	2.68**
Adj R-squared	0.12		
Number of obs.	262		

***, ** and * means significant at the 1, 5 and 10% probability levels, respectively

Source: Own computation (2019)

Figure 11 depicts the graphic representation of the average effect of treatment (dose-response) and its marginal effect (treatment effect) on households from the selected pulse commercialization. The result indicated that as commercialization level of pulse crops greater than 60%, the probability of being food secure increases from 2350kcl which implies that commercialization of pulses have positive and significant impact on food security.

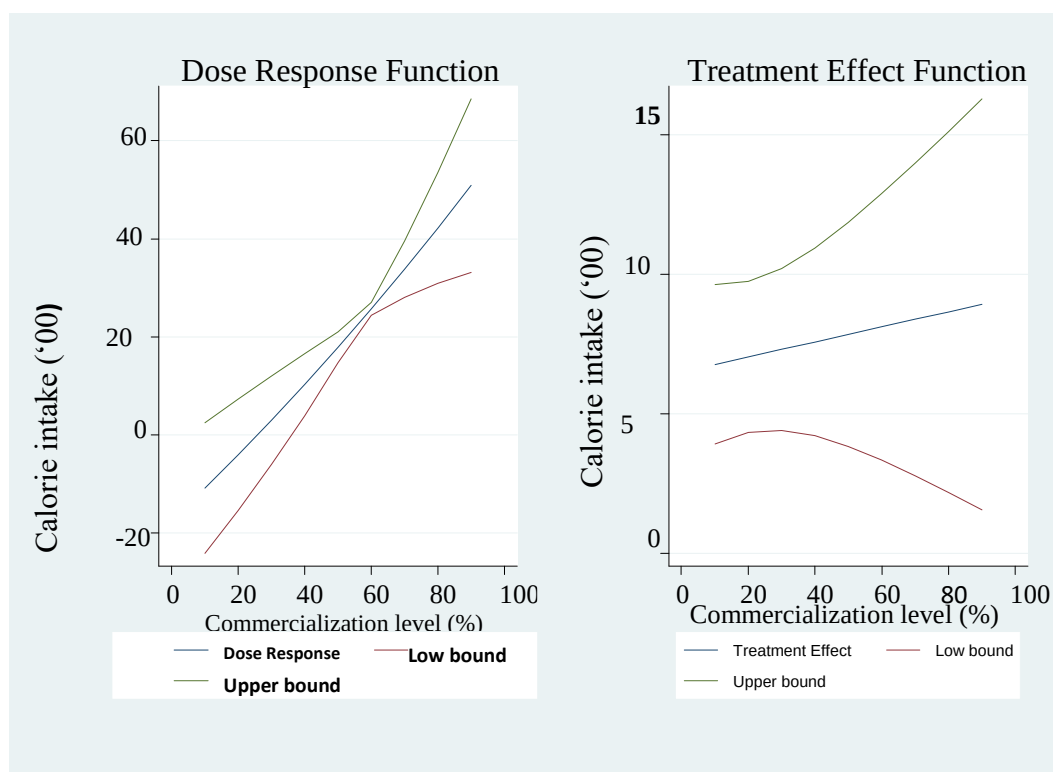


Figure 11. Estimated average dose-response function, estimated derivative, and 5% confidence bands for household food security

4.6.4. Sensitivity Analysis

The main limitation of GPS as impact analysis method is that the statistically non-testability of its key assumption i.e. weak confoundedness. Matching via generalized propensity score, in this study, conditional on sample households' covariates, commercialization level is independent of food security status (calorie intake). The plausible solution towards this is to conduct different sensitivity checks for the main finding (Kluve *et al.*, 2012). First, indirect checks were conducted through the analysis of the relationship between treatment and other rural livelihood income earning indicators which are supposed to be the determinants of the main outcome variable. In order to increase the credibility of the identifying assumption set and check the robustness of the model used in the study, different sensitivity analyses were performed.

Three livelihood income earning indicators were analyzed for their average dose-responses: These were income from main crops, household income from livestock and income from off/non-farm activities.

4.6.4.1. Impact of pulse commercialization on income from major crops

The shapes of the estimated DRFs for household income from main crops is decreasing which indicates that high commercialization level (>29.8%) has significant causal effect on household income from main crops (Figure 12). The marginal effect functions also show the same as respective DRFs (right hand sides of Figures 12).

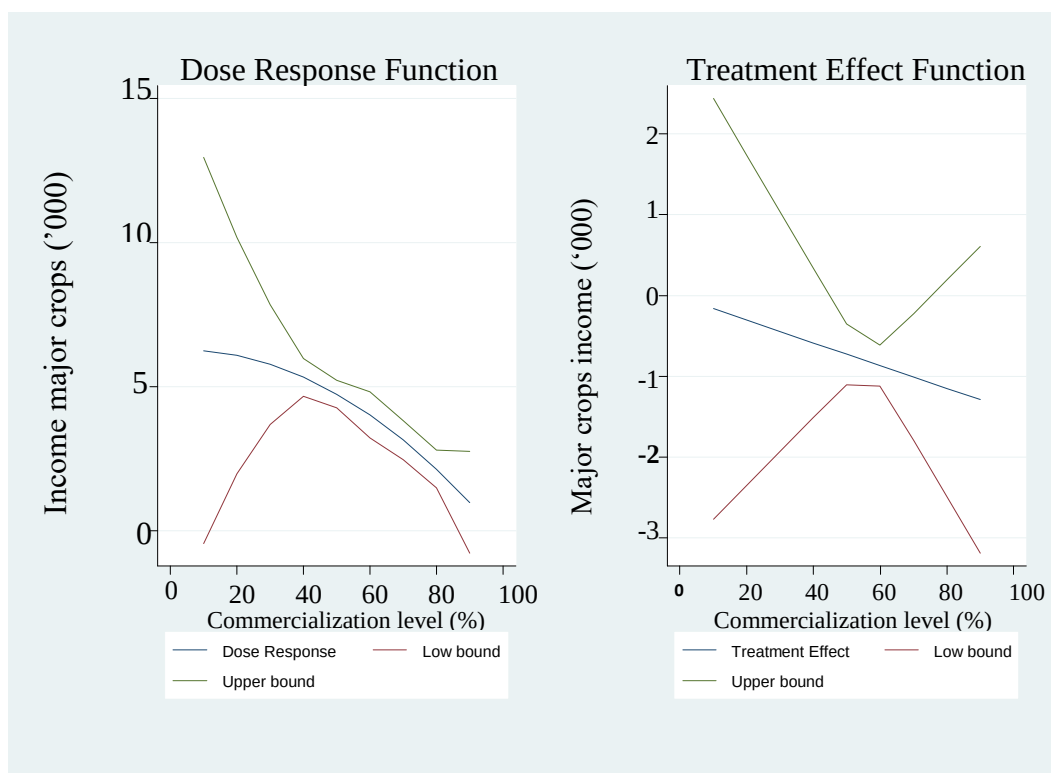


Figure 12. Estimated dose–response function of income from major crops

4.6.4.2. Impact of pulse commercialization on household income from livestock

Initially it was a decreasing dose response function of household income from livestock to commercialization level (Figure 13). The figure shows that DRF declines in which the household income from livestock is very small at 71.5% commercialization level. After this commercialization level, the figure indicates an increase of income from livestock. The integration of legumes into livestock production systems has been shown to deliver multiple benefits such as increased nitrogen supply while also increasing meat production. Globally, meat demand is expected to increase by 200 million tons per annum by 2050 with corresponding demand for livestock feed (Alexandratos and Bruinsma, 2013). Field

pea has been shown to increase dry matter intake by cows when included in the livestock feed ration and also produces benefits when used as a binding agent for pelleting formula feeds (Anderson *et al.*, 2007).

