ADDIS ABABA UNIVERSITY

SCHOOL OF GRADUATE STUDIES

RURAL ROAD TRANSPORT AND ITS EFFECTS ON SMALLHOLDER FARMERS' AGRICULTURAL PRODUCTIVITY AND MARKETING: THE CASE OF HORRO GUDURU WOLLEGA ZONE, WESTERN ETHIOPIA.

BY

SILESHI TAMENE FIKADU

ADVISOR: TEBAREK LIKA (ASSOCIATE PROFESSOR)

ADDIS ABABA, ETHIOPIA

MARCH 2020

Rural Road Transport and its Effects on Smallholder Farmers' Agricultural Productivity and Marketing: the case of Horro Guduru Wollega Zone, Western Ethiopia

Sileshi Tamene Fikadu

A Dissertation Submitted to

The Department of Geography and Environmental Studies

Presented in Fulfillment of the Requirements for the Degree of Doctor of Philosophy in Geography and Environmental Management

Advisor: Tebarek Lika (Associate professor)

Addis Ababa University

Addis Ababa, Ethiopia

March 2020

Addis Ababa University

School of Graduate Studies

This is to certify that the thesis prepared by Sileshi Tamene Fikadu, entitled: ***Rural Road Transport and its Effects on Smallholder Farmers' Agricultural Productivity and Marketing: The case of Horro Guduru Wollega Zone, Western Ethiopia*** and presented in fulfillment of the requirements for the Degree of Doctor of Philosophy in Geography and Environmental Studies (Specialization in Socio-economic Development Planning and Environment) complies with the regulations of the University and meets the accepted standards with respect to originality and quality.

Signed by the Examining Committee:

Advisor: Tebarek Lika (Associate Professor) Signature____________Date___________

Internal Examiner: Abeje Berhanu (Associate Professor) Signature_______Date_______

External Examiner: Belew Dagnew (PhD) Signature____________Date__________

Chairperson: Fikadu Gurmessa (PhD) Signature____________Date__________

Chairman of the Department: Teferi Mekonnen (PhD) Signature_________Date_______

Table of Contents

Content **Page**

List of Tables

List of Figures

Acronyms

SADC	Southern Africa Development Community
ECOWAS	Economic Community of West African States
COMESA	Common Market for Eastern and Southern Africa)
SDGs	Sustainable Development Goals
FAO	Food and Agricultural Organizations of the United Nations
UNDP	United Nations Development Program
IFAD	International Fund for Agricultural Development
SSA	Sab-saharan Africa
GDP	Growth Domestic Product
MoFED	Ministry of Finance and Economic Development
CSA	Central Statistical Agency
HGWZ	Horro Guduru Wollega Zone
GTP	Growth and Transformation Plan
RK	Rural Kebele
TLU	Tropical Livestock Unit
ETB	Ethiopian Birr
ANOVA	Analysis of Variance
MoARD	Ministry of Agriculture and Rural Development
ADLI	Agriculture led Industrialization
EPRDF	Ethiopian people's Revolutionary Democratic Front
PASDEP	Plan for Accelerated and Sustained Development to End Poverty
HCI	Household commercialization index
OECD	Organization for Economic Co-operation and Development
IMT	Intermediate means of transport
ILO	International Labour Organization
FGD	Focus Group Discusssion
KII	Key Informant Interview
COMPI	Crop output market participation index
VIF	Variance Inflation Factor
SNNPR	Southern Nations Nationalities People Region
USAID	United States Agency for International Development
PHL	Post-harvest Loss
DFID	Department for International Development
AFDB	African Development Bank
IDI	in-depth interviews

Acknowledgements

Above all, I would like to thank and give praise to the Almighty **God** for providing me with the opportunity to pursue my PhD and for keeping me healthy to finish this work. My sincere thanks go to Addis Ababa University for accepting me as a PhD candidate and for financing this research. I am also grateful to my employer Wollega University for allowing me to do the PhD study. This dissertation also appears in its present form due to the guidance and assistance of many individuals who directly or indirectly contributed and extended their valuable assistance in the preparation and completion of this study. First of all, I would like to express my deepest gratitude to my supervisor, Dr. Tebarek Lika (Associate professor), for his motivation, patience, enthusiasm and consistent support from the beginning to the end of this dissertation work. It is due to his incredible support and friendly approach that this dissertation appears in its present form. Concerning scientific paper writing and publishing, I have learned several useful qualities from Dr. Tebarek that will help me in my future career too. My sincere thanks also goes to Dr. Abeje Berhanu (Associate professor) and Dr. Solomon Mulugeta (Associate professor) for their invaluable comments and suggestions during the presentation and examination of the proposal of this dissertation, which of course significantly improved the methodology, content, structure and quality of the dissertation.

I am deeply grateful to all staffs and PhD students of Geography and Environmental studies of Addis Ababa University for their academic support and hospitality during the whole period of study. I would like to thank the many smallholder farmers in Horro Guduru Wollega Zone for lively discussions and generous hospitality. The Offices of Agriculture and Rural Development as well as offices of District Rural Road Authority in Ababo Guduru, Horroo, Amuru and Abe Dongoro are acknowledged for supporting this research by providing information and creating suitable working environments.

My sincerely acknowledgements go to my colleagues Fikadu Gurmessa, Dereje Hinew, Tesfaye Tolossa, Habtamu Tolera and Getinet Kebede for their support and advice throughout the study period. My sincerely acknowledgements go to my father Tamene Fikadu and mother Beletu Lelisa who devoted their energy and resources for educating myself and other brothers and sisters. My brother in-law Dr. Lelisa Chala and my sister Almaz Tamene are gratefully acknowledged for encouraging me and helping my family while I was not around. Las but not least, I would like to thank my beloved wife Hangarashe Alemayehu and my daughters Kaku and Bilile who paid the cost of separation and endured the test of loneliness during my field work and when I stayed in Addis Ababa.

Abstract

Lack of decent access to rural transport infrastructure is often considered as the root cause of low agricultural productivity among smallholder farmers of Ethiopia. The overall objective of this study is to assess the effect of rural transport infrastructure on smallholder farmers' agricultural productivity in Horro Guduru Wollega Zone, with a particular focus on its availability, accessibility, affordability, and quality as well as its effect on smallholder farmers' purchased input use intensification, output market participation, and post-harvest loss.

To attain the fundamental aim of this study, the necessary data were collected from both primary and secondary sources. The primary data collection was based on intensive and frequent fieldwork in four districts of the study area. A multistage simple random sampling technique was used to select 500 sample smallholder farmers. A purposive sampling technique was used to select FGD and KII participants. Household sample survey, focus group discussion, key informant interview, and field observation were the most important means of generating primary data. Secondary data were obtained from a range of governmental organizations of which the most important ones were zonal and district level agricultural and rural transport office administrations. Oromiya Bureau of Finance Economic Development and Central Statistical Authority were also essential data sources for this study.

To achieve the intended goal of the study, different statistical techniques, models, theories, and indices were used. Hierarchical multiple regression was used to see the total variation in purchased input use that can be explained by rural transport infrastructure-related variables. Pearson product-moment correlation was used to assess the association between distance to all-weather road and purchased input use. Important factors determining smallholder farmers' probability and intensity of output market participation were characterized by a two-step double-hurdle model. In the first step of the double-hurdle model, probit regression was used to asses factors that determine the binary decision of whether to participate or not in the cereal output market. In the second step of the double-hurdle model, a truncated regression model was used to identify factors that determine the intensity of cereal output market participation. One-way ANOVA and Bonferroni's post hoc tests were conducted to compare the effect of distance to all-weather road, district dummies or location dummies and agro-ecological conditions on the intensity of crop output market participation of smallholder farmers. Likert scale assessment was used to measure smallholder farmers' perception of the severity of farm-level post-harvest loss causing factors. The Tobit model was used to identify factors influencing the extent of farm-level crop post-harvest losses. Stepwise multiple regression was used to identify important rural transport-related variables that predict the agricultural productivity of smallholder farmers.

The results of the analyses reveals that farmers' purchased input use was found to be significantly and negatively related to distance to a major market, distance to all-weather road, distance to farm plot, transport cost, and size of landholding. On the other hand farmers' purchased input use was significantly and positively related to family size, off-farm income, membership in agricultural cooperative, being in Horro district, having an animal cart, and access to a good road. Furthermore, the result showed that rural transport *infrastructure-related variables contributed 13.3% to the prediction of farmers' purchased input use over and above the remaining predictors. Livestock ownership, road quality, cooperative membership, extension visit, production level, and ownership of radio, mobile phone and television had a statistically significant influence on a binary decision (probability) of output market participation at less than 0.05 significance level. Whereas, distance to the nearest market, transport cost, production level, off-farm income, household size and time spent selling crop influenced the intensity of output market participation at less than 0.05 significance level. One way ANOVA results also showed that output market participation intensity of smallholder farmers differs based on their distance to all-weather road, district location, and agro-ecological conditions.*

The Likert scale assessment result revealed that pests (52%), traditional storage facilities (45%), insufficient transportation (38%), bad weather condition (30%), wild animals (21%) and poor marketing coordination (17%) were identified as farmer level crop post-harvest loss causing factors in order of severity. The Tobit model results concerning the marginal effects of the independent variables showed that distance to the nearest market center, transport cost, distance to all-weather road, distance to farm plot, educational status, access to credit, labor reciprocity, crop price condition, storage facilities, and tropical livestock unit were found to be significant predictors of the extent of farm-level crop post-harvest losses at less than 0.05 significance level. The result of stepwise multiple regression analysis revealed that distance to the major market is important in predicting agricultural productivity of smallholder farmers at 5% levels of probability in Abe Dongoro, Amuru, and Hababo Guduru districts. The qualitative analysis results of focus group discussions, in-depth interviews, and observations indicated that women in men headed households do not have the right to control and mobilize local transport modes, and they typically control and mobilize such resources if they are female-headed household.

The results suggest that policies and priorities aimed at improving the rural road infrastructure, market information systems, access to rural transportation services, strengthening farmer cooperative associations and enhancing smallholder asset accumulation are vital to prevent barriers to smallholder farmers' input and output market participation and to enhance their agricultural productivity. To reduce farm-level post-harvest losses and increase farmers' productivity, the result of this research also calls for sound policies and strategies that encourage investment in transport infrastructure and improved rural transport services, formation, and strengthening of farmers' cooperative organizations, farm labor exchange arrangements as a form of indigenous knowledge system, better endowments of livestock resources, development of local market centers and improved storage facilities. To ease rural transport burdens of smallholder farmers in general and rural women, in particular, greater consideration needs to be given to interventions in intermediate means of transport and other load reducing measures.

Keywords: Agricultural productivity; Double-hurdle model; Gender differences; Market participation; Post-harvest loss; Purchased input use; Rural transport; smallholder farmer;Tobit model.

CHAPTER 1: GENERAL INTRODUCTION

1.1 Background of the Study

Globally, about 2.5 billion people earn their livelihood from agriculture (FAO, 2012; World Bank, 2007). To meet the increasing food demand worldwide, world food production must increase by 60% by 2050 as compared to the 2005-2007 food production levels (Ehrlicha & Harte, 2015; Rahman, 2016). Moreover, increasing agricultural production is essential to achieve Sustainable Development Goals (SDGs) of eradicating poverty (SDG1) and ensuring food security (SDG2). That is why, of the entire competing Sustainable Development Goals, world leaders could have agreed on for the year 2030, eradicating extreme poverty and ending hunger should have come first (UNDP, 2016; 2017; Janouskova, Hak, Necas, & Moldan, 2019; Singh, 2016). Therefore, the agricultural sector offers key solutions for development and is central for poverty (SDG1) and hunger (SDG2) eradication.

On the other hand, providing quality, reliable, sustainable and resilient infrastructure for all (SDG9) is another pillar of Sustainable Development Goals (Cook, Huizenga, Petts, Visser, & Yiu, 2017). Accordingly, the UN argued that affordable and equitable transport access for all is a critical issue to support economic development and human well-being (UN, 2015). Therefore, increasing access to rural transport infrastructure can be an important part of a strategy to boost long-term crop production and productivity in agriculture-based economies. It is widely accepted that transport is regarded as an important factor involved in agricultural development all over the world but rural transportation options are generally limited in most parts of the world. Soseco (2016), Motatsa and Mokwena (2014), also highlighted the nexus between rural transportation and rural development and noted that transport is seen as a necessary ingredient in all aspects of economic and social development and it plays a key role in the production and marketing of agricultural commodities.

Concerning the role of transport in economic development, Aklilu (2006) and Okoko (2011) also noted that rural transport is part and parcel of rural economic development. Their intention is that improved rural accessibility is capable of reducing the level of poverty of rural people because of the basic necessities of life will become more accessible and it can reduce the degree of deprivation among rural communities.

Agriculture is one of the cornerstones of rural development in developing countries because it employs 1.3 billion workers representing around 50% of total employment (World Bank, 2007). On top of this, there are an estimated 500 million-plus smallholder farmers in low- and middle-income countries, most of which are small and family-operated and the number of people living in these households were estimated to be 1.5 to 2.5 billion (Lowder, Skoet, & Raney, 2016; Christen & Anderson, 2013; World Bank, 2007). Therefore, one way to increase the productivity of these agricultural workers is to reduce the costs of transport and increase the price received through increased access to transport infrastructure. Furthermore, in the least developed countries, agricultural employment represents as much as 72 percent of total employment (Cheong et. al., 2013). As shown by Andersen & Shimokawa (2006), the problem of poor rural transport infrastructure is particularly severe in the least developed countries. For example, while 73% of the roads were paved in OECD countries in 1990, only 16% were paved in the least developed countries.

In Africa, 70% of agricultural food production is provided by smallholders who, for the most part, have limited access to rural transport infrastructure (IFAD, 2013). As a result, rural transportation holds the key to the rapid development of both natural and human resources in Africa as well. This is so because about 70% of the entire populace or citizenry in the continent live in rural areas (Mwabu & Thorbecke, 2014). According to Barrett et al. (2017) and Kienzle & Sims (2014), lack of roads to access rural areas and farms and its associated negative effect on transport costs of agricultural inputs and outputs are identified as a major constraint in African small-scale agriculture. Furthermore, Mercandalli and Losch (2017) and World Bank (2018) listed poor access to rural transport infrastructure among key factors leading to the low level of agricultural productivity in the continent.

Efficient rural transport infrastructure is essential for agricultural development and poverty reduction in rural areas of Africa. Because the reduced cost of rural transport increases the output price received and input price incurred by smallholder farmers, thus increasing their income and helps to reduce the price of food in the urban areas as well. An efficient rural transport infrastructure also facilitates the distribution of timely agricultural inputs (e.g. fertilizers, improved seeds, insecticides, and pesticides), increases output market participation, and reduces post-harvest losses which in turn increase agricultural production and productivity. However, currently, rural transport infrastructures in most developing countries, especially in Africa, are still far from optimal access. For instance, less than 40% of rural Africans live within two kilometers of an all-weather road (Cook et al., 2017).

Agriculture is a major source of livelihood for an estimated 86% of rural people in sub-Saharan Africa (World Bank, 2007). But, partly due to the existing weak rural transport infrastructure, the average farmer in sub-Saharan Africa produces only one ton of cereal per hectare – less than half of what an Indian farmer produces, less than a fourth of a Chinese farmer's production, and less than a fifth of an American farmer's production (World Bank, 2007; Baiphethi & Jacobs, 2009). Increasing agricultural production and productivity is of critical importance for sustainable and inclusive growth in SSA too. On the contrary, most countries in sub-Saharan Africa are characterized by poor rural transport infrastructure. Yet, it is the world's hungriest area (Sibhatu & Qaim, 2017; Chauvin, Mulangu, & Porto, 2012).

As such, the existing disrepair and deplorable transport infrastructure present a particular challenge to smallholder farmers in sub-Saharan Africa (FAO, 2015; Banjo, Gordon, & Riverson, 2012; Porter, 2007). For instance, the Economic Commission for Africa (2004) argued that transport costs in SSA have been found to be as high as 77 percent of the value of exports. Similarly, according to the study by FAO (2015), the extent of inorganic fertilizer use is considerably lower in SSA (14 kilograms per hectare in 2009–2012) which is lower than Asia (396 kilograms per hectare) and Latin America (159 kilograms per hectare) over the same period. Therefore, the inadequacy of rural transportation facilities in sub-Saharan Africa is a bottleneck to rural development. For example, analysis of historical trends in agricultural productivity and intensification confirms that, compared to other regions, SSA crop productivity, are much lower than in Latin America and Asia (Tadele, 2017; Delve & Benfica, 2016).

Overall, from 2009-2012, within SSA, the levels of average fertilizer use are considerably lower in COMESA sub-region than in the other sub-regions (SADC and ECOWAS). For instance, average fertilizer use per hectare only increased from 7 kilograms per hectare to 10 kilograms per hectare in COMESA as compared to 11 kilograms per hectare to 12 kilograms per hectare in ECOWAS (Delve and Benfica, 2016). Such a low and stagnant rate of input use (improved varieties and fertilizers) has to a great extent to do with the inadequacy of public investments and interventions in rural transport, market and institutional infrastructures.

More than 85% of the Ethiopian population, residing in a rural area, is engaged in agricultural production as a major means of livelihood. Agriculture, which accounts for about 47% of GDP, 80% of export earnings and 85% of employment is the backbone of the Ethiopian economy (Bezabih, 2010). In Ethiopia, as in other countries of sub-Saharan Africa, the condition of rural transport is very weak. This has resulted in a series of challenges in the country. For example, only 30 to 40% of Ethiopian smallholder farmers use chemical fertilizer, and those that do, only apply 37 to 40 kg on average per hectare, which is significantly below the recommended application rates resulting in low farm productivity (Spielman, Kelemwork, & Alemu, 2011).

In Ethiopia, rural transport infrastructure and services have an important role to play in the transformation of subsistence and semi-subsistence production systems into market oriented and commercialized production (International Monetary Fund, 2013). This is because rural transport infrastructure and services are a prerequisite to gain access to productivity enhancing technology and output markets particularly for the small-scale farmers in Ethiopia with little or no capital of their own. Therefore, they are a strategic component of a package of activities for agricultural development (Shimelles & Islam, 2009).

Transformation of Ethiopia’s agricultural sector requires scaling up efforts to increase agricultural production and productivity by among others promoting domestic and foreign investment through agricultural commercialization, increasing public investment in agricultural infrastructure, promoting technology transfer and adoption, ensuring efficient use of land, labor, technology and other inputs, and specifically raising the productivity of smallholder farmers (UNDP, 2013; MoFED, 2010). In Ethiopia, while agricultural productivity per hectare is 1.7 tones of cereals and just above the Sub-Saharan Africa average of 1.5 tones, agricultural production systems are largely agrarian and subsistence with over 65% of the production consumed within the farm household (UNDP, 2013).

To sum up, intensification of modern agricultural input use, increased smallholder output market participation, reduced post-harvest losses, gender balanced access to rural transport infrastructure must be built upon the establishment of efficient and well-functioning rural transport infrastructure that keep transaction costs low and minimize risk which in turn boost productivity, particularly for those living in peripheral areas.

1.2 Problem Statement

Smallholder farmers in developing countries are often at a competitive disadvantage in the wider economy because of persistent market and infrastructural failures. For example, smallholders may face difficulties in selling their small agricultural surpluses and buying inputs because of the prohibitively high transactions costs incurred in assembling, transporting and marketing (Guidi, 2011). In developing countries, smallholder farmers may be unable to access necessary public sector services needed to sustain and improve their livelihoods—services such as input supply, output marketing and credit provision because the state's infrastructure is insufficiently responsive to their needs (Cheong et al., 2013; Spielman, 2008).

Africa lacks sufficient and adequate rural infrastructure to adequately support smallholder famers. According to the findings of Feed the Future (2011), a mere 34% of the continent's rural population have adequate access to rural roads. In addition, the existing road networks are usually in a poor state due to years of neglect and under maintenance. This lack of access to rural transport infrastructure services constrains the Africa's agricultural productivity and limits its market access. For instance, according to the World Bank (2007), the average farmer in Sub-Saharan Africa produces only one ton of cereal per hectare – less than half of what an Indian farmer produces, less than a fourth of a Chinese farmer's production, and less than a fifth of an American farmer's production.

As argued by Delve and Benfica (2016), most of the agricultural production growth observed in SSA can be attributed to expansion of agricultural land rather than through an increase in agricultural productivity per unit area. But, such area expansion cannot continue forever, owing to land use change pressure due to an increasing population and negative environmental impacts. Therefore, SSA needs sustainable investments in rural transport infrastructure to stimulate smallholder farmers' agricultural productivity through increased access to productive assets.

The concern for rural transport infrastructure, agricultural productivity and marketing are particularly relevant in Ethiopia, a country where food insecurity and rural poverty persist despite a range of forward-looking policies and investments in the agricultural sector. In Ethiopia, 37% of smallholder farmers cultivate less than 0.5 hectares, 87% cultivate less than 2 hectares, and only 28% of total agricultural output is commercialized (Spielman, 2008).