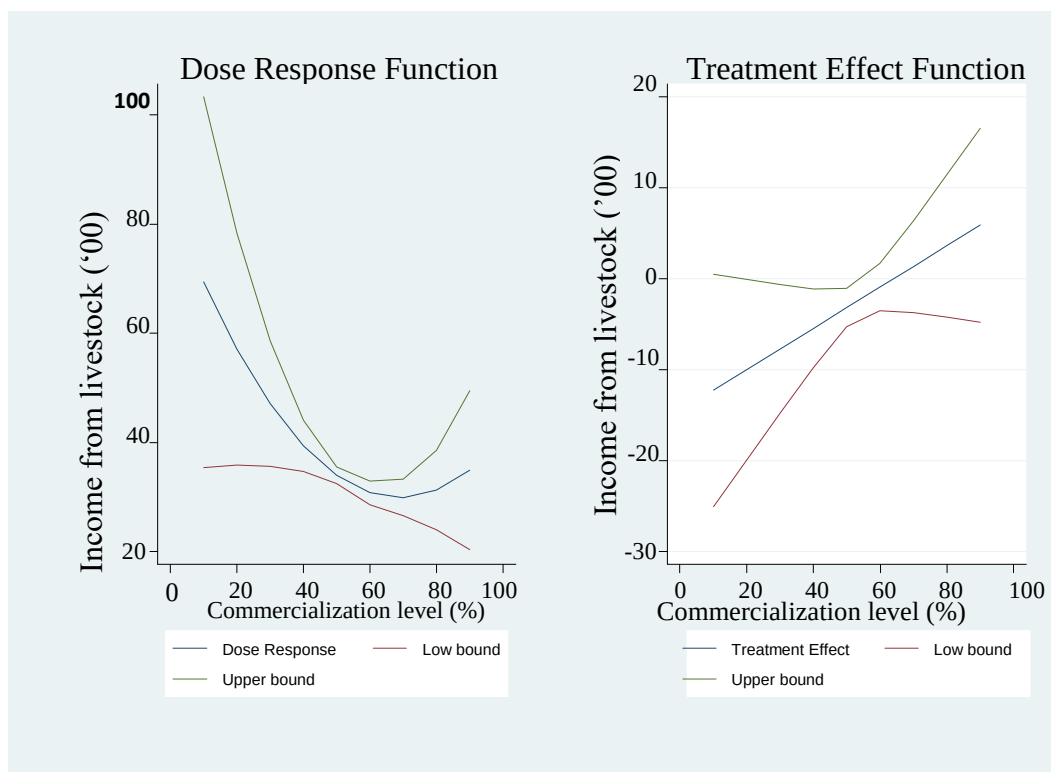


Figure 13. Estimated dose–response function for household income from livestock sales

4.6.4.3. Impact of pulse commercialization on household income from off-farm activities

Figure 14 shows that household income from off/non-farm activities highly decreases at 47.5% commercialization level. The plausible reason is that if off/non-farm income is geared toward consumption instead of investment in farm capital, then off/non-farm work ends up competing with agriculture for labor and other resources rather than being a complement. This, in turn, lowers production and marketable surplus. Research findings by Alene *et al.* (2008) and Omiti (2009) for Kenyan smallholder farmers also support this. In addition to this, there exists a positive relationship as commercialization level is above 60% which indicates that income from off/non-farm activities strongly respond to commercialization. Off/non-farm income promotes smallholder commercialization through capital investment in agriculture and risk diversification. Perhaps, participation in off/non-

farm activities helps smallholder farmers to overcome liquidity constraints. Particularly, when agricultural growth is hampered by credit constraints, additional resources can be used by farmers for the adoption of innovations and the purchase of inputs (Oseni and Winters, 2009; Babatunde, 2013).

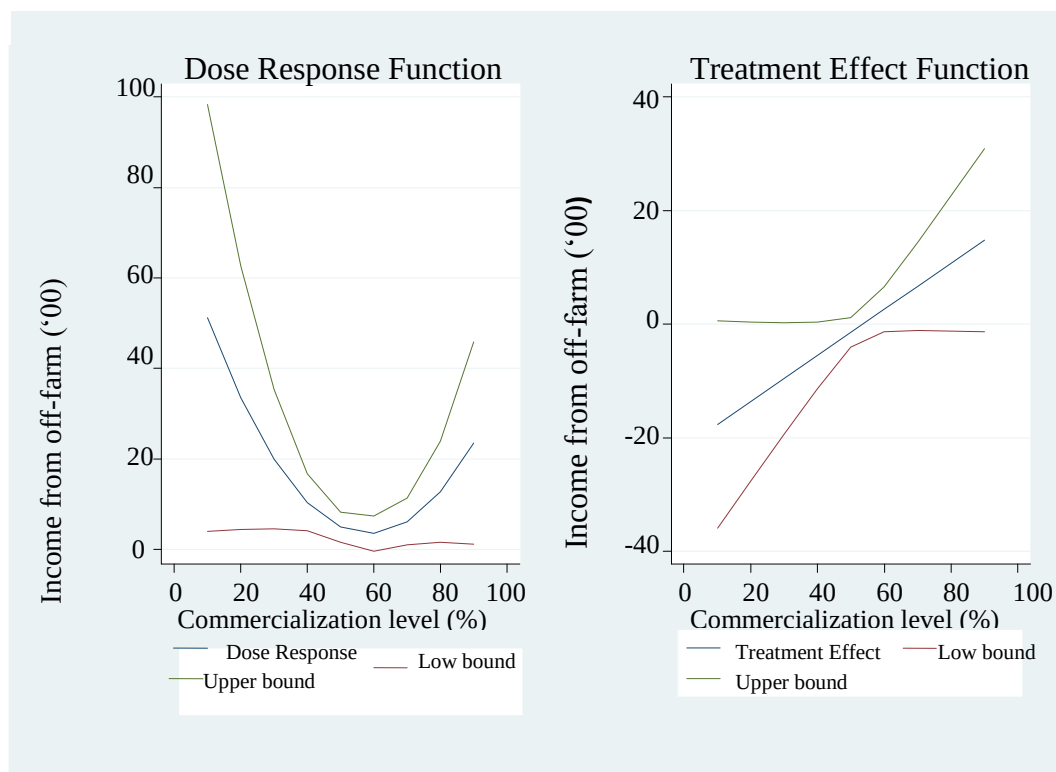


Figure 14. Estimated dose–response function for household income from off-farm activities

5. SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1. Summary

Commercialization of agriculture is one of the best indicators for agricultural development. The degree to which market forces have penetrated an area and the scale upon which they operate will be crucial factors in almost every question of agricultural development. A directed effort at commercialization of agriculture may involve articulation of farmer's psychology towards that end, provision of marketing facilities and above all a rise in the yield of agricultural produce.

Promoting commercialization of agricultural production is a cornerstone of the rural development and poverty reduction strategies of Ethiopia, as well as numerous other developing countries. Policymakers in Ethiopia and elsewhere view agricultural commercialization as an essential part of the process of agricultural modernization, specialization, and structural transformation of the economy toward more rapid and sustainable growth. The overall objective of the study was to generate information on the important factors influencing efficiency, commercialization and impact of commercialization on food security of smallholder farm households in East Gojjam zones of Amhara National Regional State, Ethiopia. A series of field surveys were carried out during the year 2017 crop season on a total of 385 sample farm household heads that were randomly drawn from 9 kebeles in three woredas through a multi-stage sampling technique.

Descriptive statistics and econometric models were used to analyze the data. The results of the descriptive statistics revealed that demographic, socioeconomic and farm specific attributes played major roles in pulse crops commercialization. Considering the socio-economic profile, farm households under study generate their main income from sales of crops (pulse and cereal), livestock, and off/non-farm activities. In addition to this a typical sample household owned 1.04 ha of land, 5.6 TLU on average and less than two oxen per household which had not been enough to plowing since the average is below two.

The highest income was generated from crop production (pulse and cereal crops) followed by income from non-farming activities and livestock income. The Gini coefficient measurement of farm household income indicated that the highest income inequality distribution was observed from non farming activities and there was also income inequality distribution among the smallholder pulse producers.

The combined effect of TE and AE factors showed that the average EE level to be 0.40. Moreover, the result also means that the farmer with average level of economic efficiency would enjoy a cost saving of about 60% derived from $(1-0.4/1)*100$ to attain the level of the most efficient farmer. Therefore, this result showed that the existence of significant technical, allocative and economic inefficiency in crop production among smallholder farmers in the study area. The result obtained from Tobit model confirmed that TE was significantly influenced by distance to development office, landholding size and off-farm participation. Moreover, extension contact, market information, improved seed used and landholdings were important factors influencing AE of crop producing households in the study area. EE was also significantly influenced by sex, extension contact, market information, improved seed used and landholdings.

This study is also initiated to investigate the commercialization of smallholder farmers in the study area. The mean commercial indices for the farm household head was 0.345 which implied that on average a household sold 34.5% of his/her total pulse crop produce. This showed that the level of crop output commercialization in the study area was very low. As compared from the four pulse crops, the households commercial indices of faba bean and field pea was larger than the commercial indices of grass pea and chick pea. This indicated that households majorly sold much of their faba bean and field pea output than that of grass pea and chick pea. The survey result showed that the farm households' crop output commercialization fall in semi-commercial level.

The econometric models including double-hurdle model and Tobit model were used to analyze factors affecting the decision and levels of market orientation and pulse commercialization respectively. Market orientation of smallholder farm households computed by double-hurdle model pointed out different determinants impacting the market orientation decisions and levels. The first-hurdle showed that distance to main road influenced the decision of commercial orientation negatively whereas landholding size,

landholding size, market information and quantity of pulse produced positively and significantly influenced households' market orientation decision. On the other hand, the results of the second-hurdle indicated that level of crop market orientation of farm households was positively and significantly influenced by educational status of household, landholding size, Extension participation, access to market information and quantity of pulse produced positively and significantly.

Two limit Tobit model was also employed to examine commercialization level. Farm household's pulse commercialization was positively and significantly influenced by access to improved seed, cooperative membership, landholding size, market information access and quantity of pulse produced and it was also negatively and significantly influenced by family size and livestock owned.

The households' food security status was measured by direct survey of consumption. Data on the available food for consumption, from home production, purchase and /or gift/loan/wage in kind for the previous seven days before the survey day by the household was collected. Then the data were converted to kilocalorie and then divided to household size measured in AE. Following this, the amount of energy in kilocalorie available for the household is compared with the minimum subsistence requirement per adult per day (i.e. 2100 kcal). As a result, about 252(65.5%) of sampled households were food insecure and 133(35.5%) were food secure. In addition, the mean energy available per AE for the surveyed respondents was 1625.5 Kcal. The binary Logit model result also revealed that food security was positively and significantly affected by landholding size, access to credit, field chemical/pesticide use and income from pulses where as it was negatively influenced by family size and distance to market.

The SUR model was applied to the modeling of interdependence between the level of efficiency, commercialization and food security status. The model result clearly showed that there was strong interdependence between and among the pulse production areas. In addition the GPS model was applied to analyze the impact of commercialization on food security and the model result indicated that there was appositive and significant impact of commercialization on food security status of smallholder pulse producers.

5.2. Conclusion and Recommendations

The male headed households were more likely efficient, market oriented and participated in crop output markets than female headed households. The probable reason might be female headed households have resource constraints, lack of factors of production (land, labor and capital) which limits their production capabilities and supply to the market. Therefore, governmental and nongovernmental organizations should empower female headed households through different policy initiatives and interventions to boost their production and productivity which improve their market oriented decisions and commercialization of their output.

Education level of the household head was found to have positive and significant effect on the level of pulse production efficiency and market orientation. Thus, improving access to education should be focused to enhance efficiency and market orientation of pulse producers and the government should give emphasis on encouraging farmers to learn adult and formal education and providing intermediate practical based training on market-oriented production. Hence, appropriate policies should be designed to provide adequate and effective basic educational opportunities to the rural farming households in general and to the study area in particular. In this regard, the regional and local government should strengthen the existing provision of formal and informal education through facilitating all necessary materials.

Farm households with high dependent members negatively affect the level of pulse commercialization and food security status in the study area. As the number of dependents increase, the need for home consumption increase rather than participating in the market to sell their crop output. Therefore, governmental and non-governmental stakeholders should give attention to strengthen and clout policies on improving rural family planning to enhance farmers' level of pulse commercialization and food security status.

Distance to the market influenced market orientation and food security of smallholder pulse producers in the study area negatively. The negative relation shows that the households located far away from the markets have poor market access which increases the final cost of acquiring farm inputs, output supply and also purchase of food items.

Therefore, government and non-governmental organizations can play their role in providing and developing a linkage between the producer and consumer and this can be assuaged by establishment of market places in farming areas, form cooperatives and support infrastructure development programs.

Landholding size positively and significantly affected production efficiency, commercialization and food security status. However, increasing the size of landholding was impossible since land is a limited resource. Interventions are needed to increase productivity of pulse per unit area of land through delivering appropriate and improved pulse production technology that increase smallholder farmers' efficiency, commercialization and food security. Hence, proper utilization of land resource and efficient utilization of existing unutilized land in the area requires intensifying the farm practices through provision of sustainable and timely supply of inputs, increasing the farmers' awareness creation on improving soil fertility and application of improved inputs which helps the farmer to produce and supply more pulse crops to the market which improves food security status of the households.

Access to improved inputs positively and significantly influenced production efficiency, commercialization and food security of the smallholder pulse producers in the study area. This implies that augmented access and better use of production inputs could lead to higher pulse production in the study areas. Improved seed contributes to an increase of agricultural productivity. Thus, efforts should be targeted at encouraging smallholder farmers to grow varieties that meet international quality standards which will require appropriate cultivation and postharvest handling practices to ensure the production and delivery of quality products. Hence, it is important to provide improved inputs at the right time and the required amount at reasonable price to increase production.

The results of the study indicated that market information has a significant effect to production efficiency and market orientation. Hence, market information services should be strengthened and addressed to smallholder producers and traders consistently and timely. Therefore, the government and NGOs should develop and facilitate market information systems in which it is symmetrically available to all stakeholders.

The findings of this study pointed out that livestock holding negatively influenced pulse production efficiency and commercialization. Hence, there should be integrated and differentiated policy interventions along with pulse production and livestock productions. In addition, farmers should be encouraged to engage on livestock husbandry as well by providing improved livestock breeds to increase production and productivity of the livestock sector.