In the World Bank's Infrastructure Index, Ethiopia is ranked 52 out of 53 countries and her paved road density is among the lowest in SSA (African Development Bank, 2011). Despite the rapidly growing population, only 17 % of Ethiopia's rural population lives within two kilometers of an all-weather road, compared to 44 % in Kenya and 38% in Tanzania (Bill & Melinda Gates Foundation, 2010). Thus, due to such limited accessibility smallholder farmers have cut off from sources of inputs and output markets. When there is a post-harvest marketable surplus, it is not always easy to reach output markets.

The fragile state of rural transport infrastructures in Ethiopia put severe constraints on agricultural productivity, economic growth and poverty reduction efforts in the country. Taken as a whole, these infrastructure constraints wear down smallholder farmers' productivity by reducing extent of output market participation and input use intensification as well as by increasing their post-harvest losses.

Regardless of the efforts made by the Government of Ethiopia to encourage the adoption of modern and intensive agricultural practices, agricultural productivity in Ethiopia remains exceptionally low. Feed the Future (2011) affirms that the use of inorganic fertilizer and improved seeds is quite limited; only 4.7% of Ethiopian farmers use improved seed, while just 39% use some form of inorganic fertilizer.

Despite Horo Guduru Wollega Zone's high agricultural production potential (CSA, 2016; Lemessa, 2003; Olana, 2006; Tessema & Simane, 2019), it remains one of the country's poorest areas in rural transport infrastructure services (Tessema & Simane, 2019; Goshu, 2016). Amazingly, with the exception of the asphalt road from Mana Begna to Finca'a sugar factory, nowhere in the zone one can find asphalt road networks. Even though a significant number of district capitals in Horo Guduru Wollega Zone (HGWZ) have narrow sandy and gravel type road networks, the majority of remote settlements are linked by poor quality feeder roads, which are seasonal in nature. Many of these areas are difficult to reach during the periods of rains while other rural settlements are totally cut off from any sort of road network.

Most farm households in HGWZ are dependent on traditional forms of transport—walking with goods carried on the shoulder, head or back, and the use of pack animals. Reliance on traditional forms of transport poses a considerable barrier to the development of market economy and locks the farmer households into a subsistence mode of existence and low quality of life from which it is difficult to escape.

1.3 Research Gaps on the nexus between Rural Transport and smallholder Farmer's Agricultural Productivity

Even though rural transport plays an indispensable role in achieving more than half of the Sustainable Development Goals (SDGs), due attention is not given to it in Ethiopia (Aklilu, 2006; Feed the Future; 2011). In spite of the growing importance of rural transport infrastructure in rural development, with some exceptions (e.g. Bogale, 2016; Aklilu, 2006; Dercon et al., 2009), little research has been carried out on rural transport infrastructure in

Ethiopia. For instance, in his recent scholarly work, Bogale (2016) assessed the temporal and spatial socio-economic impacts of road infrastructure development in three selected corridors of Ethiopia. Aklilu (2006) on his part tries to highlight issues related to the role of the transport sector in Ethiopia's economic development. Likewise, Dercon et al. (2009), studied the effect of roads on poverty and consumption in fifteen Ethiopian villages. But there is divergence between these previous studies and the current study in terms of methodology employed and theoretical lens used to investigate the topic under investigation.

Prior transportation researches in Ethiopia have mostly focused on urban transportation problems and practices (Dagnachew, 2011; Schmidt & Melkamu, 2009; Nyarirangwe, 2008, among others), and quite often, the conclusions and policy implications drawn from such urban transportation studies does not fit to the realities of rural transport. This is because interventions that are relevant to rural areas are quite different from urban areas.

Moreover, to the knowledge of the researcher, there is no any empirical research that has analyzed the effect of rural transport on smallholder farmers' agricultural productivity. As far as Horro Guduru Wollega Zone is concerned, it is possible to argue that the area is devoid of necessary rural transport infrastructures. In addition, the effect of the existing deficient rural transport infrastructure on smallholder farmers' agricultural productivity is not empirically measured so far. Thus, it is logical to conduct a study in such area that could contribute to a certain extent in bridging the knowledge gap, as well as in identifying policy implications to solve rural transport related constraints and increase smallholder farmers' agricultural productivity.

Even though rural transport (Ali & Meaza, 2015; Worku, 2011) and agricultural productivity (Stellmacher & Kelboro, 2019; Taffesse, Dorosh, & Asrat, 2011) in Ethiopia have been independently researched, empirical studies that dealt with the relationship between the two is rare. In fact, quite a few research outputs related to the nexus between rural transport and agricultural productivity are produced by Stifel, Minten, and Koro, (2012), Wondemu and Weiss (2012) and Adamopoulos (2018). But, in this research, as opposed to these prior studies econometric models like Tobit and double-hurdle models are employed to explore the interplay between rural transport and agricultural productivity. Thus, this could bridge the methodological gap to research in the field.

This research further tries to argue on the following three points

A) Insufficient rural transport infrastructure is a major bottleneck to achieve the potential benefits gained from agricultural productivity and marketing. Therefore, without significant public investments in rural transport infrastructure (roads, passenger and freight transportation, and intermediate means of transport) and related market institutions, smallholder farmers in Ethiopia will not fully integrate into the process of agricultural commercialization.

B) In Ethiopia, since the possibility of agricultural land expansion is practically impossible due to fast growing population, the only possibility to reduce poverty and meet the country's ever-growing food demand in the coming years is to place greater attention on agricultural productivity enhancement and such an effort will require significant public investment in rural transport infrastructural service.

C) The prioritization of urban and large scale transport infrastructure projects at the expense of rural and small scale transport infrastructure in Ethiopia continues to widen the gaps between the rural and urban areas in terms of the levels of social and economic opportunities.

1.4 Objective of the Dissertation

1.4.1 General Objective of the Dissertation

The principal objective of this study is to explore state of existing rural transport infrastructure in HGWZ, with a particular focus on its availability, accessibility, affordability and quality as well as its effect on smallholder farmers' agricultural productivity and marketing.

1.4.2 Specific Objectives of the Dissertation

To achieve the principal objective, the following specific objectives are identified:

i) To identify the effect of rural transport infrastructure on the intensification of purchased input use by small-scale farmers,

ii) To examine transportation and marketing constraints of smallholder farmers' intensity of output market participation,

iii) To assess rural transport and crop storage induced determinants of cereal crop post-harvest losses,

iv) To investigate rural road accessibility to basic social and economic service facilities and its effect on agricultural productivity,

v) To explore gender differences in access to rural transport infrastructure and its effect on woman's participation in agricultural production.

1.5 Research Questions

In view of the above specific objectives, the following research questions were addressed during the course of this study.

i) To what extent do rural transport infrastructure indicators predict the level of purchased input use among smallholder farmers?

ii) How do the decision and intensity of output market participation are determined by access to rural transport infrastructure and marketing facilities?

iii) What are the key rural transport and crop storage determinants of the extent of cereal crop post-harvest losses at farm-level?

iv) Is there any connection between smallholder farmers' access to rural road transport infrastructure and their agricultural productivity?

v) Are there economic, social and cultural factors in place which determine rural women's /men's travel pattern and to what extent do gender differences determine rural transport modal choice?

1.6 Rationale

The effect of rural transport infrastructure on smallholder farmers' agricultural productivity requires a top priority in Ethiopia as the lion's share of the population in Ethiopia is dependent on agriculture as a source of livelihood (Ethiopian Institute of Agricultural Research, 2016; Minten et al., 2013; Worku, 2011). However, our knowledge of the critical role played by rural transport infrastructure towards the effort of transforming age-old subsistence smallholder farmers' agricultural production is scanty. Even though, increasing agricultural productivity through input use intensification, output market participation and reduced post-harvest losses remains the only realistic option in achieving the desired agriculture sector growth and reduction in rural poverty, rural transport and market challenges that inhibit smallholder farmers' productivity growth are not given due attention in Ethiopia (Admassie, Berhanu, & Admasie, 2017; Rammelt, 2018; Aklilu, 2006).

This research study is in line with the national vision of Ethiopia, because, under the first GTP (2011-2015), the Ethiopian government set out: first, to improve agricultural technologies, particularly seeds; second, to expand rural infrastructure, and the use of modern inputs, including fertilizers and pesticides; and third, to expand rural non-agricultural opportunities to contribute to Ethiopia's achievement of middle income status by 2020. In the second GTP (2016-2020) which is of course the extension of the first GTP (2011-2015), the government of Ethiopia recognized the dynamic role of agriculture and devised key strategies for the sector to promote the intensification of marketable products from both small and large farms for the domestic and export markets (Admassie, Berhanu, & Admasie, 2016).

This goal will be achieved through rural infrastructural development, shift to high value crops and focus on high potential areas for increased commercialization of smallholder agriculture, increased application of inputs, increasing research and extension that will finally expected to increase smallholder farmers' agricultural productivity. However, despite the various supportive measures set forward in both growth and transformation plans, farm productivity in smallholder agriculture remains at a low level and in fact showed a declining trend (Admassie, Berhanu, & Admasie, 2016; Tegenu, 2010).

1.7 Scope of the Study

Rural infrastructure covers a broad range of social, economic, and institutional infrastructures. But this study is confined to rural transport infrastructure alone. Therefore, other rural infrastructure facilities or components like agricultural research, rural electrification, health facilities, irrigation facilities and potable water supply are out of the scope of this study. Concerning smallholder farmers' agricultural productivity, this study is delimited to the study of only three major food crops (maize, wheat, and *teff)*. Therefore, the scope of this research does not include other crops and animal farm enterprises. The interplay between rural transport infrastructure and agricultural productivity is said to be complex, including many explanatory variables that are related to each other in a complex way. Thus, to make it manageable this study focuses only on the most important rural transport indicator variables (distance to the nearest market, distance to all-weather road, road quality, transport cost) and their effect on smallholder farmers' access to input and output market. Similarly, the effect of rural transport infrastructure on the livelihood and food security of smallholder farmers is not within the scope of this study.

With regard to post-harvest losses, in this research, the overall postharvest losses occurring across the entire agricultural value chain are not considered, but only farm-level post-harvest loss is taken in to consideration. Smallholder or farm households are the main units of analysis used in this study. Since the emphasis is on land productivity, the other components of total factor productivity are out of the scope of this study. Finally, this study was geographically confined to four districts of Horro Guduru Wollega Zone. This study is focusing on the current state of effects of rural road transport on smallholder farmers' agricultural productivity

1.8 Limitation of the Study

The limitations of this particular study are mainly two. First and foremost, the most obvious limitation of this study is its cross-sectional design. Indeed, it would have been better to use a longitudinal (time series) study design to robustly capture the impact of rural transport infrastructure investment on smallholder farmers' agricultural productivity. The second limitation of this study lies in the fact that the post-harvest loss estimates of cereals are based on subjective self reported information from smallholder farmers. Indeed, it would have been better to use expert estimates of post-harvest losses incurred during different stages of the post-harvest chain. To overcome these limitations, the researcher has made rigorous attempts to crack the Smallholder farmers' memories about their earlier post-harvest losses at different stages of the post-harvest chain.

1.9 Organization of the Dissertation

This article based dissertation is organized into seven chapters. The first chapter deals with the general introduction part in which background of the study, the statement of the problem, objectives, research questions, justification of the study, significance of the study, delimitation and limitation of the study, and organization of the study are included. The second chapter deals with the effect of rural transport infrastructure on the intensification of purchased input use for major food crop production. Effects of distance to major market, distance to all-weather road, distance to farm plot, transport cost, size of land holding, family size, off farm income, and membership in a farmer cooperative on farmers' purchased input use are discussed in this chapter.

The third chapter discusses transportation and marketing challenges of smallholder farmers' in their way to crop output market participation. Output market participation constraints like fixed and proportional transaction costs are presented in this chapter. Chapter four elaborates the rural transport and storage induced post-harvest losses of major food crops among smallholder farmers. Farm level post-harvest loss characteristics of the three major food crops (wheat, maize and *teff*) and rural transport related factors that determine the extent or intensity of these losses are also treated under this chapter. The fifth chapter deals with the effect of access to rural road infrastructure on smallholder farmers' agricultural productivity. Rural road transport, demographic, socio-economic, institutional, and farm specific characteristic variables that determine smallholder farmers' agricultural productivity are discussed in this chapter.

In chapter six, gender differences in access to rural transport infrastructure and agricultural production is discussed based on qualitatively collected data. Gender differential access to household resources, especially gender biased control over local transport modes for the purpose of agricultural activities is discussed in this chapter. Finally, chapter seven presents the overall summary, conclusion, and recommendations, theoretical and methodological reflections as well as policy implications of the findings.

References

Adamopoulos, T. (2018). Spatial Integration, Agricultural Productivity, and Development: A Quantitative Analysis of Ethiopia's Road Expansion Program. Reference number: F-32404-ETH-1.Working paper, International Growth Center (IGC), York University

Admassie, A., Berhanu, K., & Admasie, A. (2016). Employment Creation in Agriculture and Agro-industries in the Context of Political Economy and Settlements Analysis. Partnership for African Social and Governance Research, Working Paper No. 016, Nairobi, Kenya.

African Development Bank (2011). Federal Democratic Republic of Ethiopia Country Strategy Paper 2011-2015.

Aklilu, Temesgen (2006). The Role of the Transport Sector in Ethiopia's Economic Development. *Economic Focus, 9*(4), 17-52, Ethiopian Economic Association

Ali, Mushir & Meaza, Hailemariam (2015). Geographical Analysis of Road Transportation of Ethiopia. *Ethiopian Journal of Environmental Studies & Management 8(Suppl. 1)*: 846 – 854. doi: http://dx.doi.org/10.4314/ejesm.v8i1.12S

Andersen, P. P., & Shimokawa, S. (2006). *Rural Infrastructure and Agricultural Development*. Paper prepared for presentation at the Annual Bank Conference on Development Economics, Tokyo, Japan, May 29-30, 2006.

Baiphethi, M. N. & Jacobs, P. T. (2009) The contribution of subsistence farming to food security in South Africa. Agrekon, 48(4), 459-482. doi:10.1080/03031853.2009.9523836

Banjo, G., Gordon, H., & Riverson, J. (2012). Rural Transport: Improving its Contribution to Growth and Poverty Reduction in Sub-Saharan Africa, Working Paper No. 93, the International Bank for Reconstruction and Development / The World Bank.

Barrett, C. B., Christiaensen, L., Sheahan, M., & Shimeles, A. (2017). On the structural transformation of rural Africa. *Journal of African Economies, Vol. 26*, AERC Supplement 1, i11–i35. doi: 10.1093/jae/ejx009.

Bezabih, Emana. (2010). Market Assessment and Value Chain Analysis in Benishangul Gumuz Regional State, Ethiopia- Report. SID-Consult-Support Integrated Development. Addis Ababa.

Bill & Melinda Gates Foundation (2010). Accelerating Ethiopian Agriculture Development for Growth, Food Security, and Equity: Synthesis of Findings and Recommendations for the Implementation of Diagnostic Studies in Extension, Irrigation, Soil Health/Fertilizer, Rural Finance, Seed Systems, and Output Markets (maize, pulses, and livestock). Report prepared by the Bill & Melinda Gates Foundation based on the diagnostics reports submitted by the International Food Policy Research Institute, the International Livestock Research Institute, the International Water Management Institute, and the Association of Microfinance Institutions.

Bogale, Belew Dagnew (2016). Socioeconomic Impacts of Road Development in Ethiopia: Case Studies of Gendewuha - Gelago, Mile - Weldiya and Ginchi - Kachisi Roads, PhD dissertation, University of South Africa.

Chauvin, N. D., Mulangu, F., & Porto, G. (2012). Food Production and Consumption Trends in Sub-Saharan Africa: Prospects for the Transformation of the Agricultural Sector. Working Paper 2012-011: February 2012, United Nations Development programme, Regional Bureau for Africa

Cheong, D., Jansen, M., & Peters, R. (2013). *Shared Harvests: Agriculture, Trade and Employment*. International Labour Organization and United Nations.

Christen, R. P., & Anderson, J. (2013). Segmentation of Smallholder Households: Meeting the Range of Financial Needs in Agricultural Families. Focus Note 85. Washington, D.C.: CGAP, April.

Cook, J., Huizenga, C., Petts, R., Visser, C., Yiu, A. (2017). The Contribution of Rural Transport to Achieve the Sustainable Development Goals

CSA [Central Statistical Authority] (2016). Agricultural sample survey: Report on area and production of major crops for private peasant holdings, meher season, Vol. 1. statistical bulletin 584 Addis Ababa, Ethiopia.

Dagnachew, A. B. (2011). Road and urban storm water drainage network integration in Addis Ababa: Addis Ketema Sub-city. *Journal of Engineering and Technology Research, 3*(7), 217-225

Delve, R. & Benfica, R. (2016). Agricultural Productivity through Intensification and Local Institutions. International Fund for Agricultural Development, Africa Agriculture Status Report 2016. Rome, Italy.

Dercon, S., Gilligan, D. O., Hoddinott, J., & Woldehanna, Tassew (2009). The impact of agricultural extension and roads on poverty and consumption growth in fifteen Ethiopian villages. *Amer. J. Agr. Econ.,91*(4), 1007–1021. doi: 10.1111/j.1467-8276.2009.01325.x

Economic Commission for Africa. (2004). Assessing regional integration in Africa: A Policy Research Report, ECA, Addis Ababa.

Ethiopian Institute of Agricultural Research (2016). Post-harvest handling, processing and engineering research strategy (2016-2030), EIAR, Addis Ababa Ethiopia

FAO [Food and Agriculture Organization of the United Nations] (2012). *The state of food and agriculture*. Food and Agriculture Organization of the United Nations, Rome.

FAO [Food and Agriculture Organization of the United Nations] (2015).The economic lives of smallholder farmers An analysis based on household data from nine countries, Food and Agriculture Organization of the United Nations, Rome.

FAO [Food and Agriculture Organization of the United Nations] (2015). FAOSTAT 2015. Rome, Italy: FAO Statistics Division.

Feed the Future (2011). *Ethiopia FY 2011–2015 Multi-Year Strategy*. U.S. Government Document.

Goshu, Firdisa Birru (2016). Determinants of Smallholder Farmers' Participation Decision in *Teff* Production: Evidence from Horo and Jimma Geneti Woreda, Ethiopia. Developing Country Studies, Vol.6, No.10.

Guidi, D. (2011). Sustainable Agriculture Enterprise: Framing Strategies to Support Smallholder Inclusive Value Chains for Rural Poverty Alleviation. CID Working Paper No. 53. Center for International Development at Harvard University.

IFAD [International Fund for Agricultural Development] (2012). Enabling poor rural people to overcome poverty in Ethiopia. Rome, Italy.

IFAD [International Fund for Agricultural Development] (2013). Smallholders, food security, and the environment, Rome: International Fund for Agricultural Development.

Janouskova, S., Hak, T., Necas, V., & Moldan, B. (2019). Sustainable development—A poorly communicated concept by mass media, another challenge for SDGs? *Sustainability, 11* (3181), 1-20. doi:10.3390/su11113181.

Josef Kienzle and Brian Sims (2014). Agricultural mechanization strategies for sustainable production intensification: concepts and cases from (and for) sub-Saharan Africa. Food and Agriculture Organization of the United Nations, Rome

Lemessa, Dechassa (2003). Surplus producing eastern highland parts of Eastern Wellega zone badly hit by current crisis. United Nations Office for the Coordination of Humanitarian Affairs (OCHA) Ethiopia.

Lowder, S. K., Skoet, J., & Raney, T. (2016). The number, size, and distribution of farms, smallholder farms, and family farms worldwide. *World Development* (article in press), http://dx.doi.org/10.1016/j.worlddev.2015.10.041

Mercandalli, S. & Losch, B., eds. (2017). Rural Africa in motion. Dynamics and drivers of migration South of the Sahara. Rome, FAO and CIRAD. 60 p.

Minten, B., Koro, Bethlehem., and Stifel, D. (2013). The last mile (s) in modern input distribution: Pricing, profitability, and adoption. *Agr Econ*, *44*(6), 629–646.

MoFED [Ministry of Finance and Economic Development] (2010). The Federal Democratic Republic of Ethiopia Ministry of Finance and Economic Development: Growth and Transformation Plan (GTP) 2010/11-2014/15. Draft. Addis Ababa.

Motatsa, K.W. & Mokwena, O.H. (2014). Transport and Rural Development: An Overview of the North West Province - The Case of Ngaka-modiri Molema District. Proceedings of the 33rd Southern African Transport Conference (SATC 2014), Proceedings ISBN Number: 978-1-920017-61-3, Pretoria, South Africa.

Mwabu, G. & Thorbecke, E. (2014). Rural Development, Growth and Poverty in Africa. *Journal of African Economies*, *Volume 13*, AERC, Supplement 1, pp. i16-i65.

Nyarirangwe, M. (2008). Harnessing the Utility of Urban Infrastructure Asset Management in Ethiopian Cities: Challenges and opportunities. Proceedings of the 27th Southern African Transport Conference (SATC), 7-11 july 2008, Pretoria, South Africa.

Okoko, E. (2011). Rural transportation and rural development: the instance of Akwapim South district in Ghana. *International Journal of conomic Development Research and Investment*, *2*(3), 10-26.

Olana, Bezuayehu Tefera (2006). People and Dam: Environmental and Socio-economic changes induced by reservoir in Fincha Water shades, Western Ethiopia. PhD Dissertation, Wageningen University, Netherland.

Paul R. Ehrlich and John Harte (2015). Opinion: To feed the world in 2050 will require a global revolution.*PNAS*, *112* (48). pp. 14743–14744. doi:10.1073/pnas.1519841112.

Porter, G. (2007). Transport, (im)mobility and spatial poverty traps: issues for rural women and girl children in sub-Saharan Africa. A paper prepared for the international workshop "Understanding and addressing spatial poverty traps: an international workshop" 29 March 2007, Spier Estate, Stellenbosch, South Africa. Hosted by the Chronic Poverty Research Centre and the Overseas Development Institute

Rahman, M. H. (2016). Exploring Sustainability to Feed the World in 2050. *Journal of Food Microbiology, 1* (1), 7–16. doi: http://dx.doi.org/10.20936/JFM/160102

Rammelt, C. (2018). Infrastructures as Catalysts: Precipitating Uneven Patterns of Development from Large-Scale Infrastructure Investments. *Sustainability 2018, 10*, 1286; doi:10.3390/su10041286.

Schmidt, E. & Melkamu, K. (2009). Urbanization and Spatial Connectivity in Ethiopia: Urban Growth Analysis Using GIS. Development Strategy and Governance Division, International Food Policy Research Institute – Ethiopia Strategy Support Program 2, Ethiopia.

Shimelles T., & Islam, K.M. (2009). Rural financial services and effects of microfinance on agricultural productivity and on poverty. University of Helsinki, Department of Economics and Management Discussion Papers No 37. Helsinki.

Sibhatu, K.T, & Qaim, M. (2017). Rural food security, subsistence agriculture, and seasonality. *PLoS ONE 12*(10): e0186406. doi.10.1371/journal.pone.0186406.

Singh, Z. (2016). Sustainable development goals: Challenges and opportunities. *Indian J Public Health*, *60*:247-8.

Soseco, T. (2016). The Relationship between Rural Accessibility and Development. *JESP, 8 (2)* ISSN (P) 2086-1575 E-ISSN 2502-7115.

Spielman, D. J. (2008). Mobilizing Rural Institutions for Sustainable Livelihoods and Equitable Development: A Case Study of Farmer Cooperatives in Ethiopia: An Overview. International Food Policy Research Institute Addis Ababa, Ethiopia Final Report.

Spielman, D. J., Kelemwork, Dawit & Alemu, Dawit (2011). Seed, Fertilizer, and Agricultural Extension in Ethiopia, Development Strategy and Governance Division, International Food Policy Research Institute – Ethiopia Strategy Support Program II, Ethiopia, ESSP II Working Paper 20.

Stellmacher, T. & Kelboro, Girma (2019). Family Farms, Agricultural Productivity, and the Terrain of Food (In) security in Ethiopia. *Sustainability, 11* (4981). doi:10.3390/su11184981

Stifel, D., Minten, B., & Koro, Bethlehem (2012). Economic Benefits and Returns to Rural Feeder Roads: Evidence from a Quasi-Experimental Setting in Ethiopia. Ethiopia Strategy Support Program II (ESSP II) Working Paper 40. http://www.ifpri.org/book- 757/ourwork/program/ethiopia-strategy-support-program

Tadele, Zerihun (2017). Raising crop productivity in Africa through intensification. *Agronomy, 7* (22). doi:10.3390/agronomy7010022

Taffesse, Alemayehu Seyoum Dorosh, P., & Asrat, Sinafikeh (2011). Crop Production in Ethiopia: Regional Patterns and Trends. Ethiopia Strategy Support Program II (ESSP II) Working Paper No. 0016.

Tegenu, Tsegaye (2010). Reflection on Growth and Transformation Plan (GTP) of Ethiopia 2011-2015

Tessema, Israel & Simane, Belay (2019). Agroecosystem Analysis of Fincha Sub Basin, Blue Nile River Basin, Ethiopia. *Tropical and Subtropical Agroecosystems 22* (2019): 287- 304

UNDP [United Nations Development Programme] (2013). Promoting ICT based agricultural knowledge management to increase production and productivity of smallholder farmers in Ethiopia.

UNDP [United Nations Development Programme] (2016). The 2030 Agenda for Sustainable Development Era. UNDP Support to the Implementation of the 2030 Agenda for Sustainable Development. New York, USA.

UNDP [United Nations Development Programme] (2017). Guidance Note: Data for Implementation and Monitoring of the 2030 Agenda for Sustainable Development

United Nations (2015). Transforming our World: The 2030 Agenda for Sustainable Development, the 2030 Agenda for Sustainable Development.

Wondemua, Kifle & Weiss, J. (2012). Rural Roads and Development: Evidence from Ethiopia. *EJTIR*, *12*(4), 417-439

Worku, Ibrahim. (2011). Road sector development and economic growth in Ethiopia. Ethiopia Support Strategy Program II, International Food Policy Research Institute, Addis Ababa, Ethiopia, 101–14

World Bank (2007). Agriculture for Development. World Development Report, the International Bank for Reconstruction and Development/The World Bank, Washington DC.

World Bank (2018). Poverty and Shared Prosperity 2018: Piecing Together the Poverty Puzzle. World Bank, Washington, D.C. World Bank.

CHAPTER 2: EFFECT OF RURAL TRANSPORT INFRASTRUCTURE ON THE INTENSIFICATION OF PURCHASED INPUT USE: THE CASE OF SMALLHOLDER FARMERS IN HORRO GUDURU WOLLEGA ZONE, WESTERN ETHIOPIA.

Abstract

This study examines the effect of rural transport on smallholder farmers' purchased input use major food crop production. A random sample of 500 respondents was selected and relevant data were collected. Descriptive, correlation, and regression statistics were used to analyze the data. The multiple linear regression analysis revealed that farmers' purchased input use was found to be significantly and negatively related to distance to major market, distance to all-weather road, distance to a farm plot, transport cost, and size of landholding. In contrast, farmers' purchased input use was found to be significantly and positively related to family size, off-farm income, membership in a cooperative, being in Horro district, having an animal cart, and access to a good road. Furthermore, the results of hierarchical multiple regression showed that approximately 82% of the total variation in purchased input use can be explained by the linear combination of all independent variables. Furthermore, the result showed that rural transport infrastructure-related variables, as a set, contributed 13.3% to the prediction of farmers' purchased input use over and above the remaining predictors. The results suggest that improving the rural road infrastructure and access to rural transportation services is vital in encouraging farmers' purchased input use. Therefore, it is recommended that in order to encourage smallholder farmers' use of modern agricultural inputs, rural road transport development is necessary.

Keywords: *Hierarchical regression; Horro Guduru; Intensification; purchased input use; Rural transport.*

Published in:

Tamene, S., Megento, T. L. (2019): Effect of rural transport infrastructure on the intensification of purchased input use for major food crop production: the case of smallholder farmers in Horro Guduru Wollega Zone, Western Ethiopia. AUC Geographica 54(2), 184–197
https://doi.org/10.14712/23361980.2019.15

2.1 Introduction

The achievement of major food crop intensification remains the greatest challenge facing smallholder farmers in developing countries. The poor state of rural transportation network and inefficient logistics continue to hinder agricultural intensifications in Africa (Delaney et al., 2017). The key rural transport infrastructure challenges are inadequate and poor conditions of the rural road network and limited availability of vehicles, which has led to an increase in the cost of transportation further affecting agricultural input prices (Salami et al., 2010). The very poor condition of transport infrastructure, the effect of geographic isolation, high transport costs, and time lost to roadblocks can completely undermine the returns to investments in crop intensification practices (Delaney et al., 2017).

Like in many other sub-Saharan African countries, small-scale agriculture is the most important sector for achieving sustainable household food security in Ethiopia. It accounts for 80% of the working population, 86% of the total foreign exchange earnings, and 48% of gross domestic product (GDP) (Worku, 2011). Increasing use of modern agricultural inputs such as chemical fertilizers and improved seeds remains one of the best hopes for greater agricultural production and productivity of rural Ethiopia, where more than 80% of the population lives (Minten et al., 2013). However, lack of enhanced supply and promotion of improved seeds, organic and inorganic fertilizers and low level of an irrigation system are major obstacles to sustain the agricultural production in the country (Elias et al., 2006).

As a landlocked country with largely non-navigable rivers, road transport plays a significant role in the performance of the Ethiopian economy. In Ethiopia, immature rural transport and other key physical infrastructure have led to high transport costs for agricultural products to the market as well as of farm inputs, reducing farmers’ competitiveness (Fufa & Hassan, 2006; Lulit, 2012). This could be a disincentive to the use of productivity-enhancing agricultural inputs and therefore could discourage smallholder farmer’s major food crop intensification.

Most of the literature on small-scale agriculture market participation concerns only the output side of marketing production (Arethun & Bhatta, 2012; Bekele et al., 2010;

Gebremedhin & Hoekstra, 2008). However, the sustainable marketing of smallholders also requires integration into the input markets (Pingali & Rosegrant, 1995). To bridge the gap in the literature on the marketing participation of rural households on the input side, we analyze the rural transport determinants of purchased modern agricultural inputs use. In Ethiopia, there is relatively large literature dealing with the role of technological innovation and diffusion in increasing agricultural productivity and intensification (Elias et al., 2013; Katungi et al., 2011; Weir & Knight, 2004). Past agricultural research in the country also focused on the impact of improved agricultural technologies on smallholder farm income and its implication for poverty reduction strategies (Hailu 2014; Katungi et al., 2011; Salami et al., 2010).

Although these past studies provided useful information on the trends, patterns, and determinants of agricultural input adoption, rigorous assessments of rural transport constraints on the use of purchased (variable) inputs for major food crop production, as a measure of household commercialization from the input side have rarely been studied in Ethiopia. A better understanding of rural transport constraints that hinders smallholder farmers' participation in agricultural input markets as a buyer is therefore important for designing promising pro-poor agricultural and transport policies that could stimulate the use of modern agricultural inputs and increase small-scale agricultural production. This study aims to fill this knowledge gap and provide quantitative information to empirically address the relationship between smallholder farmers' food crop intensification and rural transport infrastructure. The findings of this research are supposed to be used by different stakeholders involved in rural transport policy, agricultural land use planning, and sustainable food crop production strategies.

The overall objective of this study is to investigate rural transport constraints of major food crop intensification strategies by small-scale farmers in Ethiopia. The specific objectives of this study are to: (1) examine relationship between proximity to all-weather roads and total values of purchased input use among smallholder farmers; (2) determine the extent to which a combination of rural transport infrastructure, institutional factors, resource endowment, and physical factors predict smallholder farmers' purchased agricultural input use; (3)

identify the extent to which rural transport infrastructure (distance to major market, distance to all-weather road, distance to farm plot, transport cost, mode of transport and road conditions) predicts smallholder farmers' purchased agricultural input use, controlling for the effects of demographic, institutional, resource endowment, and physical factors.

2.2 Theoretical Underpinnings of the Study

This study aims to look at the nature and extent of rural transport infrastructure and its effect on modern agricultural input use among smallholder farmers of Horro Guduru Wollega Zone, Western Ethiopia. There are several theories that attempted to explain how rural transport infrastructure investment can bring about economic growth and development (Banerjee et al., 2012; Didenko et al., 2017; Jelilov & Kachallah, 2017; Margarian, 2011; Roland-holst, 2009). Of these multiple theories, "the theory of induced technical and institutional change" was used as relevant theoretical perspective to design the research questions that this study is based on. In addition, this theoretical perspective was used for organizing and interpreting the findings of this study. The theory of induced technical and institutional change provides the structure to define how this particular research will philosophically, epistemologically, methodologically and analytically approached.

Economic historians are increasingly drawing on the theory of induced technical and institutional change in attempting to interpret differential patterns of productivity growth among countries and over time (Ruttan, 2008; Ruttan & Hayami, 1984). Agricultural economists like Hayami and Ruttan (1993, p. 6) argue by saying that in agriculture, changes in the 'relative resource endowments', especially land and labor, induce a derived demand for technological innovations to facilitate the replacement of relatively less scarce and cheap factors for more scarce and expensive ones. For example, when labor is in short supply, there is a tendency for capital in the form of labor-saving machinery to be substituted for human labor. Whereas, in a land-scarce economy, yield-increasing and land enhancing inputs such as fertilizers and improved seeds are substituted for land which in turn depends on the agricultural input market conditions (Hayami & Ruttan, 1985, 1993; Ruttan, 2008).

Moreover, roughly 22 years ago, Ruttan (1996, p. 54) in one of his seminal papers addressed that induced technical change acts to make the ‘scare factor more abundant’.

Induced technical and institutional change theory offers a theoretical understanding appropriate to examine the complex and dynamic relations between rural transport access and smallholder farmers’ purchased input use. When we examine the appropriateness of this theory for understanding the nature of rural transport and purchased input use in the study area, two related realities emerge: first, the effort of promoting the rural agricultural economy and bringing maximum benefits to smallholder farmers needs technical change and innovations to transform the most common and tedious traditional rural transport mechanisms-human porterage (head, shoulder, and back-loading) to improved rural transport means-pack animals and animal drawn carts. Such rural transport improvements brought about by rural transport innovations can enhance the use of purchased input use among smallholder farmers. Second, this theory also acknowledges that improved production technologies (fertilizer and improved seed) as well as improved farm management practices (credit and extension institutions) can play in replacing relatively scarce resources like land and labor.

2.3 Data and Methods

2.3.1 Selection and Description of Study Site

The study is conducted in Horro Guduru Wollega Zone, western Ethiopia. This Zone lies between Latitude 9^{o}10’ N and 9^{o}50’ N and Longitude 36^{o}00’ E and 36^{o}50’ E (Figure 2.1). It has a total land area of 8,097km^2 (CSA, 2011; Tamene & Megento, 2017). Shambu is the capital town of the zone and found 314 km West of Addis Ababa. According to the report of CSA (2011), this zone had a total population of 641,575 of which 50.09% are male and 49.91% are female. According to the same source, about 89% of the population lives in the rural areas driving their livelihoods from agriculture.

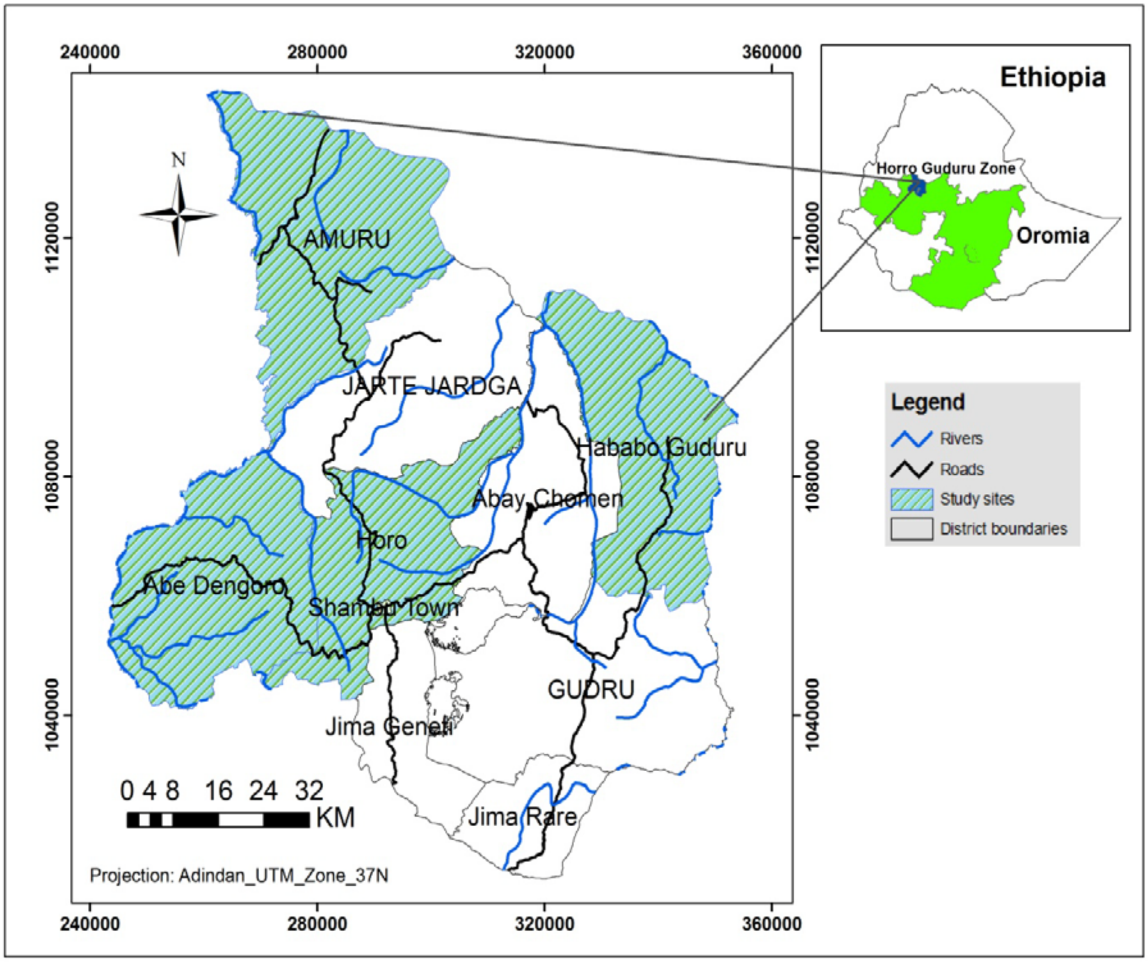


Figure 2.1. Location map of Horro Guduru Wollega Zone.

Source: Adapted from Finance and Economic Development Bureau of Oromia, 2016.

The average annual temperature in the study area is 22.1°C, with an average minimum of 13°C and an average maximum of 30°C (Beyene et al., 2015). The average altitude of Horro Guduru Wollega Zone ranges from 860 to 2657 meters above sea level (Beyene et al., 2015). Mixed crop-livestock agriculture is the mainstay in the study area with notable food crops including wheat (*Triticum aestivum*), barley (*Hordeum vulgare*), *teff* (*Eragrostis tef*), maize (*Zea mays*), pulses (*Vicia faba, Pisum sativum*) and cash crops like sesame (*Sesamum orientale*), niger (*Guizotia abyssinica*), and linseed (*Linum usitatissimum*) (CSA, 2014).

Even though few independent variables used in our previously published article (Tamene & Megento, 2017) are also used in current manuscript, a greater number of independent variables are newly introduced to the current manuscript to emphasize on the originality of this paper. Furthermore, due the following reasons each manuscript has a distinct focus and purpose. First, each manuscript addressed different research questions. Second, each manuscript studies the data from completely different angles. Third, each manuscript used different relevant literature. Fourth, they both differ in their analytic methods, interpretations, and conclusions. Lastly, the dependent variables in both manuscripts are conceptually different and empirically not related. Therefore, the manuscripts should be considered independently.

2.3.2 Study Design, Sampling, Data Collection, and Analysis

The study utilized a smallholder household based cross-sectional quantitative survey design using a structured questionnaire with face to face interview. Descriptive and analytical cross-sectional micro-level data have been used to estimate the effect of rural transport infrastructure on smallholder farmers' purchased input use. Horro Guduru Wollega Zone was identified as one of the potential cereal crop producing corridors of Ethiopia. On the contrary, the existing rural road transport infrastructure in the zone is not satisfactory to support smallholder agricultural production system including the purchases of necessary inputs (Tamene & Megento, 2017). Therefore, Horro Guduru Wollega Zone was purposively selected.

A multistage simple random sampling technique was sequentially employed to select four districts from Horro Guduru Wollega Zone, four rural kebeles (RKs) from each district, and rural farm households from each rural kebele-Kebele is the smallest administrative unit in Ethiopia. The first stage involves a random selection of four districts from the nine districts of Horro Guduru Wollega Zone. As a result, four districts (Hababo Guduru, Horro, Amuru and Abe Dondoro) were selected (Figure 2.1). The second stage involves the random selection of four RKs from each of the four districts making a total of 16 RKs.

The third and final stage was the random selection of farm households with farmland size of 0.25 ha and above from each RK. The list of farm households in each RK was compiled with the assistance of the extension agents and RK managers. According to Gray et al. (2007) suggestion, the researcher used a 95% confidence level to determine the sample size for this specific study. It is usual that RKs may vary considerably in the number of smallholder farmers they contain and hence to avoid bias, probability proportional to size (PPS) was employed. Thus, 500 smallholder farmers from the four districts were sampled for the study. The household survey was conducted from February to June 2016, which followed shortly after the main season (Meher) harvest. Interviews were conducted in places convenient to farmers either at home or in the field.

Two trained assistants, all college graduates in the field of agriculture (most of them development agents) and who had knowledge of the languages of the area, filled the questionnaire by travelling from door-to-door between the 500 household smallholder farmers. On average, the questionnaire took about 45 minutes to an hour for a respondent to respond.