Extension contact is a significant contributor to production efficiency and market orientation of pulse producers. Therefore, joint effort of development agent, agricultural experts, researchers and other stakeholders on identifying and solving problems, availing of new agricultural technology, transfer of improved technology and information to farmers are compulsory to enhance production efficiency and market orientation. As a result, policies and strategies should place more emphasis on strengthening the existing agricultural extension service provision through short and long-term training, upgrading educational level and providing non-overlapping and congruent responsibilities to extension workers.

Membership of farmer cooperatives has a significant positive influence on the pulse commercialization of smallholder producers in the study area. Farmer cooperative facilitates information provision related to price, profitability, availabilities of new technology and the provision of credit services to its members. Thus it is important to strengthen the existing farmer cooperatives to reinforce farmer-to-farmer knowledge sharing through providing awareness creation, incentives and providing various facilities by the regional and local government.

To make considerable improvement on food security situation in the study area the following measures and actions should be taken by household heads, government of Ethiopia, national and international organizations. The households should use improved inputs and participate at the market which might increase their income to purchase consumption goods. In addition they should use family planning to manage the family size. In addition international NGOs, local organizations, private sector and government should continue to work together on strengthening the livelihoods, rural market structures and providing the climate resilience services that improve the ability of poor households to cope with shocks.

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7. APPENDICES

Appendix table 1: Variance inflation factor for commercialization analysis

	VIF	1/VIF
Market information	2.514	0.398
Coops membership	2.072	0.483
Extension participation	1.861	0.537
Improved seed used	1.703	0.587
Land allocated for pulse	1.523	0.657
Age of household head	1.397	0.716
Chemical use	1.318	0.759
Literacy level	1.236	0.809
Sex of household head	1.141	0.876
Credit access	1.127	0.887
Distance to road	1.053	0.950
Family size	1.041	0.961
Distance to market	1.015	0.985
Mean VIF	1.5	

Appendix table 2. Conversion factors to compute tropical livestock unit (TLU)

No	Livestock Type	Conversion factors (TLU)
1	Camel	1.25
2	Horse	1.10
3	Cow and Oxen	1.00
4	Heifer	0.75
5	Donkey (adult)	0.70
6	Donkey (young)	0.35
7	Weaned calf	0.34
8	Calf	0.25
9	Sheep and goat (adult)	0.10
10	Sheep and goat (young)	0.06
11	Chickens	0.01

Source: Storck *et. al.*, 1991.

Appendix table 3. Multicollinearity diagnostic tests of inefficiency factors using VIF

	VIF	1/VIF
Market information	1.95	0.51
Improved seed	1.74	0.57
Extension participation	1.71	.0.58
Age	1.69	0.59
Land owned	1.58	0.63
Literate level	1.42	0.70
TLU	1.34	0.75
Social participation	1.25	0.80
Distance to road	1.09	0.92
Off-farm participation	1.08	0.92
Dist to development office	1.07	0.93
Distance to market	1.05	0.95
Mean VIF	1.43	.

Appendix table 4. Multicollinearity diagnostic tests of food security factors using VIF

Variable	VIF	1/VIF
Income from pulse	2.08	0.48
Improved seed	1.99	0.50
Land holding size	1.73	0.58
Chemical fertilizer use	1.66	0.60
Age of household head	1.60	0.63
Livestock holding	1.51	0.66
Oxen number	1.49	0.67
Chemical use	1.45	0.70
Income from livestock	1.29	0.78
Sex of household head	1.27	0.79
Literacy level	1.13	0.88
Income from Off-farm participation	1.09	0.92
Credit access	1.04	0.96
Family size (AE)	1.03	0.97
Distance to market	1.02	0.98
Mean VIF	1.43	.

Appendix Table 5. Efficiency scores summary of sample households

HHID	TE	AE	EE	HHID	TE	AE	EE
1	1.00	0.47	0.47	41	1.00	0.68	0.68
2	0.57	0.54	0.31	42	0.46	0.49	0.23
3	1.00	1.00	1.00	43	0.96	0.21	0.20
4	1.00	0.42	0.42	44	0.42	0.61	0.26
5	1.00	0.28	0.28	45	0.60	0.69	0.41
6	0.97	0.62	0.60	46	1.00	0.64	0.64
7	0.64	0.82	0.52	47	1.00	0.19	0.19
8	0.75	0.92	0.69	48	0.92	0.45	0.42
9	0.72	0.44	0.32	49	1.00	1.00	1.00
10	1.00	0.29	0.29	50	0.58	0.72	0.41
11	0.61	0.71	0.43	51	0.80	0.18	0.14
12	0.78	0.77	0.60	52	0.94	0.65	0.61
13	0.66	0.52	0.34	53	0.77	0.66	0.51
14	1.00	0.45	0.45	54	0.62	0.70	0.43
15	0.66	0.75	0.49	55	0.89	0.31	0.27
16	0.94	0.95	0.89	56	1.00	0.39	0.39
17	0.59	0.66	0.39	57	0.75	0.81	0.61
18	0.95	0.64	0.60	58	1.00	0.18	0.18
19	1.00	0.40	0.40	59	1.00	0.86	0.86
20	0.95	0.28	0.27	60	0.61	0.68	0.42
21	1.00	0.61	0.61	61	0.67	0.62	0.41
22	0.63	0.67	0.42	62	0.75	0.79	0.59
23	1.00	0.89	0.89	63	0.93	0.29	0.28
24	0.41	0.53	0.22	64	0.54	0.80	0.43
25	0.87	0.55	0.48	65	0.64	0.63	0.40
26	0.67	0.65	0.44	66	0.74	0.71	0.52
27	0.49	0.60	0.29	67	1.00	0.37	0.37
28	1.00	0.81	0.81	68	0.94	0.90	0.85
29	1.00	1.00	1.00	69	0.43	0.59	0.25
30	0.66	0.80	0.52	70	0.98	0.47	0.46
31	0.49	0.60	0.29	71	0.73	0.33	0.24
32	0.68	0.78	0.53	72	0.71	0.64	0.46
33	0.75	0.90	0.68	73	0.75	0.58	0.44
34	0.68	0.53	0.36	74	0.58	0.69	0.40
35	0.72	0.73	0.53	75	1.00	0.33	0.33
36	0.81	0.60	0.48	76	1.00	0.21	0.21
37	0.80	0.78	0.62	77	0.76	0.76	0.58
38	0.62	0.53	0.33	78	0.77	0.61	0.47
39	0.66	0.81	0.53	79	0.59	0.68	0.40
40	0.98	0.74	0.73	80	1.00	0.68	0.68