Unfortunately, the year that I undertook the survey for the present study was when Ethiopia in general and the study area in particular was suffering a severe political instability crisis. This lack of peace and stability in the study area has exerted critical challenge to the process of data collection. The other observed challenges during data collection include poor record keeping systems of smallholder farmers and unwillingness of some smallholder farmers to provide financial and other asset ownership related data. To overcome such challenges during data collection awareness creation regarding the aim and potential use of the research outcome was made before and during the data collection process.

Statistical analysis such as descriptive statistics, correlation, and multiple regression with a hierarchical model specification was performed using the Statistical Package for Social Sciences (*IBM SPSS*) software program version 20. To determine whether rural transport infrastructure added significantly to the prediction of smallholder farmers' purchased input use, over and above the variance predicted by demographic, household resource endowment, institutional infrastructure, and location specific variables, the independent variables were entered in to two separate blocks of the regression analysis (hierarchical method). In the first block, all independent variables except rural transport infrastructure related variables (variables of interest) were included in to the regression analysis. At the second step, the new independent variables (rural transport infrastructure related variables) were added, and all of the independent variables (those entered at first block) remain in the independent set to see the unique contribution of rural transport infrastructure related variables in the intensification of purchased agricultural input use.

2.3.3 Description of Variables

The variables of interest (both dependent and independent) used in this study and their levels of measurement are shown in table 2.1. These variables are supposed to capture the influence of the potential independent variables on the purchased input use as a dependent variable.

Table 2.1. Summary of variables used and their measurements

Variable name and type	**Description**	**Measurement**	**Expected sign**
Purchased input use (continuous)	A dependent variable indicating the total amount of birr spent for purchasing agricultural inputs for major food crops	Ethiopian Birr*	
Age of household head (continuous)	Age of household head	Number of years	-
Family size (continuous)	Total family size of the household head	Number	+
Size of land holding (continuous)	Area of farm land owned by the household	Hectare	+
Livestock ownership (continuous)	Tropical livestock ownership of the household	Tropical livestock unit (TLU)	-/+
Off farm income (continuous)	Income earned from non-agricultural activities	Ethiopian Birr*	+
Membership in a cooperative (Dummy)	Being a member of an agricultural cooperatives	1= Yes; 0= No	+
Extension visit monthly (Dummy)	Frequency of extension visit	1= monthly visit; 0= twice in a year	+
Level of annual rainfall (continuous)	Amount of annual precipitation	Millimeter (mm)	-/+
Distance to major market (continuous)	Distance travelled by the household to reach the nearest major market	kilometer	-
Distance to farm plot (continuous)	Average farm plot distance from the homestead	kilometer	-
Distance to all weather road (continuous)	Distance travelled by the household to reach the nearest all weather road	kilometer	-
Transport cost (continuous)	Transport cost incurred to move 100kg of agricultural input over 1 km	Birr per 100 kg per km	-
Animal cart (Dummy)	Transport mode used	1= Animal cart; 0= headloading	+
Good road (Dummy)	Road quality	1= Good road; 0= Bad road	+
High land (Dummy)	Agro-ecology type	1= Highland; 0= otherwise	-/+
Horro (Dummy)	District type	1= Horro district; 0= otherwise	-

Source: Own Development, 2019

*During data collection (2016) 1USD equals 23.73 Ethiopian birr

Rural Transport Infrastructure

It is assumed that a well-functioning rural transportation infrastructure is significant determinants of the form and pace of food crop intensification of smallholder farmers. Smallholder level purchased input use for major food crop production (Y) is therefore modeled as a function of smallholder farmers' access to rural transport infrastructures and services. Access to rural transport infrastructures and services, captured as an average distance to major market, average distance to farm plot, average distance to all weather-road, are expected to be negatively correlated to the total values of purchased input use (Bekele et al., 2010).

Availability of good quality rural access road is considered crucial to improving access to agricultural input markets, resulting in greater use of productivity-enhancing modern agricultural inputs (Jayne et al., 2003). Ownership of Intermediate Means of Transportation for local-level transport services in rural areas is also expected to promote increased use of purchased modern inputs. Hence, household level purchased input use is modeled as a function of distance to major market, distance to farm plot, distance to all weather-road, transport cost, ownership of Intermediate Means of Transportation and road quality.

Demographic Factors

To capture the effects of demographic factors on smallholder farmers' purchased input use, we used the age of household head and family size. It was assumed that older households tend to be more market-oriented and have higher agricultural input market participation. The number of members in the household is also assumed to be very important in the use of purchased input use since the use of such productivity-enhancing inputs are said to be more labor-intensive than conventional subsistence farming.

Household Resource Endowment

Off-farm income, livestock ownership and size of landholding increase the welfare of farmers because they help farmers in getting the required input needed for agricultural production (Abdullah et al., 2017). Purchased agricultural inputs are mainly financed through cash from off-farm activities and livestock sales (Christiaensen, 2017). Therefore, household resource endowment (size of land holding, livestock ownership, and off farm income) are hypothesized to increasingly recognized as a resource that can significantly influence the quantity of purchased input use among smallholder farmers.

Institutional Infrastructure Variables

Apart from household resource endowment and demographic factors several other factors such as the institutional frameworks affect the demand for and consumption of purchased farm inputs such as chemical fertilizers (DAP and urea), improved seeds (maize and wheat) and pesticides. Therefore, the third important set of factors affecting purchased input use among smallholder farmers in rural areas include the institutional infrastructure variables such as membership in a cooperative (Hellin et al., 2009; Markelova et al., 2009) and contact with agricultural extension agents (Belay, 2015).

Physical and location specific-factors

Several environmental variables were hypothesized to encourage/discourage farmers to invest in purchased agricultural input use for major food crop production. These include the amount of annual rainfall received and agro-ecology. The total values of purchased input use and physical factors (amount of annual rainfall received and agro-ecology where a household belongs) are related. It is expected that, on average, smallholder farmers in midland agro-ecology and with sufficient rainfall tend to use more purchased inputs. To capture the differences in purchased input use among study districts, district dummy was considered.

Rural transport infrastructure

Availability of good quality rural access road is also considered crucial to improving access to agricultural input markets, resulting in greater use of productivity-enhancing modern agricultural inputs (Jayne et al., 2003). Ownership of Intermediate Means of Transportation for local-level transport services in rural areas is also expected to promote increased use of purchased modern inputs.

The above described independent variables were entered into a hierarchical linear regression analysis through sequential block-enter approach so as to predict smallholder farmers' purchased input use. The choice of how to include independent variables was determined by researchers based on the overall purpose of the analysis. In the first block of hierarchical linear regression analysis, demographic variables, household resource endowment variables, institutional infrastructure variables, and physical and location specific variables were entered as the first block of independent variables.

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_{10} X_{10} + \varepsilon \qquad (1)$$

Since we are also interested in examining the effect of rural transport infrastructure variables on smallholder farmers' purchased input use after demographic variables, household resource endowment variables, institutional infrastructure variables, and physical and location specific variables have been controlled for, we entered rural transport infrastructure variables (variables of interest) in the subsequent blocks of independent variables in the hierarchical linear regression analysis (block 2). Therefore, to see if the rural transport infrastructure variables predict smallholder farmers' purchased input use above and beyond the effect of the controls and to test if successive model fit better than previous one the following model was developed.

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_{16} X_{16} + \varepsilon \qquad (2)$$

Here in the case of both models:

Y is the financial cost or monetary value of variable inputs (Ethiopian birr),

β_0 is the constant term or the intercept,

β_{1-16} are the regression coefficients associated with respective independent variables

X_1 is age of household head (years),

X_2 is family size (number),

X_3 is size of land holding (hectare),

X_4 is livestock ownership (TLU),

X_5 is off farm income (Ethiopian birr),

X_6 is membership in a cooperative (dummy),

X_7 is extension visit monthly (dummy),

X_8 is level of annual rainfall (mm),

X_9 is high land (dummy),

X_{10} is Horro (district dummy),

X_{11} is distance to major market (km),

X_{12} is distance to all weather road (km),

X_{13} is distance to farm plot (km),

X_{14} is transport cost (Ethiopian birr),

X_{15} is animal cart (Dummy),

X_{16} is good road (Dummy), and

ε is the random error component reflecting the difference between the observed and fitted linear relationship

After fitting a hierarchical linear regression model and computing the parameter estimates some predictor variables are omitted since they are much less important or most likely affect the explanatory power of the model if included.

2.4 Results

2.4.1 Preliminary Analyses

There are a number of assumptions that must be met for multiple linear regression model to be reliable (Osborne & Waters, 2002). Preliminary analysis to ensure the non-violation of the assumptions of normality (Kim, 2015; Miot, 2017; Yap & Sim, 2011), linearity (Osborne & Waters, 2002), homoscedasticity and multicollinearity (Daoud, 2017; Friday and Emenonye, 2012; Imdadullah et al., 2016) were completed prior to the analysis. The preliminary analysis revealed that these assumptions were not seriously violated.

2.4.2 Descriptive Statistics

Descriptive statistics were used to summarize data. Table 2.2 shows a descriptive analysis of continuous variables by presenting numerical facts about the quantitative dataset. The total number of observations (*n*) was 500 smallholder farmers in four districts of Horro Guduru Wollega Zone, Western Ethiopia. The mean score for household size was 6.48, with a standard deviation of approximately 3.31 points, figures which are above the national average of 4.6 persons (CSA, 2017).

The average distance to the nearest major market is about 20.18 km, indicating poor market access of smallholders in the study area, while the average distance to all-weather roads is 12.97 km. The values for skewness and the kurtosis indices are very small and fall within the acceptable range which indicates that the variables most likely do not include influential cases or outliers (see table 2.2).

The average purchased input (chemical fertilizer, improved seed, and herbicides) value used for major food crop production (maize, wheat, and *teff*) is ETB 10096.92. The result also indicates that on average smallholder farmers get about ETB 2416.30 income from off-farm employment. A household on average operates about 2.41 ha (*SD* = 1.18), a result which is two times greater than the national average of 1.14 ha (CSA, 2015; Tamene & Megento, 2017). Finally, on average, households incur a 2.18 ETB to transport one kg of farm input for 100 km from input market center to home.

Table 2.2. Descriptive statistics for continuous variables (n=500)

Variable	Minimum	Maximum	Mean	Std. Dev	Skewness	Kurtosis
Age of household head	17	64	34.29	13.02	.56	-.77
Family size	2	12	6.48	3.31	.19	-1.29
Size of land holding	.4	6.0	2.41	1.18	.45	-.48
Livestock ownership (TLU)	.55	11.51	3.26	1.64	.95	1.59
Off farm income	0	9100	2416.30	2730	.89	-.68
Distance to major market	5	35	20.18	7.87	-.15	-1.16
Distance to farm plot	.4	13.0	6.41	3.38	-.08	-1.07
Distance to all weather road	0	27	12.97	6.76	-.16	-.79
Transport cost	.50	3.20	2.18	.78	-.53	-.74
Purchased input use	717.50	37644.43	10096.9	9357	1.44	1.09

Source: Compiled from field data, 2016

2.4.3 Correlation Analysis

The strongest negative significant Pearson product-moment correlation coefficient for the total values of purchased input use was with the proximity to all-weather roads: $r(498) = -.772$, $p<.001$. Whereas the strongest positive Pearson product-moment correlation coefficient for the total values of purchased input use was with off-farm income: $r(498) = .654$, $p <.001$ (Table 2.3). The simple coefficient of determination ($r^2 = 0.596$) indicated that distance to all weather road explains 59.6% of the variation in total values of purchased input use by smallholder farmers. Approximately, the other 40 % of the total variance between distance to all weather road and purchased input use remains unexplained. This value of simple coefficient of determination shows the binary linear relationship between distance to all weather road and purchased input use in the absence of other independent variables. Thus distance to all weather road seems to explain a significant amount of variation in purchased input use.

Table 2.3. Pearson correlations of purchased input use (dependent variable) and independent variables

Independent Variables	Correlation coefficient (r)	P value
Age of household head (years)	-.419**	.000
Family size (no)	.571**	.000
Size of land holding (ha)	-.416**	.000
Livestock ownership (TLU)	.263**	.000
Off farm income (ETB)	.654**	.000
Distance to major market (km)	-.745**	.000
Distance to farm plot (km)	-.467**	.000
Distance to all weather road (km)	-.772**	.000
Transport cost (ETB)	-.727**	.000
Level of annual rainfall (mm)	.114*	.011

n= 500 ; ***P*<.001 (2-tailed) and **P*<.05 (2-tailed)

Source: Compiled from field data, 2016

2.4.4 Hierarchical Multiple Regression

A multiple regression analysis was conducted to examine whether rural transport infrastructure, institutional factors, resource endowment, and physical factors could significantly predict smallholder farmer's purchased input use. The results of multiple regression analysis using all sixteen independent variables are summarized in table 2.4 of model 2. A strong relationship between purchased input use and the independent variables was observed and the model was a significant predictor of purchased input use (R^2 =.822, F(16, 483) = 138.95, p< .001).

The multiple coefficient of determination (R^2) value of 0.822, indicates that approximately 82.2% of the total variation in purchased input use can be accounted for by the linear combination of explanatory variables. But the remaining 17.8% of the variance has been attributed to other variables not included in the model and disturbance term. The adjusted R^2

value is 0.816, which is very close to the multiple R^2, indicating that we shouldn't worry too much about whether we are using too many variables in the model.

Rural Transport Infrastructure

The estimated unstandardized regression coefficients displayed in table 2.4 showed the relative importance of each predictor in the model. Among rural transport infrastructure variables, transport cost was the strongest negative predictor as indicated by its estimated unstandardized regression coefficient, (β = -3707.88, p <. 001) followed by good road dummy (β = 1832.57, p< .001) and animal cart dummy (β = 1090.49, p<. 05). The unstandardized regression coefficients for the association between distance to major market, distance to all weather road and distance to farm plot on one hand and smallholder farmers' purchased input use on the other hand are -160.57, -316.43 and -215.48 respectively; the associated standard errors for these regression coefficients are 46.67, 50.34 and 61.13 respectively.

Household Demographics

The results of the regression model showed that family size is an important factor identified to influence purchased input use (β = 189.18, t(485) = 2.29, p = .02).

Household Resource Endowment

Size of land holding significantly predicted purchased input use, β = -1070.48, t(485) = -4.35, p< .001. Off-farm income is positively associated with total values of purchased input use such that, holding everything else constant, for each additional ETB off-farm income, the total values of purchased input use is predicted to increase by .81 ETB, and this association is statistically significant (p < .001).

Institutional Infrastructure Variables

As can be seen in table 2.4, membership in a cooperative had a significant positive regression coefficient, indicating smallholder farmers who are members of cooperative associations were expected to invest ETB 1457.59 more than the nonmembers, after controlling for the other variables in the model, and this result is statistically significant (p = .002).

Location Specific Factors/District Dummy

The value associated with being a farmer living in Horro district is ETB 3379.73 (adjusting for the other variables in the model), and the coefficient on this dummy variable is both positive and statistically significant ($p < .001$).

The Unique Contribution of Rural Transport Variables to Purchased Input Use

The percent of the variability in the purchased input use that can be accounted for by all the predictors together is 82.2%. This is a significant contribution and hence is an excellent model. The change in variance accounted for (ΔR^2) was equal to .689 - .822 = .133, which was significantly different from zero $F(6, 483) = 59.76$, $p < .001$. In this case, the percentage of variability in purchased input use accounted for went up from 68.9% to 82.2%. The F change associated with R^2 change of .133 is statistically significant showing that adding rural transport infrastructure variables to the model increases the model's predictive capacity. This is to mean that rural transport infrastructure explained additional 13.3 % of the variance in purchased input use, after controlling for the possible effects of potential confounding variables [ΔR^2=0.133, ΔF (6, 483)=59.764, p<0.001].

Table 2.4. Hierarchical Regression for variables predicting purchased input use (n = 500)

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	22750.229	11824.431		1.924	.055
	Age of household head	-98.328	23.189	-.137	-4.240	.000
	Family size	651.186	102.507	.230	6.353	.000
	Size of land holding	-2572.812	288.302	-.325	-8.924	.000
	Livestock ownership (TLU)	577.724	205.493	.101	2.811	.005
	Off farm income	1.240	.113	.362	10.989	.000
	Membership in a cooperative	2801.652	602.726	.145	4.648	.000
	Extension visit monthly_Dummy	571.666	542.847	.027	1.053	.293
	Level of annual rainfall (mm)	-8.864	7.432	-.038	-1.193	.234
	High land_Dummy	2078.012	725.521	.100	2.864	.004
	Horro_Dummy	1046.011	611.352	.044	1.711	.088
2	(Constant)	22594.157	10233.971		2.208	.028
	Age of household head	-7.988	18.552	-.011	-.431	.667
	Family size	189.180	82.571	.067	2.291	.022
	Size of land holding	-1070.479	246.050	-.135	-4.351	.000
	Livestock ownership (TLU)	38.776	168.814	.007	.230	.818
	Off farm income	.812	.092	.237	8.848	.000
	Membership in a cooperative	1457.595	467.319	.076	3.119	.002
	Extension visit monthly_Dummy	722.301	424.473	.035	1.702	.089
	Level of annual rainfall (mm)	1.000	6.519	.004	.153	.878
	High land_Dummy	-269.070	574.761	-.013	-.468	.640
	Horro_Dummy	3379.733	492.646	.142	6.860	.000
	Distance to major market	-160.575	46.674	-.135	-3.440	.001
	Distance to all weather road	-316.427	50.336	-.229	-6.286	.000
	Distance to farm plot	-215.478	61.132	-.078	-3.525	.000
	Transport cost	-3707.879	380.257	-.310	-9.751	.000
	Animal cart_Dummy	1090.493	548.139	.044	1.989	.047
	Good road_Dummy	1832.569	457.855	.096	4.003	.000

a. Dependent Variable: Purchased input use

Note. R^2 = .689 for model 1, R^2 = .822 for model 2 and ΔR^2 = .133

Source: Compiled from field data, 2016

2.5. Discussion

2.5.1 Family Size and Purchased Input Use

The results of hierarchical multiple regression revealed a positive relationship between family size and purchased input use indicating that large families spend more on purchased input use as compared to small families. There are many prior research findings that explain how the number of family members' influences purchased input use decisions of smallholder farmers. For example, Nambiro (2008) found a significant positive effect of family size on the proportion of farm allocated to the cultivation of improved hybrid maize seed. Another study by Kamara (2004) and Perz (2003) found availability of family labor as a precondition for greater use of chemical fertilizers, pesticides, and improved seeds. Therefore, labor-augmenting technologies are important to encourage small families so that they can take part in input market participation. As a result, this finding supports induced technical innovation theory that agricultural equipment designed for use in small farm plots make it feasible for farmers to shift from labor-intensive practices to higher-yielding mechanized practices (Hayami & Ruttan, 1993).

2.5.2 Household-level Asset Variables and Purchased Input Use

Landholding

This study found a negative and statistically significant relationship between farm size and smallholder farmer's purchased input use. Past studies have found a mixed result. For instance, the largest share of households renting mechanization is more likely related to large farming size (Diao et al., 2016; Ma et al., 2018)**.** In addition, Ma et al. (2018) investigated the determinant role of increased farmland values on the level of supplementary feed used for dairy production**.** Kiplimo and Ngeno (2016) and Hung et al. (2007) also found a negative relationship between a continuous reduction in farm size (farm fragmentation) and farm household level input use. In contrary to these findings, FAO (2015) found the use of seed and fertilizer technologies to be scale-neutral, which is their use intensity, does not depend on farm size. FAO further underlined that, since fertilizer is 'a land augmenting input', smallholders use it intensively, probably to substitute for land (p. 10). Our finding goes in line with FAO's finding supporting the theory of induced technical innovation which advocates the need to substitute the relatively less scarce and cheap factors of production (fertilizer) for more scarce and expensive ones (land) (Hayami & Ruttan, 1985; Hayami & Ruttan, 1993).

Off-farm Income

The study revealed that income from off-farm sources positively influenced the application of complementary inputs such as fertilizer, pesticides, and high yielding seed varieties. This is because off-farm income was an important source for smallholder farmers to increase their market access to agricultural inputs to intensify production. Findings of this study are in line with those of Dahal et al. (2007), who concluded that off-farm income earning opportunities drive smallholders towards agricultural intensification. Kamara (2004) also found that farmers' access to adequate and sustainable off-farm income has a significant effect on their use of modern agricultural inputs. Moreover, in their seminal work, Lim-Applegate et al. (2002) pointed out the significance of off-farm employment as a source of income for Australian farm families.

2.5.3 Cooperative Membership and Purchased Input Use

Membership in agricultural cooperatives is among the variables that determine the propensity of smallholder farmer's participation in the agricultural input market. In this research, it was expected to have a positive influence. Accordingly, membership in farmer cooperatives was found to significantly influence the level of participation in agricultural input marketing. There are several points that help us to maintain this view. Firstly, agricultural cooperatives play a pivotal role in subsidizing fertilizer and seed distribution. Secondly, participating in farmer organizations has the potential to secure better prices for produce. And thirdly, they also play a key role in improving farmer's access to technical advice. The results thus obtained are compatible with previous studies. For instance, in their research findings, Birachi et al. (2011) indicated that membership to cooperative society was the significant driver of agricultural commercialization among food crop farmers in Burundi. Furthermore, Carrer et al. (2018) found significant and positive relationship between participation in pools (cooperatives) and the adoption of forward contracts among citrus growers in the State of Sao Paulo, Brazil.

2.5.4 Rural Transport Infrastructure and Purchased Input Use

Distance to Major Market

Access to agricultural input markets is expected to be negatively correlated with the total values of purchased input use. It is, therefore, hypothesized that reduced distance to major market will positively affect smallholder farmers' purchased input use. As expected, there was a negative and significant association between distance to the nearest major market and total values of purchased input use. The current results confirmed the hypothesis that farmers with reduced physical distance to input markets have a higher probability of using modern agricultural inputs than those who are remote (Hailu & Fana, 2017). This is partly because the costs of obtaining agricultural inputs increase more quickly with increased distance to input supply centers. This finding also corroborates the ideas of Nin-Pratt (2016) and Katungi et al. (2011), who suggested that greater access to urban markets increases the intensity of input use and productivity in the rural sector.

Distance to Farm Plot

As expected, the regression result showed that plot distance from the homestead has a negative and significant relationship with total values of purchased input use. It may be the case therefore that the more remote the farm plot from farmer's residence, the lesser would be the probability of purchased agricultural input utilization. This result is in line with the findings of a great deal of the previous work in this field. For instance Hailu et al. (2014) found a statistically significant negative relationship between plot distance from the homestead and probability of chemical fertilizer adoption decision. By using a dataset from Ghana, Kotu et al. (2017) also found that plots located adjacent to the homestead are more likely to adopt sustainable agricultural intensification practices than the more distant ones.

Distance to all Weather Road

The current study found a negative and statistically significant association between distance to all weather road and total values of purchased input use. It is evident that the cost of transport is determined by taking account of road roughness and seasonality. All weather road were reported from earlier studies to be an important variable which explains variations in purchased input use. For example, in Madagascar, Ninnin (1997) reported that dry season fares were less costly than wet season fares. By using data drawn from longitudinal Ethiopian Rural Household Surveys, Wondemu and Weiss (2012) also reported that improving the class of rural roads to a degree that allows all-weather road access sharply increases average household income. They further established that with the equal level of farmland ownership, having paved road access allows a smallholder farmer to generate 82% higher income than would be the case with poor access road. Using cross-sectional data, Beshir (2014) also examined the factors that affect the probability of improved forage seeds adoption in two districts of South Wollo zone, Ethiopia. He found a negative and statistically significant relationship between distance to all weather road and the probability of adoption and intensity of use of improved forage seeds.

Transport Cost

The coefficient of transport cost incurred had the expected negative sign and significant effect on the total values of purchased input use (see table 2.4). This is because, on the whole, it has been established that there is a strong correlation between transport cost incurred and the ability of smallholder farmers to purchase and use modern agricultural inputs. This finding is consistent with previous studies of Kotu et al. (2017), who reported that because of inefficient input markets characterized by high transaction and transport costs, in Ghana, farmers mostly pay higher than official prices for nitrogen, phosphorus and potassium (NPK) fertilizer. In another study in Australia, Freebairn (2003) reported that Australians who live in remote rural areas will incur additional transport costs to get access to some services offered in large urban areas. Similarly, according to Wondemu and Weiss (2012), high input prices due to lack of infrastructure, such as underdeveloped rural road networks have led to high transport costs for farm inputs, thus holding back farmers' demand for purchased input use.

Mode of transport

The survey showed a marked variation in the purchased input use among smallholder farmers by type of transport mode owned and used. This research found that an improvement in the mode of rural transport use from head-loading to animal cart will result in an additional 1090.493 birr investment in purchased input use by smallholder farmers. The supply of agricultural inputs was expected to increase substantially with the increased probability of modal shift. The overall efficiency of the transport mode used can seriously affect access to farm inputs. As a result, with respect to transport mode owned and used, modern input use was expected to be higher for smallholder farmers who owned animal cart as compared to those who use the various methods of human porterage (head, shoulder, and back-loading). Our finding reveals that ownership of pack animals is the most deriving factor for input market participation where the difference in purchased input use was seen among those who own and not.

Past empirical findings suggested that limited access to an improved mode of transport that helps to move farm inputs from input delivery center to homestead and from homestead to farm remains a major challenge for smallholder farmers (Hine, 2004). According to Zewdie (2015), those households who face binding transport constraints may be unsuccessful to afford the maximum desired levels of input use. The traditional mode of transport like human porterage negatively affected the level of input use for agricultural production in Nigeria (Akramov 2009; Orakwue et al., 2015). Yet, the use of improved inputs, such as fertilizer and improved seeds is very low among those smallholders who do not own transport animals as compared to those who own the same. In Ethiopia too, transport mode choice is said to be an increasingly important area in getting access to agricultural inputs for smallholder farmers (Kassa, 2014).

Road Condition

Linking smallholder farmers with a good road network was found to be positive and significant in access to and utilization of purchased farm inputs. If all other variables are controlled, a good road condition, as opposed to bad road condition, will result in an additional ETB 1832.569 investment in purchased input use by smallholder farmers. This current study further showed that a good road system from input market to the farms would allow easy and timely access to purchased inputs. This might also partly explain why good-quality roads (paved roads) provide a good stimulus to farm profitability and productivity of the rural economy.

A study by Quan (2009) showed that good physical connections to input markets are a fundamental enabler for smallholder farmer's purchased input use. He further showed that good road access being paramount for farm input commercialization through new technologies that increased the yield of basic food crops. Another recent study in Kenya and Tanzania by Bradbury et al. (2017) explicitly revealed the poor accessibility challenges that smallholder farmers experience in getting agricultural inputs from the market to the farms. In their examination of the transport costs and access constraints for well connected and remote rural farmers of Kenya and Tanzania, they found that smallholders who are linked by a network of unclassified, earth access tracks that are poorly maintained and mostly impassable during the rainy seasons are less likely to use purchased inputs than those who are connected to good road networks linking farming areas to major markets.

2.6 Conclusion and policy implications

It is incontestable that rural road connectivity and rural transport services are among the key components for rural development, as it promotes access to economic and social services, stimulating the demand and consumption of purchased agricultural inputs that in turn enhance production and productivity of the farmers. To this end, this study revealed that size of land holding, distance to major market, distance to all-weather road, distance to farm plot, transport cost have a significant negative relationship with purchased input use. Whereas family size, off-farm income, and membership in a cooperative are found to be significant and positively related to smallholder farmers' purchased input use.

Two important policy implications emerged from the study: First, to free smallholder farmers from a vicious cycle of subsistence production, policy reforms in the area of rural infrastructure, access to input markets and to credit facilities must be the central government and local government's rural development top priority. Second, input use intensification need a close policy follow-up so as to enhance production and productivity of farmers. Hence, a policy-mix that can increase smallholder farmers' off-farm income is desirable as income is a critical predictor of improved seed and fertilizer use.

2.7 Limitations and future research directions

First and foremost, the most obvious limitation of this study is its cross-sectional design. This limitation calls upon future research to adopt a longitudinal (time series) study approach to robustly capture the impact of public infrastructure investment towards determining the exact role of rural transport infrastructure in purchased input use. Second, the environmental and health costs of modern agricultural input use were overlooked by this study; therefore, future research concerns should consider a more in-depth analysis of the impact of modern agricultural input use on environmental quality. To measure smallholder farmers' purchased input use intensity, the total financial cost (monetary value) of variable inputs was used. Purchased input use in this study is therefore refers to the quantity of money that smallholder farmers spent on major food crop variable inputs (chemical fertilizer, improved seed, and pesticides) in 2015/16 crop production season. Indeed, in order to estimate the extent of purchased input use we used information on quantity of variable inputs used and the prices at which they are purchased. Since the effect of agricultural input use on farmers' productivity is not the concern of this paper, it can be another potential area for future study.

References

Abdullah, A. R., Ali, S., Chandio, A. A., Ahmad, W., Ilyas, A., & Din, I. U. (2017). Determinants of Commercialization and its impact on the Welfare of Smallholder rice Farmers by using Heckman's two-stage approach. *Journal of the Saudi Society of Agricultural Sciences*, 1–28. https://doi.org/10.1016/j.jssas.2017.06.001

Akramov, K. (2009). Decentralization, agricultural services and determinants of input use in Nigeria (*IFPRI Discussion Paper No. 00941*). Washington, D.C., USA: International Food Policy Research Institute (IFPRI). Retrieved from http://www.ifpri.org/category/publication-type/discussion-papers

Arethun, T. & Bhatta, B. P. (2012). Contribution of rural roads to access to- and participation in markets Theory and results from Northern Ethiopia. *Journal of Transportation Technologies, 2,* 165–174.

Banerjee, A., Duflo, E., & Qian, N. (2012). On the Road Access to transportation Infrastructure and economic. Paper presented at IGC Conference, London.

Bekele, A., Kassa, B., Legesse, B. & Lemma, T. (2010). Effects of crop commercial orientation on productivity of smallholder farmers in drought-prone areas of the Central Rift Valley of Ethiopia. *Ethiop. J. Agric. Sci*, *20*, 16–34.

Belay, K. (2015). Agricultural extension in Ethiopia The case of participatory demonstration and training extension system. *Journal of Social Development in Africa*, *18*(1), 49–84.

Beshir, H. (2014). Factors affecting the adoption and intensity of use of improved forages in North East Highlands of Ethiopia. *American Journal of Experimental Agriculture*, *4*(1), 12–27.

Beyene, B., Hundie, D. & Gobena, G. (2015). Assessment on dairy production system and its constraints in Horoguduru Wollega Zone, Western Ethiopia. *Science, Technology and Arts Research Journal*, *4*(2), 215–221.

Birachi, E. A., Ochieng, J., Wozemba, D., Ruraduma, C., & Niyuhire, M. C. (2011). Factors influencing smallholder farmers' bean production and supply to market in Burundi. *African Crop Science Journal*, *19*(4), 335–342.

Bradbury, A., Hine, J., Njenga, P., Otto, A., Muhia, G.and Willilo, S. (2017). Evaluation of the effect of road condition on the quality of agricultural produce (*Report No. RAF2109A*). United Kingdom: Cardno Emerging Markets (UK) Ltd.

Carrer, M. J., Silveira, R. L. F., & Filho, H. M. (2018). Factors influencing hedging decision: evidence from Brazilian citrus growers. *Australian Journal of Agricultural and Resource Economics,* 1–19. https://doi.org/10.1111/1467-8489.12282

Christiaensen, L. (2017). Agriculture in Africa – Telling myths from facts A synthesis. *Food Policy*, *67*, 1–11.

CSA [Central Statistical Authority] (2011). *Federal Democratic Republic of Ethiopia Central statistical Agency Statistical Abstract*. *Addis Ababa, Ethiopia*.

CSA [Central Statistical Authority] (2014). *Agricultural sample survey: Report on farm management practices for private peasant holdings, Vol. 3. . Addis Ababa, Ethiopia*.

CSA [Central Statistical Authority] (2015). *Key Findings of the 2014/2015 Agricultural Sample Surveys*. The Federal Democratic Republic of Ethiopia Central Statistical Agency. *Addis Ababa, Ethiopia*.

CSA [Central Statistical Authority] (2017). *Ethiopia: Demographic and health survey 2016. Central Statistical Agency, Addis Ababa, Ethiopia and ICF International, Maryland, USA.*

Dahal, B. M., Sitaula, B. K.and Bajracharya, R. M. (2007). Sustainable agricultural intensification for livelihood and food security in Nepal. *Asian Journal of Water, Environment and Pollution*, *5*(2), 1–12.

Daoud, J. I. (2017). Multicollinearity and regression analysis. *Journal of Physics: Conference Series 949*, 1–6.

Delaney, S., Livingston, G., & Schonberger, S. (2017). Right place, right time Increasing the effectiveness of agricultural development support in sub-Saharan Africa development support in sub-Saharan Africa. *South African Journal of International Affairs*, *18*(3), 341–365.

Diao, X., Silver, J. & Takeshima, H. (2016). *Agricultural mechanization and agricultural transformation (Background Paper for African Transformation Report 2016: transforming Africa's agriculture) International Food Policy Research Institute.*

Didenko, N., Skripnuk, D., Mirolyubova, O. & Radion, M. (2017). Analysis of rural areas development of the region using the adl-model. *research for rural development*, *2*. https://doi.org/10.22616/rrd.23.2017.061

Elias, A., Nohmi, M., Yasunobu, K. & Ishida, A. (2013). Effect of agricultural extension program on smallholders ' farm productivity: Evidence from three peasant associations in the highlands of Ethiopia. *African Journal of Agricultural Research*, *6*(2), 476–487.

FAO [Food and Agricultural Organization of the United Nations] (2015). The economic lives of smallholder farmers: An analysis based on household data from nine countries, Rome, Italy.

Freebairn, J. (2003). Economic policy for rural and regional Australia. *Australian Journal of Agricultural and Resource Economics*, *47*(3), 389–414.

Friday, O. R. & Emenonye, C. (2012). The detention and correction of multicollinearity effects in a multiple regression diagnostics. *Elixir International Journal*, *49*, 10108–10112.

Fufa, B. & Hassan, R. (2006). Determinants of fertilizer use on maize in Eastern Ethiopia: A weighted endogenous sampling analysis of the extent and intensity of adoption. *Agrekon*, *45*(1), 38–49.

Gebremedhin, B. & Hoekstra, D. (2008). Market orientation of smallholders in selected grains in Ethiopia: Implications for enhancing commercial transformation of subsistence agriculture. IPMS (Improving Productivity and Market Success) of

Ethiopian Farmers Project Working Paper No.11. ILRI.

Gray, P. S., Williamson, J. B., Karp, D. A. & Dalphin, J. R. (2007). The Research Imagination: An Introduction to Qualitative and Quantitative Methods. Cambridge: Cambridge University Press. https://doi.org/10.1017/CBO9780511819391

Hailu, B. K., Abrha, B. K. & Weldegiorgis, K. A. (2014). Adoption and impact of agricultural technologies on farm income: evidence from Southern Tigray, Northern Ethiopia. *International Journal of Food and Agricultural Economics*, *2*(4), 91–106.

Hailu, C. & Fana, C. (2017). Determinants of Input Commercialization as Buyers of Agro-chemicals and improved seed Evidence from farm households' of Ambo and Toke Kutaye districts , West Shewa Zone, Ethiopia. *American Research Journal of Agriculture*, *3*(1), 1–14.

Hayami, Y. & Ruttan, V. W. (1985). Agricultural development, the Johns Hopkins University Press, Baltimore.

Hayami, Y. & Ruttan, V. W. (1993). Induced techincal and institutional change evaluation and reassessment: two chapters. *Bulletin Number 93-1*, University of Minnesota Economic Development Center, Minnesota, USA.

Hellin, J., Lundy, M. & Meijer, M. (2009). Farmer organization, collective action and market access in Meso-America. *Food Policy*, *34*(1), 16–22.

Hine, J. (2004). Good Policies and Practices on Rural Transport in Africa Planning Infrastructure and Services (SSATP Working Paper No. 100). Washington, D.C., USA: The World Bank.

Hung, P. Van, MacAulay, T. G. & Marsh, S. P. (2007). The economics of land fragmentation in the North of Vietnam. *Australian Journal of Agricultural and Resource Economics*, *51*, 195–211.

Imdadullah, M., Aslam, M. & Altaf, S. (2016). mctest: An R Package for Detection of Collinearity among Regressors. *The R Journal*, *8*(2), 495–505.

Jayne, T. S. Ã., Govereh, J., Wanzala, M. & Demeke, M. (2003). Fertilizer market development : a comparative analysis of Ethiopia , Kenya , and Zambia. *Food Policy*, *28*, 293–316.

Jelilov, G. & Kachallah, M. B. (2017). The nexus among road transport and the economic growth in Nigeria. *The Journal of Middle East and North Africa Sciences*, *3*(9), 22–29.

Kamara, A. B. (2004). The impact of market access on input use and agricultural productivity : evidence from Machakos district, Kenya, *Agrekon43*(2).202-218.

Kassa, B. (2014). Assessment of factors affecting agricultural production: Evidence from smallholder farmers of Southern Tigray, Northern Ethiopia (master's thesis). Mekelle University, Mekelle, Ethiopia.

Katungi, E., Horna, D., Gebeyehu, S. & Sperling, L. (2011). Market access, intensification and productivity of common bean in Ethiopia: A microeconomic analysis. *African Journal of Agricultural Research*, *6*(2), 476–487.

Kim, N. (2015). Tests based on skewness and kurtosis for multivariate normality. *Communications for Statistical Applications and Methods, 22*(4), 361–375.

Kiplimo, L. B. & Ngeno, V. (2016). Understanding the effect of land fragmentation on farm level efficiency: An application of quantile regression-based thick frontier approach to maize production in Kenya. P*aper presented at the 5th International Conference of the African Association of Agricultural Economists, September 23-26, 2016, Addis Ababa, Ethiopia*.

Kotu, B. H., Alene, A., Manyong, V., Hoeschle-Zeledon, I. & Larbi, A. (2017). Adoption and impacts of sustainable intensification practices in Ghana. *International Journal of Agricultural Sustainability*, *15*(5), 539–554.

Lim-Applegate, H., Rodriguez, G. & Olfert, R. (2002). Determinants of non-farm labour participation rates among farmers in Australia. *Australian Journal of Agricultural and Resource Economics*, *46*(1), 85–98.

Lulit, A. (2012). Impact of Road on Rural Poverty Evidence Form Fifteen Rural Villages in Ethiopia (master's thesis). Erasmus University Rotterdam, Institute of Social Studies (ISS), The Hague, the Netherlands.

Ma, W., Bicknell, K. & Renwick, A. (2018). Feed use intensification and technical efficiency of dairy farms in New Zealand. *Australian Journal of Agricultural and Resource Economics*. https://doi.org/10.1111/1467-8489.12283

Margarian, A. (2011). (2011, July).Endogenous Rural Development: Empowerment or Abandonment ? Paper presented at the 4th International Summer Conference in Regional Science, Dresden.

Markelova, H., Meinzen-dick, R., Hellin, J. & Dohrn, S. (2009). Collective action for smallholder market access. *Food Policy*, *34*(1), 1–7.

Minten, B., Koru, B., & Stifel, D. (2013). The last mile (s) in modern input distribution: Pricing, profitability, and adoption. *Agr Econ*, *44*(6), 629–646.

Miot, H. A. (2017). Assessing normality of data in clinical and experimental trials. *Vasc Bras*, *16*(2), 88–91.

Nambiro, E. (2008). Trends in land use and agricultural intensification in Kakamega, Western Kenya (Doctoral dissertation,Rheinische Friedrich-Wilhelms University, Nairobi, Kenia). Retrieved from http://hss.ulb.uni-bonn.de/diss

Negari, K. I. (2017). Compiled Body of Works in Field Epidemiology. *Ethiopia Field Epidemiology Training Program(EFETP) Addis Ababa University*.

Nin-Pratt, A. (2016). *Agricultural Intensification and Fertilizer Use. In Samuel Benin (Ed.), Agricultural productivity in Africa: trends, patterns, and determinants (pp. 199 -246). Washington, DC : International Food Policy Research Institute.*

Ninnin, B. (1997). Transport et Developpement A Madagascar. French Co-operation Ministry and Malagasy Public Works Ministry, INRETS.

Olana, B. T. (2006). People and Dam: Environmental and Socio-economic changes induced by reservoir in Fincha Water shades, Western Ethiopia. *PHD Dissertation*, *Wageningen*

University, Netherland.

Orakwue, C., Umeghalu, I. & Ngini, J. (2015). Effects of Road Transport on Agricultural Productivity: A Case Study of Ayamelum Local Government Area of Anambra State, Nigeria. *Inter J Appl Sci Engr*, *3*(1), 1–4.

Osborne, J. W. & Waters, E. (2002). Four assumptions of multiple regression that researchers should always test. *Practical Assessment, Research, and Evaluation*, *8*(2), 1–5.

Perz, S. G. (2003). Social determinants and land use correlates of agricultural technology adoption in a forest frontier: A case study in the Brazilian Amazon. *Human Ecology*, *31*(1), 133–165.

Pingali, P. L. & Rosegrant, M. W. (1995). Agricultural commercialization and diversification: processes and policies. *Food Policy*, *20*(3), 171–185.

Quan, T. T. (2009). Transition from subsistence farming to commercial agriculture in Quang Binh province, Vietnam (doctoral dissertation). Lincoln University, Oxford, USA.

Roland-holst, D. (2009). Infrastructure as a Catalyst for Regional Integration, Growth, and Economic Convergence: Scenario Analysis for Asia. In F. Zhai (Ed.), From Growth to Convergence: Asia's Next Two Decades (pp. 108−149). Palgrave Macmillan UK.

Ruttan, V. W. (2008). Induced technical change induced institutional change and mechanism design. Paper presented at the 10th International Workshop on Institutional Economics, Institutions, Technology and their Roles in Economic Growth, University of Hart.

Ruttan, V. W. (1996). Induced Innovation and Path Dependence: A Reassessment with Respect to Agricultural Development and the Environment. *Technological Forecasting and Social Change*, *53*, 41–59.