HHID	TE	AE	EE	HHID	TE	AE	EE
81	0.49	0.60	0.29	121	0.87	0.56	0.48
82	0.97	0.22	0.21	122	0.92	0.65	0.60
83	0.75	0.79	0.59	123	0.93	0.27	0.25
84	0.78	0.69	0.53	124	0.79	0.31	0.24
85	0.92	0.61	0.56	125	0.71	0.53	0.37
86	0.72	0.19	0.14	126	0.93	0.39	0.36
87	0.68	0.52	0.35	127	0.61	0.68	0.42
88	1.00	0.44	0.44	128	0.84	0.36	0.31
89	0.63	0.77	0.49	129	0.49	0.54	0.26
90	0.61	0.83	0.50	130	1.00	0.17	0.17
91	0.82	0.27	0.22	131	0.87	0.55	0.48
92	1.00	0.87	0.87	132	0.51	0.85	0.43
93	0.81	0.61	0.50	133	0.78	0.25	0.19
94	0.51	0.60	0.31	134	0.77	0.61	0.47
95	0.44	0.66	0.29	135	1.00	0.97	0.97
96	0.53	0.75	0.40	136	0.80	0.46	0.37
97	1.00	0.38	0.38	137	1.00	0.55	0.55
98	0.89	0.61	0.54	138	0.53	0.75	0.40
99	0.82	0.85	0.69	139	0.89	0.60	0.53
100	0.53	0.75	0.40	140	0.82	0.70	0.57
101	1.00	0.40	0.40	141	0.76	0.77	0.59
102	1.00	0.37	0.37	142	0.75	0.77	0.58
103	0.78	0.23	0.18	143	0.58	0.68	0.40
104	0.95	0.64	0.61	144	0.76	0.83	0.63
105	0.68	0.71	0.48	145	0.93	0.27	0.26
106	1.00	0.24	0.24	146	0.83	0.73	0.61
107	0.54	0.71	0.38	147	1.00	0.38	0.38
108	0.54	0.73	0.40	148	0.58	0.71	0.41
109	0.62	0.68	0.42	149	0.96	0.33	0.31
110	0.92	0.58	0.54	150	0.56	0.63	0.35
111	0.59	0.51	0.30	151	0.75	0.72	0.54
112	0.53	0.65	0.34	152	0.79	0.35	0.28
113	0.96	0.27	0.26	153	1.00	0.20	0.20
114	0.76	0.80	0.61	154	0.75	0.80	0.60
115	0.54	0.73	0.40	155	0.56	0.49	0.27
116	0.73	0.63	0.46	156	0.75	0.76	0.57
117	0.72	0.27	0.20	157	0.46	0.56	0.25
118	0.58	0.71	0.41	158	0.59	0.57	0.34
119	0.97	0.37	0.36	159	0.74	0.83	0.62
120	0.46	0.56	0.25	160	0.87	0.56	0.48

HHID	TE	AE	EE	HHID	TE	AE	EE
161	0.95	0.31	0.29	201	0.83	0.30	0.25
162	0.45	0.49	0.22	202	0.48	0.41	0.20
163	0.58	0.47	0.27	203	0.50	0.55	0.28
164	0.95	0.30	0.29	204	0.69	0.77	0.53
165	0.51	0.66	0.33	205	1.00	0.76	0.76
166	0.87	0.21	0.18	206	1.00	1.00	1.00
167	1.00	0.71	0.71	207	0.52	0.49	0.26
168	0.62	0.60	0.38	208	0.72	0.73	0.53
169	0.75	0.83	0.62	209	0.54	0.54	0.29
170	0.56	0.77	0.44	210	0.71	0.50	0.35
171	0.59	0.17	0.10	211	0.48	0.35	0.17
172	0.56	0.52	0.29	212	0.75	0.41	0.31
173	0.62	0.76	0.47	213	0.66	0.75	0.49
174	0.48	0.41	0.20	214	0.85	0.74	0.63
175	0.58	0.46	0.27	215	0.57	0.58	0.33
176	1.00	0.20	0.20	216	0.63	0.46	0.29
177	0.78	0.74	0.58	217	0.48	0.35	0.17
178	0.84	0.33	0.28	218	0.90	0.41	0.37
179	0.74	0.57	0.42	219	1.00	0.54	0.54
180	0.54	0.57	0.30	220	0.59	0.52	0.31
181	0.78	0.58	0.45	221	0.70	0.77	0.54
182	0.48	0.53	0.26	222	0.48	0.35	0.17
183	0.61	0.80	0.49	223	1.00	0.53	0.53
184	0.39	0.25	0.10	224	0.65	0.81	0.52
185	0.81	0.59	0.48	225	0.39	0.56	0.22
186	0.65	0.78	0.51	226	0.56	0.52	0.29
187	0.48	0.41	0.20	227	1.00	0.26	0.26
188	0.68	0.52	0.36	228	0.62	0.53	0.33
189	0.59	0.28	0.17	229	0.76	0.71	0.54
190	0.82	0.70	0.57	230	0.54	0.74	0.40
191	0.76	0.53	0.40	231	0.93	0.30	0.28
192	0.76	0.73	0.56	232	0.75	0.82	0.61
193	0.54	0.74	0.40	233	0.76	0.85	0.64
194	0.65	0.60	0.39	234	0.64	0.79	0.51
195	0.50	0.27	0.14	235	0.70	0.50	0.35
196	0.75	0.56	0.42	236	0.79	0.34	0.27
197	0.97	0.63	0.61	237	0.76	0.60	0.46
198	0.48	0.35	0.17	238	0.91	0.37	0.34
199	0.50	0.51	0.25	239	0.53	0.51	0.27
200	0.64	0.77	0.49	240	0.75	0.70	0.52

HHID	TE	AE	EE	HHID	TE	AE	EE
241	0.89	0.16	0.14	281	0.67	0.47	0.32
242	0.69	0.42	0.29	282	0.93	0.27	0.25
243	0.64	0.61	0.39	283	0.50	0.60	0.30
244	0.93	0.27	0.25	284	0.68	0.71	0.48
245	0.68	0.47	0.32	285	0.80	0.27	0.22
246	0.82	0.84	0.69	286	0.76	0.81	0.62
247	0.61	0.60	0.36	287	0.87	0.25	0.22
248	0.82	0.27	0.22	288	0.81	0.70	0.57
249	0.67	0.76	0.51	289	0.87	0.25	0.22
250	0.55	0.50	0.27	290	0.52	0.61	0.31
251	1.00	0.38	0.38	291	0.95	0.40	0.38
252	0.75	0.26	0.20	292	0.68	0.75	0.51
253	0.72	0.71	0.51	293	0.39	0.56	0.22
254	0.52	0.49	0.26	294	1.00	0.30	0.30
255	0.51	0.20	0.10	295	0.64	0.74	0.47
256	1.00	0.45	0.45	296	0.50	0.97	0.48
257	0.78	0.77	0.60	297	0.77	0.80	0.62
258	1.00	0.52	0.52	298	0.64	0.77	0.49
259	0.72	0.74	0.53	299	0.57	0.17	0.10
260	0.50	0.51	0.25	300	0.74	0.72	0.53
261	0.55	0.56	0.31	301	1.00	0.89	0.89
262	0.97	0.29	0.28	302	0.53	0.45	0.24
263	1.00	0.80	0.80	303	0.45	0.49	0.22
264	0.59	0.77	0.45	304	0.87	0.64	0.55
265	0.83	0.73	0.61	305	0.74	0.68	0.50
266	0.48	0.46	0.22	306	0.66	0.72	0.48
267	0.51	0.20	0.10	307	0.50	0.87	0.43
268	0.59	0.48	0.28	308	0.80	0.34	0.27
269	0.94	0.34	0.32	309	0.53	0.45	0.24
270	0.67	0.77	0.51	310	0.83	0.26	0.22
271	0.38	0.57	0.22	311	0.64	0.75	0.47
272	1.00	0.37	0.37	312	0.83	0.19	0.16
273	0.64	0.80	0.51	313	0.39	0.25	0.10
274	0.64	0.80	0.51	314	0.47	0.64	0.30
275	0.48	0.21	0.10	315	0.93	0.27	0.26
276	0.83	0.55	0.46	316	0.79	0.44	0.35
277	0.75	0.21	0.16	317	0.61	0.66	0.40
278	0.63	0.91	0.57	318	0.68	0.71	0.48
279	0.51	0.50	0.26	319	0.96	0.32	0.30
280	0.58	0.71	0.41	320	0.75	0.76	0.57

HHID	TE	AE	EE	HHID	TE	AE	EE
321	0.67	0.40	0.26	354	0.62	0.75	0.46
322	0.53	0.45	0.24	355	0.56	0.18	0.10
323	0.52	0.77	0.40	356	0.83	0.50	0.42
324	0.46	0.56	0.25	357	0.93	0.27	0.26
325	0.79	0.43	0.34	358	0.47	0.57	0.27
326	0.56	0.18	0.10	359	0.66	0.81	0.53
327	0.52	0.49	0.26	360	0.39	0.25	0.10
328	0.76	0.63	0.48	361	0.59	0.51	0.30
329	0.83	0.19	0.16	362	0.67	0.70	0.47
330	0.86	0.27	0.23	363	0.53	0.51	0.27
331	0.50	0.79	0.40	364	0.56	0.72	0.40
332	0.52	0.52	0.27	365	0.75	0.92	0.69
333	0.90	0.28	0.25	366	0.63	0.28	0.18
334	0.87	0.55	0.48	367	0.45	0.57	0.25
335	0.63	0.65	0.40	368	0.80	0.27	0.22
336	0.50	0.89	0.45	369	0.48	0.53	0.25
337	0.69	0.52	0.36	370	1.00	0.45	0.45
338	0.66	0.75	0.49	371	0.82	0.27	0.22
339	0.74	0.64	0.47	372	0.53	0.75	0.40
340	0.79	0.44	0.35	373	0.57	0.18	0.10
341	0.59	0.29	0.17	374	0.70	0.31	0.22
342	0.63	0.59	0.38	375	0.64	0.77	0.49
343	0.79	0.60	0.47	376	0.72	0.19	0.14
344	0.79	0.44	0.35	377	0.65	0.74	0.48
345	0.84	0.68	0.58	378	0.50	0.37	0.18
346	1.00	0.26	0.26	379	0.37	0.59	0.22
347	0.76	0.69	0.53	380	0.50	0.33	0.16
348	0.54	0.50	0.27	381	0.87	0.25	0.22
349	0.79	0.44	0.35	382	0.42	0.60	0.25
350	0.66	0.75	0.49	383	0.98	0.28	0.28
351	0.53	0.51	0.27	384	0.77	0.69	0.53
352	0.75	0.82	0.62	385	0.50	0.51	0.25
353	0.83	0.32	0.27	Mean	0.72	0.56	0.40

Results from DEAP Version 2.1; Cost efficiency DEA; Scale assumption: CRS.

Source: Own computation (2019).

Appendix 2: Stata Commands and Estimation Procedures

1. Efficiency Analyses

Clustering efficiency DEA analyses

- cluster wardslinkage te ae ee , measure (L2squared)
- cluster wardslinkage te ae ee , measure (L2squared) name (wards_linkage)
- cluster dendrogram wards_linkage, cutnumber(10) showcount countinline
- cluster dendrogram wards_linkage, cutnumber(10) showcount
- cluster stop wards_linkage, rule(duda) groups(1/10)
- cluster generate claste_wal = groups(6), name (wards_linkage) ties(error)
- cluster stop wards_linkage,rule(calinski) groups(2/11)
- cluster stop wards_linkage,rule(calinski) groups(2/11) matrix (claster_wal)
- tabulate claste_wal,missing
- tabstat te ae ee ,statistics(mean) by(claste_wal)

Inefficiency Facors Analyses

- tobit te sex age literate distmkt distdeveoffi distroad landowned improvedseed socialpartice marketinfor exteparticc offfarmparti tlu, ll(0) ul(1) robust
- mfx
- tobit ae sex age literate distmkt distdeveoffi distroad landowned improvedseed socialpartice marketinfor exteparticc offfarmparti tlu, ll(0) ul(1) robust
- mfx
- tobit ee sex age literate distmkt distdeveoffi distroad landowned improvedseed socialpartice marketinfor exteparticc offfarmparti tlu, ll(0) ul(1) robust
- mfx

3. Market Orientation of Smallholder Households

- craggit moipartic sex grade age leteracy distmkt improvedseed distroad landowned pulseland oxenno extensionpartic extecontact coopsmember socialpartic marketinfo tlu pulseyield, second (moi sex grade age leteracy distmkt improvedseed distroad landowned pulseland oxenno extensionpartic extecontact coopsmember socialpartic marketinfo tlu pulseyield)

4. Commercialization Analysis

- tobit ci sex age education famsize distmkt distroad landowned improvedseed chemfertiusse trainingacc chemicaluse coopsmember marketinfo offfarmpartic tlu pulseyield, ll(0) ul (1) robust
- mfx, predict(e(0,.))

5. Food Security Analysis

- logistic foodsecurity sex age grade famsize distmkt land oxenno improvedseed chemfertiusse chemicaluse creditaccess pulseincome tlu livestockincome offfarmpartic

5. Interdependence Analysis-SUR Model

Commercialization & Efficiency relationship

- sureg(technicalefficiency sex farmexpe literate famsize distmkt distroad landowned oxenno extecontacts improveedseed chemifertiusse chemicaaluse creditaccess marketinfor totpulseyield)(allocativeefficiency sex farmexpe literate famsize distmkt distroad landowned oxenno extecontacts improveedseed chemifertiusse chemicaaluse creditaccess marketinfor totpulseyield)(economiefficiency sex farmexpe literate famsize distmkt distroad landowned oxenno extecontacts improveedseed chemifertiusse chemicaaluse creditaccess marketinfor totpulseyield), corr

Efficiency and food security relationship

- sureg(technicalefficiency sex farmexpe literate famsize distmkt distroad landowned oxenno extecontacts improveedseed chemifertiusse chemicaaluse creditaccess totpulseyield)(allocativeefficiency sex farmexpe literate famsize distmkt distroad landowned oxenno extecontacts improveedseed chemifertiusse chemicaaluse creditaccess totpulseyield)(economiefficiency sex farmexpe literate famsize distmkt distroad landowned oxenno extecontacts improveedseed chemifertiusse chemicaaluse creditaccess totpulseyield)(caloriintake sex farmexpe literate famsize distmkt distroad landowned oxenno extecontacts improveedseed chemifertiusse chemicaaluse creditaccess totpulseyield), corr

Commercialization & foodsecurity relationship

- sureg(commercialindex sex farmexpe literate famsize distmkt distroad landowned oxenno extecontacts improveedseed chemifertiusse chemicaaluse creditaccess

marketinfor totpulseyield)(caloriintake sex farmexpe literate famsize distroad
dismkt landowned oxenno improvedseed chemifertiuse chemicaaluse
extecontacts marketinfor totpulseyield), corr

Efficiency,commercialization and food security relationship

- sureg(technicalefficiency sex age literate famsize distmkt landowned oxenno
improvedseed chemifertiuse chemicaaluse extecontacts totpulseyield)(
allocativeefficiency sex age literate famsize distmkt landowned oxenno
improvedseed chemifertiuse chemicaaluse extecontacts totpulseyield
) (economiefficiency sex age literate famsize distmkt landowned oxenno
improvedseed chemifertiuse chemicaaluse extecontacts totpulseyield)(
commercialindex sex age literate famsize distmkt landowned oxenno
improvedseed chemifertiuse chemicaaluse extecontacts totpulseyield)(
foodsecurity sex age literate famsize distmkt landowned oxenno improvedseed
chemifertiuse chemicaaluse extecontacts totpulseyield), corr

6. Commercialization impact on food security analysis

- qui gen cut1 =0.5 if CI<=0.5
- qui replace cut1 =0.56 if CI>0.5 & CI<=0.56
- qui replace cut1 =0.75 if CI>0.56
- mat def tp1 = (0.10\0.20\0.30\0.40\0.50\0.60\0.70\0.80\0.9)
- doseresponse2 Sex Age Education Famsize Landowned Distroad Dismkt
Trainingacce Marketinfo Credittaccess TLU Totpulseyield, t (CI) gpscore
(mygpscore) predict (y_hat_ns) sigma (sd_ns) cutpoints (cut1) index(mean)
nq_gps (5) family (binomial) link (logit) outcome (Caloriintake) dose_response
(dose_response) tpoints (tp1) delta (0.1) reg_type_t (quadratic) reg_type_gps
(quadratic) interaction(1) filename ("output_bin") graph ("graphoutputbin")
bootstrap (yes) boot_reps (10) analysis (yes) det

Production Efficiency, Commercialization and Its Impact on Food Security of Smallholder Pulse Producers in East Gojjam Zone, Amhara Region, Ethiopia.