Ruttan, V. W. & Hayami, Y. (1984). Toward a theory of induced institutional innovation. *The Journal of Development Studies*, *20*(4), 203–223.

Salami, A., Kamara, A. B. & Brixiova, Z. (2010). Smallholder Agriculture in East Africa Trends , Constraints and Opportunities. *Working Papers Series No. 105 African Development Bank, Tunis, Tunisia.*

Tamene, S. & Megento, T. L. (2017). The effect of rural road transport infrastructure on smallholder farmers' agricultural productivity in Horro Guduru Wollega zone, Western Ethiopia. *AUC Geographica*, *52*(1), 79–89.

Vandercasteelen, J., Tamru, S., Minten, B. & Swinnen, J. (2016). Cities and Agricultural Transformation in Africa: Evidence from Ethiopia (Working Paper No. 374/2016). BELGIUM : LICOS Centre for Institutions and Economic Performance.

Weir, S. & Knight, J. (2004). Externality effects of education: Dynamics of the adoption and diffusion of an innovation in rural Ethiopia. *University of Chicago*.

Wondemu, K. A. & Weiss, J. (2012). Rural Roads and Development: Evidence from Ethiopia. *EJTIR*, *12*(4), 417–439.

Worku, I. (2011). Road sector development and economic growth in Ethiopia. *Ethiopia*

Support Strategy Program II, International Food Policy Research Institute, Addis Ababa, Ethiopia, 101–146.

Yap, B. W. & Sim, C. H. (2011). Comparisons of various types of normality tests. *Journal of Statistical Computation and Simulation*, *81*(12), 2141–2155.

Zewdie, T. D. (2015). Access to Credit and the Impact of Credit constraints on Agricultural Productivity in Ethiopia : Evidence from Selected Zones of Rural Amhara (master's thesis). Addis Ababa University, Ethiopia.

CHAPTER 3: TRANSPORT AND MARKETING CONSTRAINTS OF SMALLHOLDER FARMERS' AGRICULTURAL OUTPUT MARKET PARTICIPATION THE CASE OF HGWZ, WESTERN ETHIOPIA

Abstract

This study analyses factors influencing crop output market participation decisions and the intensity of participation among smallholder farmers in Horro Guduru Wollega Zone, Western Ethiopia. The study used cross-sectional farm household-level data collected in 2016 from a randomly selected sample of 500 smallholder farmers. The two-stage decision-making process of output market participation was modeled and analyzed using a two step Double-hurdle econometric procedure. The results showed that fixed transaction costs related to information search, bargaining about the prices and the best periods for selling crop produce and household characteristics such as livestock ownership, road quality, credit access, cooperative membership, extension visit, and ownership of radio, mobile phone and television had a statistically significant influence on binary decision of output market participation. Proportional transaction costs (distance to the nearest market, transport cost) and variables such as time spent selling crop influenced the intensity of output market participation. Whereas, off-farm income, ownership of animal cart, household size and amount of crop production influenced both market participation decision and intensity or extent of participation. One way ANOVA results also showed a statistically significant effect of distance to the nearest all-weather road, district dummy (location) and agro-ecological conditions on crop output market participation intensity of smallholder farmers. The results suggest that policies and priorities aimed at improving the rural road infrastructure, market information systems, strengthening farmer cooperative associations, improving market-oriented extension services, enhancing smallholder asset accumulation, boosting agricultural production and productivity could enhance output market participation and increase the market supply of smallholder farmers.

***Key words**: Double-hurdle model; Horro Guduru; Market participation; Output market; Transaction cost.*

3.1 Introduction

The deprived people in the world are small-scale farmers with meager output market participation and diminished agricultural productivity. Higher output market participation of smallholder farmers could drive their productivity by providing cash flow for working capital, while higher productivity could induce output market participation since smallholders with higher productivity are more likely to have surplus crops to sell. Therefore, increasing either one could help to promote the other (Rios, Masters, & Shively, 2008).

Smallholder agriculture continues to be a strategic sector in the development of most low-income countries like Ethiopia where smallholder agriculture is the leading livelihood activity. The agriculture sector in Ethiopia remains the backbone of the Ethiopian economy in terms of income generation and employment for the majority of households. Agriculture contributes over 48% of Ethiopia's GDP, employs about 80% of the total working population and still accounts for 86% of the total foreign exchange earnings (Worku, 2011). The sector also contributes about 70% of the raw material supply for local industries and is the major source of food for rural and urban consumers in the country (Demeke & Haji, 2014). Furthermore, the Ethiopian agricultural sector is dominated by small-scale farming which accounts for about 97% of agricultural output produced and 96% of the total area cultivated (MoARD, 2010).

In Ethiopia, cereals covered about 78% of the total grain cultivated area of about 11 million hectares in the 2004/05 production season (CSA, 2006). In the same production season, cereals contributed about 85% of total grain production of 12.5 million tons (Gebremedhin & Hoekstra, 2008). Measured in terms of contributions to total cereal production, maize, wheat, and *teff* are the top three most important cereal crops covering for about 27%, 21% and 19% of the proportion of total cereal production respectively (Gebremedhin & Hoekstra, 2008).

Ethiopia has adopted the commercialization of smallholder agriculture as a strategy for its economic transformation through different agricultural growth agenda of the country. In Ethiopia, government and development agencies are confronted with the challenge of bringing about agricultural transformation through smallholder farmers' output market participation. In line with this, the Government of Ethiopia has adopted commercial transformation of subsistence production as the basis of the Agricultural Development-led Industrialization (ADLI) development strategy (Gebremedhin, Jaleta & Hoekstra, 2009; Gebremedhin & Hoekstra, 2008). Therefore, smallholder agricultural commercialization through the improvement of marketing systems, well-coordinated agricultural extension and research systems and promotion of agricultural cooperatives was anchored in the Agricultural Development-Led Industrialisation (ADLI) strategy which was introduced since 1994 (Alemu & Berhanu, 2018).

ADLI strategy was introduced by Ethiopian People's Revolutionary Democratic Front (EPRDF) to ensure the processes of agricultural commercialization to promote growth by increasing productivity in the agricultural sector as well as bringing sustained industrialization in Ethiopia. The ADLI strategy as an agricultural transformation policy was aimed at linking farmers to markets. To this end, to make this development strategy successful, the government has been heavily investing on rural infrastructure, agricultural extension, research and development, rural credit institutions and technology transfer (Agricultural Economics Society of Ethiopia, 2006).

Commercialization of smallholder farming has been reflected in the second Poverty Reduction Strategy Paper for Ethiopia (PRSP), Plan for Accelerated and Sustainable Development to End Poverty (PASDEP) policy agenda which covers the period between 2005/06 and 2009/10 (MoFED, 2010). This plan has set greater commercialization of smallholder agriculture as one of its pillars or major emphasis. According to PASDEP, the transformation from subsistence to a more market-oriented agriculture was planned to be achieve via different interventions like constructing farm to market roads, specialized extension services and development of agricultural credit markets (MoFED, 2006; Teshome, 2006).

In the new Growth and Transformation Plan (GTP) of Ethiopia, promotion of small-scale commercialization is one of the key pillars of the agricultural transformation and development (MoFED, 2014; Gebremedhin, Jaleta, & Hoekstra, 2009; Mussema, Kassa, Alemu, & Rashid, 2013). In line with this, increasing the commercialization level of smallholder farmers was further reinforced in the first Growth and Transformation Plan (GTP I), which covered the period 2010/11 to 2014/15 (MoFED, 2010). Five years later, PASDEP was replaced by the first Growth and Transformation plan (GTP I). The main concern of the first GTP agricultural sector plan was to strengthen the agricultural marketing systems of smallholder farmers and boosting their efficacy of output market participation (Admassie, Berhanu, & Admasie, 2016; Berhanu, 2013).

Growth and Transformation Plan II (2016–2020) was a continuation of Growth and Transformation Plan I (2011–2015) agricultural commercialization activities. One of the components of the ongoing GTP II (2015/16–2020) is to support agricultural production and commercialization of smallholder farmers through rural infrastructure development, institutional strengthening, scaling-up of best practices, and market and agribusiness development (Alemu & Berhanu, 2018). The new GTP II agricultural sector plan puts considerable emphasis on: (1) enhancing the capacity of agricultural cooperative societies and transforming them into market-oriented entities; (2) developing mechanisms to ensure agricultural cooperatives' access to finance capital and encourage them to engage in output commercialization; and (3) expanding agricultural cooperatives' capacity in infrastructure development to enhance product aggregation (Alemu & Berhanu, 2018; Ministry of Agriculture and Natural Resources, 2015).

In spite of all these smallholder market reforms and policy decision efforts of the government of Ethiopia to transform smallholder agriculture from subsistence production to commercial production, performance has been significantly below expectations (National Planning Commission [NPC], 2016; Ademe, Legesse, Haji, & Goshu, 2017).

Although smallholder agriculture in Ethiopia remains the major engine for the growth of rural economies, many studies revealed the low status of smallholder farmers' crop output market participation (Gebremedhin, Jaleta, & Hoekstra, 2009; Muthyalu, 2013; Demeke & Haji, 2014; Ademe et al., 2017). For instance, a study aimed to examine the status of smallholder commercialization in Ethiopia by Demeke and Haji (2014) found that the average crop output market participation was 25% in 2009, indicating moderate crop output market participation. A study on smallholder commercialization and the role of markets in Ethiopia by Negassa and Jayne (1997) also revealed that the proportion of total cereal sales was about 26% of total cereal production. The same study reported that, in Ethiopia, the share of maize, wheat, and *teff* sold by smallholder farmers was about 30, 31 and 28% of the total production of each crop, respectively (Gebremedhin & Hoekstra, 2008**).** Compared with the other countries of Africa, the level of smallholders' output market participation in Ethiopia is said to be low. For example**,** evidence drawn from Kenya indicates that the share of production sold for maize was 40% by 2002 (Friesen & Palmer, 2002 in Alene et al., 2008). In another study in Kenya, it was reported that the amount of marketed surplus for maize was approximately 43% by 2013 (Mather et al., 2013) and 42% by 2015 (Olwande, Smale, Mathenge, Place, & Mithofer, 2013).

Poor marketing skills and limited bargaining power are among the several factors influencing the participation of small-scale farmers in output agricultural marketing. Other barriers that keep resource-poor smallholder farmers in Ethiopia to be subsistence-oriented are proportional and fixed transaction costs (de Janvry et al., 1991; Sadoulet & de Janvry, 1995; Key et al., 2000; Woldeyohanes, 2013). Proportional or per-unit transaction costs are costs related to transferring crop outputs traded to market such as transportation costs, time spent to deliver the product to the market and storage costs (Alene et al., 2008; Woldeyohanes, 2013). Consequently, distance to market centers and associated transport costs as well as ownership of transport means are expected to limit smallholder farmers' output market participation level (Alene et al., 2008; Woldeyohanes, 2013; Jagwe, 2011). Fixed transaction costs, on the other hand, include costs of market information, costs associated with searching for a trading partner, bargaining and supervision costs. Fixed transactions costs are invariant or do not change with the volume of transaction that takes place. According to Nikolaeva and Pletnev (2016) and Jagwe (2011), high fixed transaction costs faced by smallholder farmers can reduce the likelihood of farmers to participate in agricultural produce markets.

Regardless of the significant role that output market participation plays in transforming smallholder farmers' agricultural production, productivity, and welfare, there is a dearth of information about the effects of transportation and marketing costs on output market participation of smallholder farmers. There is also a dearth of information on the level or degree of participation in crop commercialization. This article is aimed at contributing to addressing this gap in knowledge. From the pioneering work by Goetz (1992) till recent years, the literature on smallholder farmers' output market participation has highlighted the role of transaction costs in cash crop market participation (i.e. crops grown almost exclusively for sale) and little attention has been paid to the marketing of staple food grains.

Despite the research on smallholder commercialization in Ethiopia (Demeke & Haji, 2014; Gebremedhin & Hoekstra, 2008; Gebremedhin, Jaleta, & Hoekstra, 2009; Alene et al., 2008), the role of transaction costs in smallholder farmers' output market participation in Horro Guduru Wollega Zone is still unexplored. Despite the income and rural employment benefits of smallholder farmers' output market participation, it has not been studied and quantified in Horro Guduru Wollega Zone. To bridge the gap, this paper focuses on transaction cost related determinants of smallholder farmers' output market participation in Horro Guduru Wollega Zone, Western Ethiopia. Many previous studies used a joint (simultaneous) decision model of market participation or set no boundary between output market participation decision (binary decision- whether to participate or not in output market) and sales magnitude or level (intensity of participation), despite the differences in determinants of the two. Hence, to bridge the gap, this paper looked at determinants of the binary decision to participate or not and the amount transacted separately.

Therefore, this study empirically examines factors that hinder smallholder farmers' output market participation in Horro Guduru Wollega Zone, Western Ethiopia using a more comprehensive farm-level HCI (household commercialization index) to answer the following specific research questions:

1) What are the determinants of smallholder farmers' binary decision to participate or not in the crop output market?

2) What factors determine smallholder farmers' output market participation intensity (the share of the value of crop sold to the total value of crop produced)?

3) Is there a difference in the intensity of output market participation for different geographical locations and agro-ecological conditions?

4) Does smallholder farmers' intensity of output market participation differ across distances from all-weather road?

Given of the above research questions, this paper is devoted to addressing the following specific research objectives:

1) To examine determinants of smallholder farmers' crop output market participation decision
2) To explore the degree or intensity of crop output market participation among smallholder farmers and to identify the determinants of smallholder farmers' crop output market participation.
3) To explore differences in crop output market participation intensity among smallholder farmers by distances from all-weather road
4) To explore differences in crop output market participation intensity among smallholder farmers by geographical location and agro-ecological conditions

3.2 Transaction Cost Theory: Theoretical Base of the Study

In this section, we examine the theory underlying the relationship between transport infrastructure and marketing information on one hand and crop output market participation of smallholder farmers on the other hand. This research was guided by Transaction Cost Theory in conducting an investigation that involves both fixed and variable transaction costs. Transaction Cost Theory was used to justify the research question, organize the collected data, explain the research context and organize the findings and discussions of this study. Thus, Transaction Cost Theory is taken to be one that gives a very clear and precise picture of why some smallholder farmers decide to participate in output markets as sellers while others fail to do so.

Transaction cost theory was first originated in 1937 by Ronald Coase who was considered to be a welfare economist and the founding father of transaction-cost economics (Madhok, 2002). Ronald Coase tried to define the relationship between the firm and the market. As opposed to neoclassical microeconomic theory, according to Buitelaar (2004, p. 2547), in transaction cost theory market exchange is not "frictionless". So, costs are always incurred because of the friction involved in the market exchange process.

As Coase (1937, p. 396) puts it: "the costs of carrying out exchange transactions through the price mechanism will vary considerably as will also the costs of organizing these transactions within the firm". Coase's point is that the level of transactions inside firms can best explain and determine how and why the economic activity was organized within firms and this will further determine the mutual interdependence between production and exchange of firms.

Ronald Coase was awarded a Nobel award in Economics in 1991 for his seminal work on the nature of the firm where he took account of transaction cost theory to examine firms' strategic choices (Martins et al., 2010; Buitelaar, 2004). The other Nobel Prize award in Economics given to Oliver Williamson, in 2009, was also based on the recognition of the significance of Transaction Costs Economics Theory (Martins et al., 2010).

Later on, many transaction-cost theorists (Williamson, 1975; North, 1990b; Williamson & Masten, 1999) extended and enriched this line of thought or perspective to examine organizational structures as rational responses to the presence of transaction costs. For example, Williamson (1975; 2002), in his seminal paper considered transaction cost theory as a vital perspective to understand the role of organizational innovation for firm development. According to Williamson's perspective transaction costs are "the economic counterpart of friction in physical systems" (Williamson, 1985, p. 19). Williamson's point is that firms are considered to be an avoider of negative frictions. In his Nobel Prize Lecture, Oliver Williamson (2009) also addressed that non-marketable assets are a principal cause of transaction costs. Therefore, effective governance of individual transactions is important to economize on transaction costs.

Even though Transaction cost theory has been extensively used in the areas of finance and management disciplines (Baumol, 1986; Gorringe, 1987), there is, however, increasing interest among researchers in fields of agricultural economics to understand how and why transaction costs affect smallholder farmers' participation in agricultural output markets. For example, transaction cost theory is said to be a powerful vehicle to study smallholder farmers' output market participation and is being applied frequently to explain the behavior of smallholder farmers in relation to market participation (Kherallah & Kirsten, 2002; key et al., 2000; Mussema et al., 2013). According to this theory, farmers' decision to participate in markets and the degree of participation are determined by the magnitude of transaction costs.

Transaction cost theory is based on the basic assumption that agricultural output market access is not uniform because of the high transaction costs that smallholder farmers face in their marketing decision process. High transaction costs may extend the price margin between the effective price paid by buyers and the effective price received by sellers and ultimately determine smallholder farmers' marketing decisions. Therefore, Transaction costs are important determinants of output market participation decision (a binary decision) and the amount sold by resource-poor smallholder farmers (continuous decision) on condition that they have decided to participate in output marketing.

Several past studies, such as Goetz (1992), Key et al. (2000) and Makhura et al. (2001), have found high transaction costs as one of the key rationales for smallholder farmers' failure to participate in markets. Such transaction costs that limit or restrict the decision and extent of output market participation include costs resulting from distance from markets, imperfect market information, poor infrastructure, transportation costs due to poor road quality, costs for bargaining procedures in search of market partners, and supervision and incentive costs. Therefore, if these transaction costs rise so high that they surpass the gap between the price at which smallholder farmers would be willing to sell and the price offered by the end-users, then smallholder farmers will be restrained from participating in the output market.

Smallholder farmers incur both fixed and proportional transaction costs in selling their agricultural outputs on markets (Key et al., 2000). Fixed transaction costs are invariant to the quantities of output sold and mostly determine a smallholder farmer's initial decision to participate in the market (Goetz, 1992). They include costs of searching for a marketing partner, costs for price information (negotiating and bargaining costs), supervision and monitoring costs and costs of specifying the output to be marketed. These fixed transaction costs are further influenced by the proximity of the market place and sources of market information.

On the other hand, the variable or proportional transaction costs are those costs that increase proportionally in quantity with the quantities of output sold and mostly determine the intensity or volume of output market participation. In another way, proportional transaction costs determine how much a smallholder farmer sells. Proportional transaction costs include transportation, storage, handling; time spent delivering the product to the market and marketing costs (Henning, 2007; Jagwe et al., 2010). Therefore, smallholder farmers' intensity of output market participation is further influenced by geographic location (distance to market), the price of the output, ownership of means of transport and availability of family labor.

The current research paper used transaction costs theory as a blueprint to illustrate the main arguments of the current study for three main reasons. First, transaction costs are used to better explain why the output market might be missing or incomplete among smallholder farmers. Second, transaction costs theory is one of the leading lines of thought in market participation studies (Key et al., 2000). Third, the behavioral assumption of transaction costs theory has received an increasing amount of attention from a broad range of researchers. Therefore, this research argues that transaction costs are the main obstacles preventing smallholder farmers from participating in output agricultural markets.

In this particular study, transaction cost theory contributes to the understanding of the role of transport and marketing infrastructure in smallholder farmers' output market participation in several ways. In HGWZ, most smallholder farmers are located in remote areas with poor rural transport and market infrastructure, which leads to high transaction costs to sell their crop produce. In addition, these smallholder farmers lack reliable and timely information on crop market prices and potential exchange partners.

3.3. Conceptual Framework of the Study

3.3.1. Definition of Concepts

A) Smallholder Farmers

The four basic concepts underpinning this study are smallholder farmers, output market participation, transport infrastructure, and transaction costs. In scholarly literature, farm size is the dominant way of characterizing smallholder farmers. Chamberlin (2007) for example, defined smallholder farmers based on landholding size, market orientation, wealth status and levels of susceptibility to risk. Even though using landholding size as a criterion to define smallholder farmers is relatively the easiest way of characterizing them, a comparison among countries becomes problematic as farm landholding sizes are often divergent among countries. On the other hand, Hazell, Poulton, Wiggins, and Dorward (2006) viewed smallholder farmers in terms of their limited resource endowments (land, labor, capital, technology, and skills) relative to other farmers in the sector. Therefore, this study defines smallholder farmers based on their limited resource endowments following the definitions of Hazell et al. (2006).

B) Output Market Participation

As illustrated by Barrett (2008), market Participation has two aspects: smallholder farmers participating either as buyers (demand side) or sellers (supply-side). While the demand side market participation of smallholder farmers refers to the input market participation, the supply-side market participation usually refers to the output market participation. Even though agricultural commercialization entails the transition from subsistence-oriented production to increased market-oriented production, market participation and agricultural commercialization are used interchangeably (Abu, 2015).

Rios, Masters, and Shively (2008, P. 4) defined output market participation as “sales as a fraction of total output, for the sum of all agricultural crop production in the household, which includes annuals and perennials, locally-processed and industrial crops, fruits and agro-forestry.” According to them, crop sales index is the ratio of total crop sales to the total crop production i.e the proportion of crop production that is marketed (sold). Hence, the crop sales index would be zero for a smallholder farmer that sells nothing (total subsistence-oriented production), greater than zero for smallholder farmers who made or participated in some kind of crop sale and could be a unity (when 100% of crop production is sold) in a given specified period. Therefore, for the purpose of this study, we adopted the definition of output market participation as given by Rios et al. (2008). Moreover, in our case, Output market participation is defined here in terms of three major food crop sales (maize, wheat, and *teff*) as a fraction of total outputs produced for these three crops in the household.

C) Transport Infrastructure

Transport infrastructure is one of the most important elements of the overall system of economic infrastructure that facilitates the development of connections between local areas within a region and between regions within a country as well as between countries (Skorobogatova & Kuzmina-Merlino, 2017). As defined here, transport infrastructure covers transport vehicles, roads, bridges and intermediate means of transport that form a complex system of delivery of goods, services, and people. As the most important parts of economic infrastructure, transport infrastructure is the fundamental part of the transport system of any region or country. The relationship between transport infrastructure and output market participation are the subjects for discussions in both non-academic and academic circles (Skorobogatova & Kuzmina-Merlino, 2017; Organization for Economic Co-operation and Development (OECD), 2002).

More deeply, Roberts and Thum (2005, p. 10) defined sustainable access to rural transport as "the number of rural people who live within 2 km (typically equivalent to a walk of 20 minutes) of an all-season road as a proportion of the total rural population." In this definition, an "all-season road" is a road that is motorable all year round by the prevailing means of rural transport (often a pick-up or a truck). According to Roberts and Thum rural transport includes rural transport infrastructure, rural transport services, and its quality. Hence, this research also adheres to this definition.

A good transport network is important in sustaining smallholder farmers' output market participation. Well developed transport infrastructure allows reducing the time and cost of transportation, and hence it decreases the risk of post-harvest losses by improving the relative ease and efficiency with which products can be moved from production area to points of sale (Snieska & Simkunaite, 2009; Organisation for Economic Co-operation and Development (OECD), 2002). Improved rural transport can also create a fertile environment for the proliferation of local or village markets that would increase the market participation of smallholder farmers that would finally raise their productivity. Taken together, transport infrastructures are critical to sustainable economic growth and are among factors that determine the level of productivity of an economy.

D) Transaction Costs

As defined by Jagwe (2011, p. 8), transaction costs are “costs incurred in making an economic exchange or the cost of participating in a market.” Jagwe further noted that costs relating to searching and gathering information on agents and goods or services have resulted into high transaction costs in rural areas which hinder smallholder farmers from participating in market effectively. By focusing on fixed transaction costs, Kahkonen and Leathers (1999, p. 4) defined transaction costs as “the costs of dealing with imperfect information”. According to Isinika et al. (2003), smallholder farmers’ output market participation can be affected by transportation costs because in most of the developing countries, rural roads are underdeveloped especially rural feeder roads.

Transactions cost factors are responsible for the significant market failures and barriers to market participation in developing countries (Mmbando et al., 2015). The term transactions costs appear to mean different things to different people. But, for purposes of this study, "transaction costs” shall refer to costs incurred by smallholder farmers when looking for a trading partner, negotiating with them, and transporting the product to the market place. In summary, high transaction costs facing smallholder farmers in developing countries are mostly contributed by high transportation costs due to long distances from rural markets and poor road infrastructures. Such high transaction costs deter entry of small farmers into the output market. In addition, high costs of bargaining and negotiating contracts can also weaken the decisions of smallholder farmers to participate in the market.

3.1.5. Measuring Output Market Participation

This sub-section presents the measurement techniques of output market participation. Output market participation takes many forms and is measured in different ways. Generally, a smallholder farmer's degree of output market participation is conceived of and measured in a number of ways. That means Scholars tend to measure output market participation based on their point of view or the situation at hand. For instance, Gebreselassie and Sharp (2006) measured a household's level of market participation in terms of gross income from crop sales. In another way, according to Kostov and Davidova (2012) output commercialization of smallholder agriculture is measured in terms of the share of crop output sold in the total crop output produced; i.e. the share of the value of output sold in total crop production. Therefore, in their attempt to measure output market participation, Kostov and Davidova measured the HCI as the ratio of the gross value of crop sales by a smallholder farmer to the gross value of all crops produced by the same farmer in the same year expressed as a ratio or a percentage.

Household commercialization index (HCI) as suggested by Rios, Masters and Shively (2008), is being used as a proxy for output market participation to measure the intensity of smallholder farmers output market participation. Household commercialization index measures the extent to which smallholder farmers' crop production is oriented toward the market. The output aspect of market participation indices were, therefore, derived for all smallholder farmer participants and measured along a continuum from zero (for total subsistence-oriented production) to unity (where 100% of production is sold, showing increased output market orientation of smallholder farmers). In the current study, the focus is on output market participation as opposed to the input side market participation.

Musah (2013) and Camara (2017) pointed out the pitfall or downside of using HCI as a measure of the extent of output market participation. These pitfalls include: first, it fails to include the livestock subsector. Second, the HCI value itself could be confusing, since a smallholder farmer who grows only one quintal of crop and sells that one quintal (HCI = 100%) would appear more market oriented than a smallholder farmer who produced 90 quintals and sells 40 (HCI = 44%). But, in developing countries like Ethiopia, where it is more likely to get very large smallholder farmers selling none of their crop output and where it is less likely to get smallholder farmers selling all of their crop output, HCI is a more adequate and appropriate measure of smallholder farmers' output market participation (Musah, 2013). Hence, HCI is therefore used as a proxy for output market participation in this particular research.

The dependent variable (smallholder farmers' output market participation) in this study is constructed through three steps: First, the total value of crop sales was established for the three crops (maize, wheat and *teff*) and derived by multiplying the sale price of each crop by its quantity sold. Second, the total value of crop output produced by smallholder farmer was derived for each crop (maize, wheat and *teff*) by multiplying the quantities produced by the price. Third, the share of crop output sold was calculated as a ratio and a percentage of sales value in the value of the total crop output produced. The corresponding values for crop outputs were expressed in terms of Ethiopian Birr, which is the national currency of the country.

3.3.2 Conceptualization of a Smallholder Farmers' Output Market Participation

This sub-section presents the conceptual framework that help identify and articulate key concepts under study and shows how the various concepts relate to each other. A conceptual framework in research is the researcher's idea on how the research problem will have to be explored. A conceptual framework is basically founded on the theoretical framework (Berman, 2013). It embodies the specific direction by which the research will have to be undertaken and it describes the relationship between and among specific variables identified in the study (Imenda, 2014). The literature on smallholder farmers' marketing decision behavior is very diverse and usually relates to socio-economic, institutional, infrastructure, market and household specific analysis. Smallholder output market participation usually takes a long alteration process from subsistence to semi-commercial and then to a totally commercialized agriculture with the central objective of achieving higher level of agricultural commercialization, thus leading to higher productivity (Osmani & Hossain, 2015).

Since the major objective of the present study is to examine the effect of transaction costs on smallholder farmers' output market participation and intensity of their market integration, household market participation behavior approach appears to present a more adequate conceptual framework. The conceptualization of this study is given in figure 3.1. It identifies transaction cost factors that influence smallholder farmer's discrete decision to participate or not and extent of output market participation.

Although various improvements have been made to the various models of macroeconomic and trade (Barrett, 2008), these models appear less useful in explaining market participation of poor smallholder farmers in developing world. In spite of its conceptual importance, the conventional, top-down macroeconomic and trade model has not been accompanied by systematic empirical analyses and proved insufficient and ineffective to better explain and promote farm-level market participation (Barrett, 2008). So, macroeconomic and trade models fail to capture the real picture in their quest to provide an explanation of smallholder farmers' marketing decision behavior in the developing world. According to FAO (2010), since the core conceptual points in macroeconomic and trade models are far more general to describe poor smallholder farmers' output market participation; it only fits to better resourced smallholder farmers selling into well-integrated markets. Therefore, this calls on a conceptual framework that is simple, micro-level model of household market participation behavior. Accordingly, for this particular research, our conceptual frame work is anchored in the household market participation behavior model.

The model of household market participation behavior was first developed by Strauss (1984, 1986) to account for smallholder production patterns in Sierra Leone, which clearly relies on assumptions of both spatial price transmission and smallholder market participation. Goetz (1992), key et al. (2000) and Barrett (2008) later extended and refined this basic model by separating the decision of whether or not to participate in markets from the decision of how much to sell, conditional on participation.

The conceptual framework adapted in this research (Figure 3.1) is therefore an improvement of Barrett's (2008) and Goetz's (1992) model where the model helps in identifying the role of transaction costs (fixed and proportional) in market participation behavior of smallholder farmers. The model views principle of utility maximization (i.e the utility obtained from selling) as the underlying assumption for smallholder farmer to decide to participate and degree of participation in an output market. The key characteristics of the model are that smallholder farmer’s market access is not uniform because farmers may face different transactions costs to market participation (Barrett, 2008). Thus, the decision and the intensity of participation are informed by multiples of factors.

The behavior of market participation model of farm household also used to articulate the complex set of linkages between the process of smallholder agricultural commercialization and institutional infrastructure, physical infrastructure, household-specific characteristics and household’s productive assets that constrain such process at the farm household level (Barrett, 2008). The institutional infrastructure factors include; extension service information on crop marketing strategies, membership to farmer cooperatives, market information services and access to credit. The physical infrastructure and market access factors include; road accessibility to market, distance to market center, ownership of IMT (pack animal, animal cart, pickup truck), price of outputs, means of transport and road quality. The household-specific characteristics include; marketing experience, household size, output level, educational attainment, years of farming, gender and age. Lastly, the household’s productive assets include; off-farm, non-farm income, livestock ownership and land size. These factors are believed to constrain the process smallholder farmers’ output market participation at the farm household level (Barrett, 2008). The participation leads to the extent of participation (amount of crop output sales) and the extent of participation in turn leads to increased crop productivity.

The model below identifies two major factors as causational factors that influence smallholder farmers’ output market participation decision and degree of commercialization (key et al., 2000; Jagwe, 2011). These factors are namely: fixed transaction costs (costs of searching for marketing partner, costs for price information (negotiating and bargaining costs), supervision and monitoring costs and costs of specifying the output to be marketed) and proportional transaction costs (transportation, storage, handling, time spent delivering the product to the market and marketing). In general, while the discrete decision of smallholder farmers’ market participation is affected by both fixed and proportional transaction costs, the intensity of participation is only affected by the proportional transaction costs (Alene et al., 2008). This implies that for those farmers who decided to participate in crop output marketing, the quantity sold is unaffected by fixed transaction costs.

This conceptual framework illustrates the importance of reduced fixed and proportional transaction costs (or improved transporting and marketing efficiency) in achieving widespread smallholder farmers' output market participation. The model demonstrates that efficient rural development policy and project interventions targeted at removing social, economic, and institutional impediments are necessary to further reduce in these costs (fixed and proportional transaction costs) and stimulate output market participation.

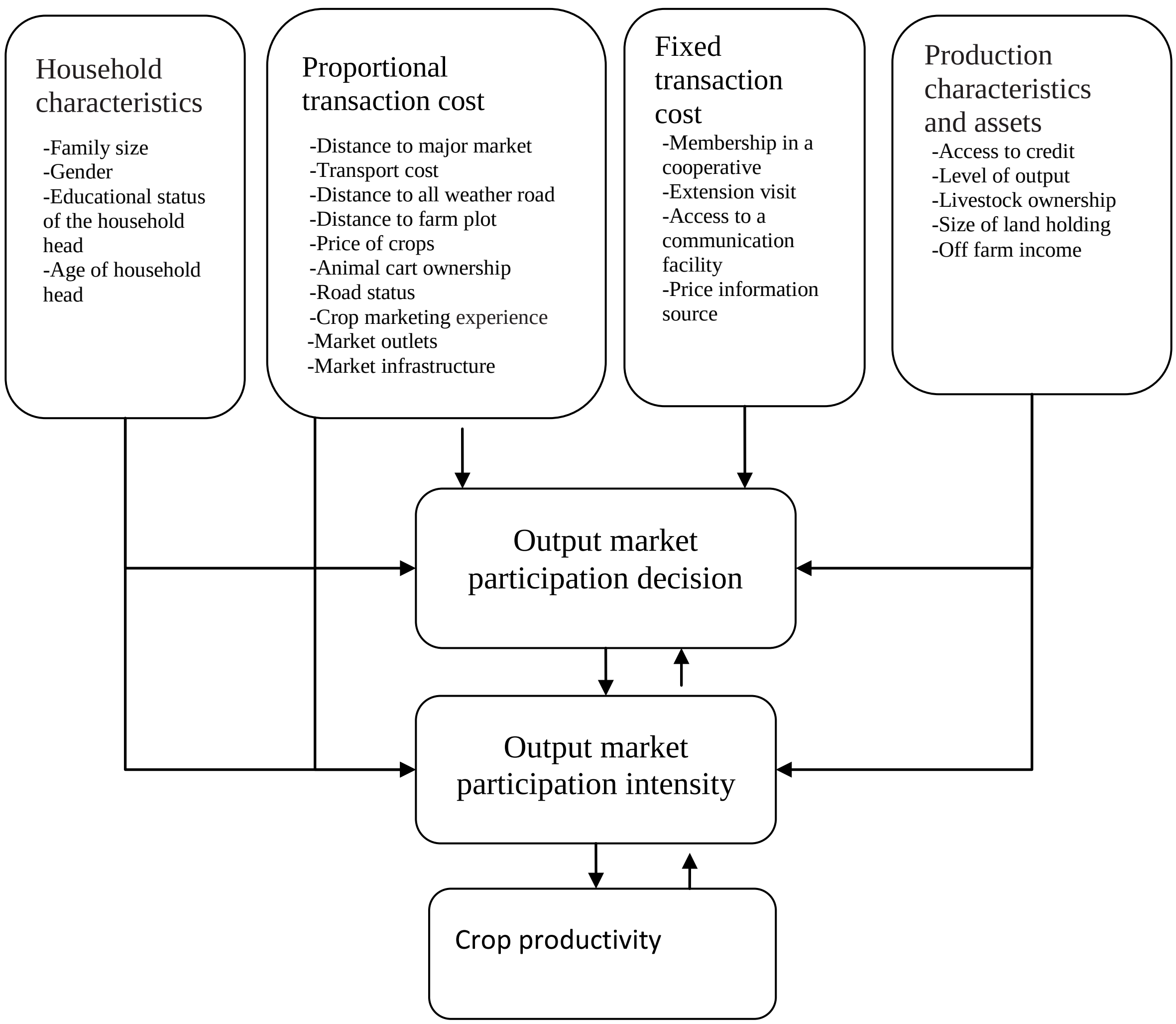


Figure 3.1. Conceptual framework of smallholder farmers' output market participation.
Source: *Author conceptualization.*

3.4. Research Design and Methodology

3.4.1 Study Sites

The study took place in Horro Guduru Wollega Zone, Western Ethiopia. Specifically, the research was carried out in four districts of Horro Guduru Wollega Zone named: Horro, Amuru, Abe Dongoro and Habobo Guduru. Horro Guduru Wollega Zone is located between latitudes 9^0 10' and 9^0 50' north and longitudes 36^0 00' and 36^0 50' east (Figure 3.2). With a size of 8,097 sq km and a total population size of 641,575, this zone is one of Ethiopia's largest major food crop producing areas of the country (CSA, 2011). Maize (*Zea mays*), wheat (*Triticum aestivum*) and *teff* (*Eragrostis tef*) are the dominant staple food crops satisfying the largest share of household‘s calorie intake in the study area. Other staple food crops grown include; sorghum, barley (Hordeum Vulgare), beans (*Vicia faba*), and pea (*Pisum sativum*) (Gurmessa, Tolemariam, Tolera, & Beyene, 2016). In 2017 /18 (2010 E.C) crop production calendar, wheat, maize and *teff* production in Ethiopia's main food crops accounted for 54.02% of total cereal crop area and 59.86% of the total cereal crop production (CSA, 2018), which basically reflected the overall situation of crop production in Ethiopia. Farm level data on major food crop output market participation was obtained primarily from smallholder farmers self-report for 2015 /16 crop production calendar.

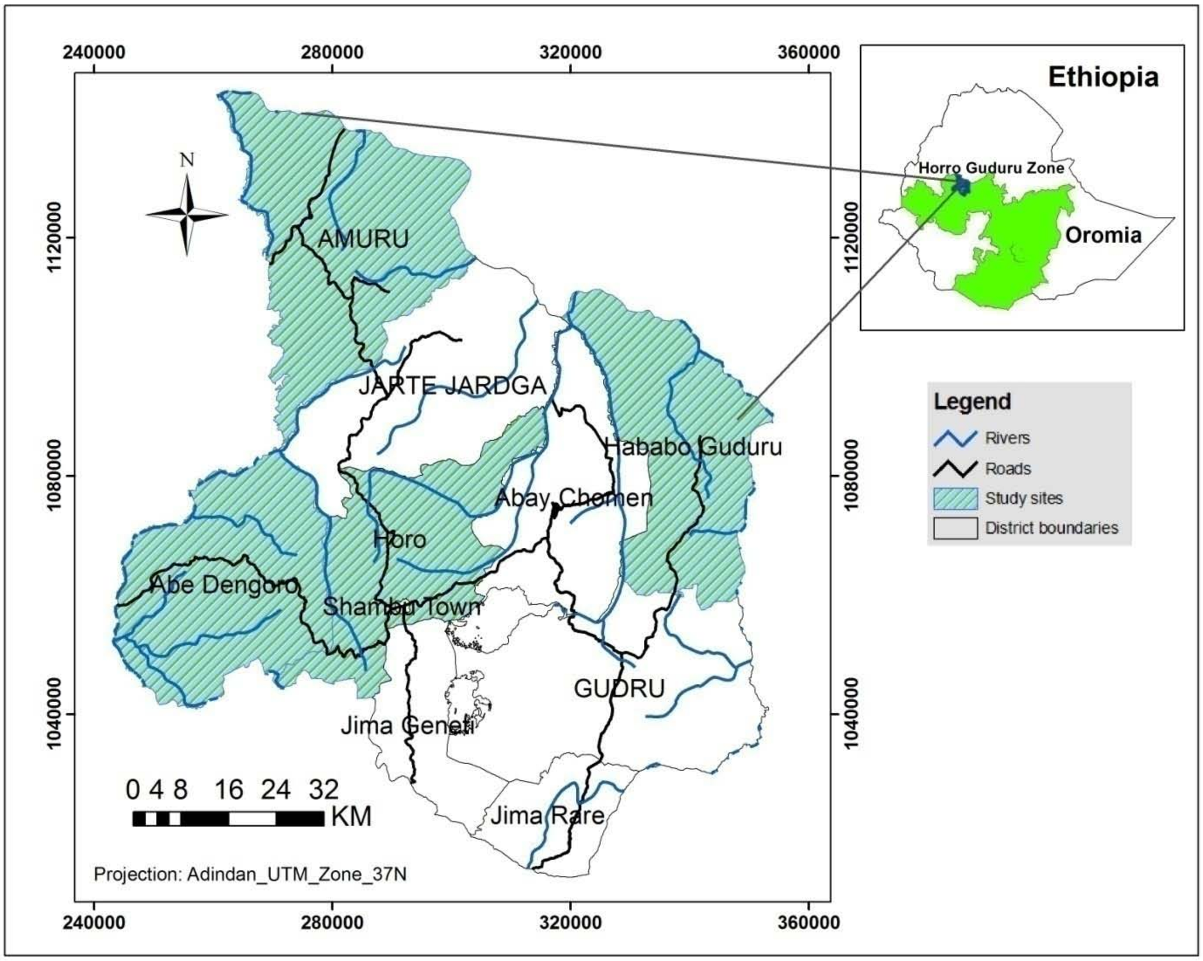


Figure 3.2: Location map of Horro Guduru Wollega Zone.

Source: Adapted from Finance and Economic Development Bureau of Oromia, 2016.

3.4.2 Philosophical Underpinnings of the Study

For social science researchers, it is essential to take a firm stand about how they view the social world, how they can best understand it and how they go for the process of investigation. Although there are several philosophies of knowledge to social research that structure and organize social science research (e.g., postpositivism, constructivism, or pragmatism), pragmatism philosophical doctrine strives towards solving practical problems in the real world by rejecting traditional philosophical dualism or dichotomies of objectivity and subjectivity (Creswell & Clark, 2011; Morgan, 2014b). The pragmatist worldview which sometimes called American pragmatism is a comprehensive and fully developed philosophy that helps in bringing together scientific (positivist) and humanistic (constructivist) domains of understanding issues of interest in different fields of study including social science research (Pratt, 2016).

Unlike constructivist and positivist researchers, pragmatist researchers ascertain that “the process of acquiring knowledge is a continuum rather than two opposing and mutually exclusive poles of either subjectivity or objectivity” (Kaushik & Walsh, 2019, p. 6). Even though positivists/post-positivists, constructivists and pragmatists each regarded their worldview as the appropriate paradigm for conducting research, pragmatists straddle both the positivist/post-positivist and constructivist paradigms by having both objective and subjective features of a research. Since pragmatist paradigm have a much greater potential for explaining reality more fully than is possible when only one research paradigm (either quantitative or qualitative) is used, This research will sit more comfortably in the pragmatist paradigm.