PhD Dissertation Research Household Sample Survey Interview Schedule

Postgraduate Program Directorate, Haramaya University

General Instruction for Enumerators:

Please introduce yourself before starting the interview.

Inform the purpose of the study which will be used only for the Ph.D. dissertation writing on the topic indicated above.

Carefully read and complete the questionnaire.

Where exact figures are not available, please provide careful estimates.

This questionnaire should be completed for 2017/18 cropping season.

Circle the appropriate code, 1, 2,3,4,5, 6 and 7 fill in the blank spaces, accordingly.

GENERAL INFORMATION

Interviewer Name: ____

Woreda Name _____

Agro-ecology: 1. Dega 2. Woina Dega 3. Kola

Name of Kebele: ____

Name of household head: ____

I. HOUSEHOLD CHARACTERISTICS

Note-This part of the questionnaire should be posed to the household head. Only if the head is absent or is expected to be absent for the next two days should the question be posed to another adult member of the household preferably the spouse of the household head.

1. Sex of household head: 0. Female 1. Male

2. Age of household head: _ _ _ _ years

3. Marital Status: 1. Single 2. Married 3. Widow/Widower 4. Divorced

4. Religion: 1. Orthodox 2. Muslim 3. Protestant 4. Other

5. Education level of household head? 0. Illiterate 1. Read and write only 2.

Primary school 3. Secondary school 4. Tertiary 5. Others _____

6. Please specify your household size

No.	Household size category	Total family size
1	Children 10 years age and below	
2	A male children between 10-13 years of age	
3	A female children between 10-13 years of age	
4	A male family member (b/n 14 and 65 years)	
5	A female family member (b/n 14 & 65 years)	
6	Family member above 65 years of age	
Total		

7. Main occupation of the households: 1. Farmer 2. Civil servant 3. Business man

4. Employee in a private company 5. Other, specify, ____

8. Farming experience of the household head?-----years

9. Infrastructure facilities for your locality in walking hours:

The types of infrastructure	Distance in Walking hours
Nearest Market	
Road	
Major town	
Development agents' office	
Farmers Training Center(FTC)	
Cooperative office	

II. Information on pulse production and marketing for 2017 cropping season

10. Did you grow pulse crops for 2017? 0. No 1. Yes

11. If yes, List the types of pulse crops that you grow? 1-----2-----3-----
4-----5-----

12. For what purpose did you grow these pulse crops? 1. For home consumption only

2. For market only 3. For consumption and market 4. Others, specify

13. If you grow pulse crops in 2017, please estimates land allocated for these pulse crops?

No.	The type of land used?	Landholding size	Land Allocated for pulses (in ha)	Types of pulse crop			
1	Own land						
2	Share land						
3	Leased land from others						
4	Land obtained by other means						

14. What was the rental price of land per hectare in your *Kebele*? _____Birr

15. Did your families participate in pulse production? 0. No 1. Yes

16. If yes for question no. 15. How did they participate? 1. Full time 2. Part time

17. What types of labor did you use for pulse production of during the farming season?
(Multiple answers possible) 1. Hired labor 2. Family labor 3. Exchange labor 4.
Others_____

18. Estimate the total number of labor, days spent and amount of payment cropping for each activity for 2017?

No.	Labor used	The types of farm activity								
		Land preparation and planting			Weeding and cultivation			Harvesting		
		no.of days	Payment /day	Total payment	No.of days	Payme nt/day	Total pay	No.of day	Payme nt/day	Total pay
1	Hired labor									
2	Family labor									
3	Exchange labor									
4	Other									

19. How did you prepare your farm land for pulse crops growing? 1. By oxen 2. By Tractor 3. Others, specify-----

20. If you used oxen power, what types of oxen did you use for pulse cropping? (Multiple answers possible) 1. Own 2. Shared 3. Leased 4. Others specify_____

21. What was the rental price of a pair of oxen in your *Kebele*? _____ Birr

No.	Types of oxen	Pairs of Oxen	No. of days used for farm activities	Payment per day	Total payment
1	Own				
2	Shared				
3	Leased				
4	Others, specify				

22. Which types of pulse crops' seed did you use during 2017 cropping season? (Multiple answers possible) 1. Improved/ hybrid variety 2. Local variety 3. Both

23. What were the sources of pulse seed used in during cropping season? (Multiple answers) 1. Stock from previous harvest 2. From local market 3. From extension

service 4. Loan from farmer cooperatives 5. Loan from private 6. Other, specify_____

24. Did you use only improved pulse seed variety during the cropping season? 0. no 1. yes

25. If no, what was your reason? 1. High price of improved pulse crops seed variety 2. Lack of credit arrangement 3. Lack of supply 4. Lack of transportation 5. Other, specify_____

26. Please estimate the pulse crops seed utilization during the farming season, 2017?

No.		Types of pulse crops seed used	
		Improved variety	Local variety
1	How much kilogram of pulse seed sown?	1. ____ kg 2. ____ kg 3. ____ Kg	1. ____ kg 2. ____ kg 3. ____ kg
2	Can you estimate the land covered by these seed?	1. ____ ha 2. ____ ha 3. ____ ha	1. ____ ha 2. ____ ha 3. ____ ha
3	Can you estimate the price of pulse crops seed purchased?	1. ____ birr/kg 2. ____ birr/kg 3. ____ birr/kg	1. ____ birr/kg 2. ____ birr/kg 3. ____ birr/kg

27. Did you apply fertilizers for pulse crops production during 2017 farming season?

0. No 1. Yes

28. If you used fertilizer, please estimate the amount of fertilizer during 2017 farming season?

No.		Amount of fertilizer purchased for various pulse crops	
		UREA	DAP
1	How much money spend to purchase fertilizer for pulse crops?	1. ____ birr/kg 2. ____ birr/kg 3. ____ birr/kg	1. ____ birr/kg 2. ____ birr/kg 3. ____ birr/kg

29. If you did not use fertilizer, what were the major constraints faced for fertilizer utilization? 1. High price of fertilizer 2. Lack of credit 3. Inappropriate loan repayment time 4. High transportation cost 5. Other, specify _____

30. Please specify your soil fertility management practice applied for pulse cropping

No	Types of soil fertility management practices	0.no	1.yes
1	Did you use farmyard manure?		
2	Did you use compost?		
3	Did you use fallowing?		
4	Did you use crop rotation?		

31. Did you face incidence of plant disease and pest in your pulse crops farming? 0. No
1. Yes

32. If yes, did you apply pesticide and herbicide for pulse crops cropping? 0. No 1. Yes

33. If you applied pesticide and herbicide, please estimate your chemical utilization for 2017?

No.		Types of chemicals used for various pulse crops	
		Pesticide	Herbicide
1	How much litter did you use for 2016/17 cropping?	1. ____ litter 2. ____ litter 3. ____ litter	1. ____ litter 2. ____ litter 3. ____ litter
2	How many amount of money did you spend for chemical purchase?	1. ____ birr/litter 2. ____ birr/litter 3. ____ birr/litter	1. ____ birr/litter 2. ____ birr/litter 3. ____ birr/litter

34. Did you apply pest and weed control methods for pulse cropping? 0. No 1. Yes

35. If yes, which types of methods did you apply? 1. Mulching 2. Inter-cropping maize with other crops 3. Crop rotation 4. Spread of wood ash around base of crop 5. Hand weeding 6. Others, specify

36. How did you plant pulse crops? 1. Row planting 2. Broadcasting

38. Did you practice inter-cropping (*growing pulse crops with other crop simultaneously on the same field*) during the current farming season? 0 .No 1. Yes

39. If you practiced inter-cropping pulse crops with other crops, what was your main reason?(Multiple answers possible) 1. Reduce diseases incidence 2. Increase soil

fertility 3. Better use of the land resource 4. Erosion control 5. Food consumption
6. Others

III. Access of Service issues

40. Did you have access to credit? 0. No 1. Yes

41. If yes for question 40, who was the service provider? 1. Government organizations
2. NGO 3. Friends 4. Relatives 5. Money lenders 6. Others
(specify)_____

42. What was the mount of credit received? 1. In cash-----Birr 2. In kind-----birr

42. If your answer for 41 is yes, for what purpose do you take the credit? 1. For pulse
production 2. To purchase fertilizer 3. To purchase animals 4.to purchase food
grains 5. To purchase grain seed 6.Others (specify)_____

43. If you didn't received credit, what were the reasons? 1. Fear of risk 2. Not
qualified 3.Reason not known 4. Religion 5. Credit service not available 6. Others

44. Did you participate in the government extension program package? 0. No 1. Yes

45. If you participated, in which types of extension packages? (More than one choice
possible): 1. Chemical fertilizer use 2. Pesticides useage 3. Credit usage 4. Water
conservation practices 5. High yielding crop variety 6. Improved livestock breeds
7. Beehives usage 8. Others

46. Did extension workers visited your pulse crops field ? 0. No 1. Yes

47. If yes, can you estimate the number of visited frequencies by the extension agents
during the cropping season? 1. Once a week 2. Twice a month 3. Once a month 4. Once a
year 5.others

48. Did you get market information for your pulse marketing in 2017/18 cropping season?
0. No 1. Yes.

49. How was the frequency of getting market information?

1. Daily 2. Weekly 3. Monthly 4. Twice a week 5. Others-----

50. If you did not get market information, what was the reason?1.-----2.-----
-----3.-----4.-----5.-----

51. Were you a member of farmers' cooperative? 0. No 1. Yes

52. Were you involved in any type of civic engagement (like government official, leader of
Edir local representative, religious leadership, etc)? 0. No 1. Yes

III. Household Income

53. Did you get income from the sale of your crops in 2017 cropping season?

0. No 1. Yes

54. Types of crop production, amount produced and sales 2017 cropping season.

Types of crop grown	Amount produced		Amount sold			Total income (Birr)
	Unit of measurement	Quantity	Unit of measurement	Quantity	Average unit price	
Cereals						
Teff						
Wheat						
Mize						
Barley						
Sorghum						
Pulses/legumes						
Faba bean						
Field pea						
Grasspea						
Haricot bean						
Lentils						
Chickpea						
Others						
Tuber and vegetables						
Potato						
Carrot						
Onions						
Cabbage						
Tomato						
Fruits						
Orange						
Papaya						
Avocado						
Mango						
Banana						

57. Types of livestock product sales activity within 2017 cropping season

Types of livestock product	Amount sold			
	Unit of measurement	Quantity	Average unit selling price	Total income(Birr)
Milk	Lit.			
Cheese	Kg			
Butter	Kg			
Egg	Kg			
Honey	Kg			
Skins and hides	No.			
Others, (specify)_____				
Total				

58. Did you participate in off-farm activities? 0. No 1. Yes

59. If yes, what was the estimated income from off-farm activities within the cropping season?

No.	Description of off-farm activities	Family members participated	Frequency of income generation	amount of income generated per month (Birr)	Cost	amount of income generated per year (Birr)
1	Agricultural wage labor					
2	Sales of firewood /charcole					
3	Crop trade					
4	Livestock trade					
5	Trade in livestock products					
6	Others					
	Total					

60. What was the income amount earned from non-farm activities within cropping season.

No.	Description of off-farm activities	Members participated	Frequency of income generation	Estimated amount of income generated per month (Birr)	Estimated amount of income generated per year (Birr)
1	Handcrafting (e.g. weaving/, metal works, etc)				
2	Guard				
3	Non-agricultural wage				
4	Sale of local drinks				
5	Others (specify)_____				
	Total				

V. Food consumption score (FCS) questions

63. Could you please tell me how many days has the household eaten any food made from each food items in the last 7 days)?

No.	Food groups	Food items	Unit	Total weekly consumption	Number of days eaten over the past 7 days
1	Cereals	Sorghum	Kg		
		Maize	Kg		
		Wheat	Kg		
		Barley	Kg		
		Teff	Kg		
2	Pulses/Legumes	Faba bean	Kg		
		Field pea	Kg		
		Lentil	Kg		
		Haricot bean	Kg		
		Chick pea	Kg		
3	Meat, Egg or Fish	Meat	Kg		
		Egg	No.		
		Fish	Kg		
4	Dairy products	Milk	Liter		
		Yogurt	Kg		
		Cheese	Kg		
5	Tubersand Vegetables	Potato	Kg		
		Carrot	Kg		
		Onion	Kg		
		Cabbage	Kg		
		Tomato	Kg		
6	Fruits	Orange	Kg		
		Papaya	Kg		
		Avocado	Kg		
		Mango	Kg		
		Banana	Kg		
7	Oil, fat or butter	Processed oil	Kg		
		Fat	Kg		
		Butter	Liter		
8	Sugar, sugar product or honey	Sugar	Kg		
		Honey	Kg		

Summarized food consumption for 7 days

64. Household home prepared Food Consumptions summary

List the food items prepared and consumed by the HHs in the last 7 days in the house	The food items are prepared/made from	Amount in Kg/Liter/piece/cup/spoon	Value in (Br)
1 st day			
2 nd day			
3 rd day			
4 th day			
5 th day			
6 th day			
7 th day			

65. Household outside the home prepared Food Consumptions summary

List the food items consumed by the HHs outside the house in the last 7 days	The food items are prepared/made from	Amount in Kg/Liter/piece/cup/spoon	Value in (Br)
1 st day			
2 nd day			
3 rd day			
4 th day			
5 th day			
6 th day			
7 th day			

67. Household from gift/food aid Food Consumptions summary

List the food items consumed by the HHs Consumed from gift/food aid in the last 7 days	The food items are prepared/made from	Amount in Kg/Liter/piece/cup/spoon	Value in (Br)
1 st day			
2 nd day			
3 rd day			
4 th day			
5 th day			
6 th day			
7 th day			

The End

Thank You