Pragmatism as a third alternative philosophical paradigm took a middle position between positivist and constructivist/interpretivist philosophical paradigms. The pragmatist ontological position was labeled as constructive realism or symbolic realism (Goldkuhl, 2012). But, its epistemological stance centers on the concept of inquiry and the process of knowledge-seeking (Cooke, 2007). Therefore, according to Goldkuhl, pragmatism worldview is based on both realist and idealist metaphysics. A common feature of a Pragmatist philosophical position is the integration of realist ontology and a constructivist epistemology. This is to mean that pragmatists view things and events as existing independent of any observers (physical), but at the same time they emphasize reason and thought as originators of elements in the external world (mental) (Bishop, 2015).

Pragmatism calls upon a methodological pluralism and disciplinary tolerance and it encourages a multi-perspective style of inquiry. Pragmatist philosophy is therefore, an appropriate theoretical perspective that may help us address our problematic and heated meta-scientific debates between positivist and constructivist camps of knowledge inquiry (Vo, 2012; Bishop, 2015). To maximize their contribution to the overall research goals, pragmatists emphasize on the complementarities, rather than oppositions of different knowledge inquiry methods. Another pragmatist philosopher, Pratt (2016) has elaborated on the disadvantage of taking a dogmatic position and advantage of pluralist position for the research study in question. A similar stand has been taken by Bishop (2015) who encouraged researchers to blend interpretivism (idealism) and positivism (materialism) rather than using separate research paradigms as they are not exclusive to each other.

Even though Pragmatism as a research paradigm deeply rooted within the works of contemporary American pragmatists such as Rorty, Richard Bernstein, and Richard Shusterman, it originates in the early work of notable classical pragmatist philosophers such as John Dewey, William James, Charles Sanders Peirce, and George Herbert Mead among others (Hildebrand, 2008; Goldkuhl, 2012; Pratt, 2016). These classical pragmatist philosophers adopted a pragmatist epistemology to develop a more refined approach to mixed methods research and they consider knowledge as both constructed and grounded in the world and it could be obtained through diverse sources of experience and experimentation (Bishop, 2015).

The essence of pragmatist ontology is actions and change; humans acting in a world which is in a constant state of becoming. That is why Kaushik & Walsh (2019) asserted that pragmatism philosophy is based on dynamism that views the world as a constantly changing and boundless pattern. Therefore, due to this dynamic nature of knowledge, nothing is fixed and final and it is practically impossible to offer a universal and eternal solution to all human affairs.

Actions are a central and a universal philosophical question and they cannot be separated from the contexts in which they occur (Goldkuhl, 2012; Kilpinen, 2009). The fundamental nature or essence of society lies in an ongoing process of action (Dewey, 1931 cited in Goldkuhl, 2012). Goldkuhl further argued that there is inseparable link between human action and human knowing. Hence, positiviststs/post-positiviststs and constructivist philosophy of knowledge to social research are equally important claims and they are considered to be two sides of the same coin. One of the basic ideas within pragmatism philosophy is that the meaning of an idea or a concept is the practical consequences of the idea or the concept (Peirce, 1878 cited in Goldkuhl, 2012).

3.4.3 Application of Pragmatism Philosophy to the Study of Smallholder Farmers' Output Market Participation

The existing research outputs are concentrated on the implications of pragmatist world view for demand side market participation or consumer market (Silcock, 2015; Majeed, 2018). On the contrary, there is a dearth of research outputs on the relevance and application of pragmatist world view in output side or supply side market participation. Therefore, in this paper an attempt will be made to describe the significance and application of pragmatist perspective to issues like smallholder farmers' output market participation research.

For output market participation researchers, to be more accountable and transparent in their inquiries, they have to adopt evidence-based practice approaches and they should base their inquiry on careful consideration of the most convincing evidence about the effects of fixed and proportional transaction costs hindering output market participation. To determine the effectiveness of policy intervention in output market participation of smallholder farmers, researchers in the field need to know the relevant determinant factors impacting on the situation.

In addition to using quantifiable and measurable variables (positivist paradigm) to determine factors determining smallholder farmers' decision to participate and level of output market participation, narrative interviews and focus group discussions (constructivist paradigm) are also argued to be appropriate approach to investigate smallholder farmers' output market participation questions. These qualitative inquiry methods offer the understanding of the importance of policy interventions in farmer's real-life practice situations and are suggested as useful in understanding the quality, nature, and context of such interventions in smallholder farmers' output market participation through raising production and productivity of marketable surpluses on one hand and improving market access by reducing transaction costs on the other hand.

In summary, for the following basic reasons, we argue that pragmatism approach or lens is an appropriate research paradigm that fits closely with the objectives stated to address the dynamic nature of smallholder farmers' agricultural output market participation. First, agricultural output market participation research questions demand the most appropriate method from multiple research methods to gather evidences from a range of sources to determine the determinant factors influencing output market participation. Second, both qualitative and quantitative research approach, can contribute to the advancement of knowledge in agricultural output market participation. Third, the pragmatist paradigm has the ability to analyze both numerically coded and narrative data. Fourth, pragmatism provides a middle position both philosophically and methodologically by offering a mix of qualitative and quantitative methods to answer research questions. Fifth, research questions can best be answered and research problems can best be tackled by integrating the results of qualitative and quantitative research. Sixth, pragmatic research challenges the traditional distinction between both quantitative (objective) and qualitative (subjective) research approaches. Seventh, a pragmatic approach allows researchers to be flexible enough in their choice of methods and encourage them to adopt the most practicable approach to address research questions.

One of the intended benefits of mixed methods research is that it can minimize the drawbacks that are inherent when using either the quantitative or qualitative research methods (Bishop, 2015; Morgan, 2007). But, despite its importance in mixed methods research, this version of paradigm has received relatively little attention in smallholder farmers' output market participation studies in general and in social science research in particular. Therefore, it is useful to consider mixed methods research in the context of pragmatist paradigms.

Previous literature on the field of human geography also acknowledged the significance and value of pragmatism worldview as a research paradigm to address the research needs in the field (see Harney, McCurry, Scott, & Wills, 2016; Bridge, 2019; Wood & Smith, 2008; Barnes, 2008; Gaudin, 2018). Several other studies that are not in the field of geography have also adopted pragmatism worldview as the research paradigm (see Brierley, 2017; Kalolo, 2015; Ralston, 2011; Yefimov, 2004; Kaushik, 2019). In summary, we argue that pragmatism worldview offers cohesive and constructive conceptual scaffolding for practitioners and researchers in the field of smallholder commercialization.

3.4.4 The Research Design

Research design is important in any research because it provides a framework or blueprint for conducting the research project to best meet certain research objectives. Creswell (2009) defined research design as plans and the procedures for a study that covers the decisions from broad assumptions to detailed methods of data collection, analysis, interpretation and final reporting. Similarly, Tobi and Kampen (2017) defined it as a systematic plan to study a scientific problem to seek answers to research questions.

For a better understanding of the research under study, in this research, mixed methods research was adopted which involves the collection and analysis of both quantitative and qualitative data, and integrating the two sets of results at some point in the research to draw inferences from the quantitative and qualitative results. Mixed methods research follows flexible approach and addresses a variety of different research questions as compared to mere quantitative or qualitative approach. Mixed methods research combines both quantitative and qualitative research in a single study. Mixed methods design refers to the research mixing or integrating both qualitative and quantitative approach within a single study to best understand and explain a research problem. According to Creswell (1999) and Creswell & Plano Clark (2007), a mixed methods research design at its simplest level requires mixing both quantitative and qualitative approaches of data collection, analysis, and reporting research in the same study to produce a fuller account of the research problem.

Any weaknesses in the quantitative data can be compensated for by the strengths of qualitative data, thereby increasing the reliability and validity of the results. Mixed methods research strengthens conclusions about findings and helps reduce the risk of misleading analysis and wrong interpretations, where the results from one method are used to enhance, augment and clarify the results of another. Using both quantitative and qualitative data will provide a much clearer picture of the overall phenomenon or situation of the study than simply using either quantitative or qualitative data. Therefore, the intention of adopting mixed methods research is to decrease the deficiencies and biases that come from any single method.

Creswell, Clark, Gutmann, and Hanson (2003) further defined mixed method research design as:

> A mixed methods study involves the collection or analysis of both quantitative and/or qualitative data in a single study in which the data are collected concurrently or sequentially, are given a priority, and involve the integration of the data at one or more stages in the process of research (p. 165).

The basic justification for the use of a mixed methods research design is that the combination or merging of quantitative and qualitative data provides a better understanding of a research problem than either quantitative or qualitative data by itself (Creswell, 2012). A mixed methods research design encourages researchers to use multiple approaches to collecting and analyzing data within a single study and it can increase the generalizability of the results. To conclude, mixed methods are a relevant research design to study the dynamics in determinants of smallholder farmers' output market participation.

3.5 Research Methodology

3.5.1 Data Sources

Mixed research design is interested more in combining and comparing quantitative and qualitative data sources to provide more comprehensive information that might be missed when only a single data source is used (Migiro & Magangi, 2011; Creswell, 2012). Mixed method inquirers triangulate or check among different data sources to answer a broader and more complete range of research questions and enhance the accuracy and credibility of a study. Data triangulation, according to Creswell (2012), concerns itself with the use of multiple data sources that complement each other and it minimizes the shortfall of single data source. Creswell further pointed out that data triangulation is a technique used by investigators to improve their inquiries by collecting and integrating different kinds of data bearing on the same phenomenon.

Data triangulation was defined as a process of combining data from different sources to study a particular social phenomenon in several different settings (Hammersley, 2008; Shenton, 2004). With triangulation, it is more likely that the data will be drawn from a much more diverse set of sources and this diversity makes certain a more expansive look at the phenomenon under study. Such data triangulation could help in blending the strengths of one type of data source and neutralizing the weaknesses of the other. The three data sources used in this particular study include: questionnaires, focus group discussions, and key informant interviews (Figure 3.3).

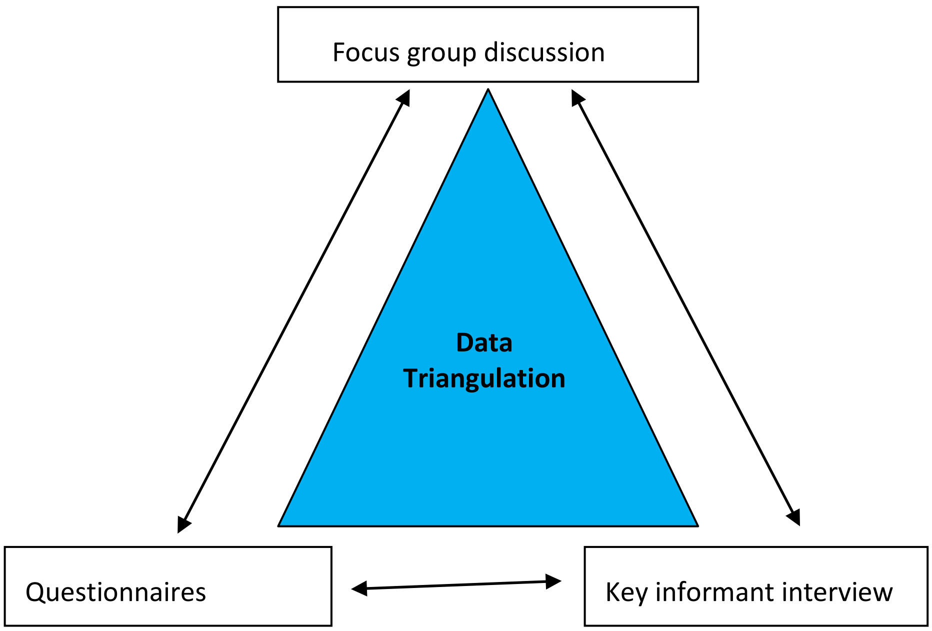


Figure 3.3: The three data sources used in this study

Source: Own construction

3.5.2 Sampling Techniques and Sample Size

The sample for this study was selected in a series of sampling stages, i.e. multi-stage sample. In the first stage, Purposive or judgemental non-probability sampling was used to select Horro Guduru Wollega Zone from the total number of Zones in Oromia region. In Addition, the focus group participants and key informant interviewee were selected purposively. Despite the limitations associated to purposive sampling due to the subjective nature in choosing the sample units, there were three reasons for the deliberate or purposive selection of Horro Guduru Wollega Zone: first, this zone is very important and must be included as it is one of major food crop producing corridors of Ethiopia. Second, it can improve the coverage, supervision, follow-up and other aspects that have a bearing on the quality of data collected. Third, financial, accessibility and time constraints should be taken into account in the selection of the first-stage sample. Generally speaking, as a non-probability sampling techniques, purposive sampling is an acceptable and preferable kind of sampling for special situations. It is the selection of units based on personal or an expert judgement rather than randomization to guarantee representativeness (Palys, 2008; Dolores & Tongco, 2007).

In this study, from the second stage to the fourth stage, simple random sampling techniques were used. The word random in this case illustrates the procedure used to select units or elements (districts, rural kebeles and smallholder farmer respondents) from a population. In the second stage, four districts (Hababo Guduru, Horro, Amuru and Abe Dondoro) were randomly selected from Horro Guduru Wollega zone. In the third stage, based on proportionate random sampling procedure, four rural kebeles were selected in each district comprising a total of 16 rural kebeles. In the fourth and final stage, based on proportionate random sampling procedure, 15–57 smallholder farmers were selected in each rural kebele administration based on Gray et al. (2007:113) suggestion about sampling techniques at 95% confidence level. As a result, a total of 500 smallholder farmers were selected for the final study.

Even though motorized transport was used to reach the district capitals, it was mainly local mode of transport (horse) that was used to access rural kebeles during field works. Though a survey questionnaire (quantitative) was filled with the assistance of 2 trained data collectors (research assistants) at each district, it was the researcher himself who mostly conducted the qualitative data collection in all the districts.

Unlike the non-probability sampling (purposive sampling), the goal of simple random sampling is to choose n different random numbers, between 1 and “n” and any household whose number is chosen will be surveyed (International Labour Organization [ILO], 2009). If the same number comes up twice, the second observation is ignored. Therefore, each element in the population has an equal chance of being selected for the sample. A simple random sampling is commonly used for inference in surveys because it provides adequate estimates of the population parameters, provided the sample size is sufficient (Stehman, 1992). Another advantage of a simple random sampling is that it is generally more accurate in representing the population than is purposive sample.

3.5.3 Methods and Instruments of Data Collection

The study has utilized cross-sectional data obtained from the survey of 500 sample smallholder farmers in Horro Guduru Wollega Zone, Western Ethiopia. The data for this research were collected by the researcher and trained data collectors between February to June 2016. A total of 16 rural kebeles from four different cereal crop growing districts of Horro Guduru Wollega Zone were included in the study. The household questionnaire, FGD guides and KII guides were the main instruments used for primary data collection. Quantitative data were collected from smallholder farmer respondents by using structured and pre-tested questionnaires, which were administered with the assistance of trained data collectors (extension agents) in the respective rural kebeles of the study area. The qualitative data (FGD and KII) were conducted by the investigator himself and trained interviewer by the use of focus group discussion and key informant interview guides. Four Focus group discussions, one at each district were made with selected model farmers, community elders, and extension agents. Key informant interview was conducted with the heads of district agricultural office and rural kebele managers.

The aim of combining heterogeneous groups with regard to socioeconomic status (model farmers, community leaders and DAs) in one FGD was to figure out the theme of the study thoroughly from the ideas and opinions arising from varied groups.

Data were collected on a range of variables, including general information about the transaction cost determinants of smallholder farmers' output market participation, household assets and output prices. The questions also included the proportional transaction cost indicators (distance to the nearest market center, road type, and ownership of a means of transport) and fixed transaction costs (costs of searching for marketing partner, costs for price information, supervision and monitoring costs and costs of specifying the output to be marketed). In addition the structured questionnaire was set to collect data on the socio-economic and demographic characteristics of smallholder farmers that determine output market participation decision and intensity of participation.

The questionnaire has been refined by a preliminary test carried out on three smallholder farmers in the study area in order to adapt it to the reality of the field and has been translated into vernacular language (Afaan Oromo). The actual survey took place through interviews at the home or work place of each respondent smallholder farmer. A total of 500 copies of structured questionnaires were distributed in this survey, and the sample effective rate was 100% (zero non-response).

3.5.4 Data Processing and Analysis

Statistical Package for Social Sciences (IBM SPSS) software program version 20 was used in computing descriptive statistics (mean, standard deviation, frequencies and percentages). Whereas, excel spreadsheet was used to compute Household Commercialization Index (HCI). Descriptive analysis was used to describe socio-economic and demographic data in order to understand the general characteristics of smallholder farmers' profiles. The descriptive analysis involved the use of frequency tables and percentages to categorize smallholder farmers under the different demographic and socio-economic characteristics. The summary measures used included the standard deviation and mean.

Data on fixed and proportional transaction cost determinants of smallholder farmers' decision on output market participation and the intensity of participation were analyzed with the help of probit and truncated regression models respectively using STATA 12.1 software. In addition to probit and truncated regression models, smallholder farmers were asked qualitative research questions framed by focus group discussion and key informant interview question guides which were further analyzed by the help of content analysis method.

Unlike the quantitative data, the qualitative data collected are non-numeric and hence the analysis is narrative and non-statistical. For example, with regard to key informant interview, the experiences of the key informant interviewee were analyzed to identify common patterns and to compare patterns between different sub-groups. Similarly, Transcripts of the focus groups discussions were analyzed qualitatively through coding and grouping participants' comments around key themes that stemmed from the question guide.

3.6 Ethical Considerations

Adhering to the code of ethics in research are the norms for conduct that distinguish between wrong and right and works towards the protection of dignity of participants. Hence, it differentiates between acceptable and unacceptable behaviors on the part of the researcher. Adherence to the most important ethical issues (respect for privacy, respect for anonymity and confidentiality and informed consent) is becoming a crucial element in social research, because it increases the reliability, integrity, generalizability and validity of the research findings (Madushani, 2016; Fouka & Mantzorou, 2011; Akaranga & Makau, 2016; Manti & Licari, 2018). According to Madushani (2016) and Nijhawan, et al. (2013), keeping an eye on ethical considerations in the research process is compulsory to make sure that the cultural, legal, economic, and political rights of the respondents is respected.

The following ethical standards were taken into account in this specific research. First, pertaining to information confidentiality, participants are told that their participation in the study will be treated with the utmost confidentiality and their anonymity is assured (appendix 3.1). They are also informed that their personal identity (anonymity) will not be used throughout the study process and in the final research report. Second, concerning the proper treatment of participants, they were given a chance to sign informed consent form (appendix 3.2). Participants are also informed that participation in this study is voluntary and they are free to choose to take part in the research and can withdraw at any time without providing any reason.

3.7 Variable Definition and Measurement

Our variables of interest (both dependent and independent) used in this study and their levels of measurement is shown in table 3.1. These variables are supposed to capture the influence of the potential independent variables on smallholder farmers' output market participation.

Table 3.1. Descriptions of variables used in probit and truncated regressions and their measurements

Variable name and type	Description	Measurement	Expected sign
Output market participation decision, dummy (Y_1)	A dependent variable expressed as a decision to participate or not in output crop marketing (1= if a household made any sale of the crop (maize, *teff*, wheat) and 0= otherwise	(1 = Yes, 0 = No)	NA
Output market participation intensity, continuous (Y_2)	A dependent variable expressed as percentage share of value of crops sold out of the total values of crop produced-household Level commercialization Index	Percentage/ratio	NA
Age of household head, continuous (X_1)	Age of household head	Number of years	-
Livestock ownership, continuous (X_2)	Tropical livestock ownership of the household	Tropical livestock unit (TLU)	-
Off-farm income, continuous (X_3)	Total income earned by a household head from off-farm income sources	Eth. Birr	-
Family size, continuous (X_4)	Total family size of the household head	Number	-
Road quality, dummy (X_5)	Road status (condition) that a smallholder farmer has access to	1=if good, 0 if bad	+
Sex, dummy(X_6)	Sex of household head	1=if male, 0= if female	+
educational status of the household head, dummy (X_7)	Literacy status of the household head	1=if attended any formal education, 0= otherwise	+
Access to credit, Dummy (X_8)	Whether farmers get access to credit facility or not	1=if access credit; 0=otherwise	+
Ownership of transport animals, dummy (X_9)	Whether a farmer household head has his/her own local mode of transport or not	1= own animal cart, 0= otherwise	+
Membership in a cooperative, dummy (X_{10})	Whether a farmer household head is being a member of agricultural cooperative or not	1= member, 0= otherwise	+
Extension visit, dummy (X_{11})	Whether a farmer household head is being visited by an extension worker or not	1= monthly visit 0= otherwise	+
Ownership of Radio, dummy (X_{12})	Whether a farmer household head owns radio or not	1= yes 0= no	+
Ownership of mobile phone, dummy (X_{13})	Whether a farmer household head owns mobile phone or not	1= yes 0= no	+
Ownership of Television, dummy (X_{14})	Whether a farmer household head owns Television or not	1= yes 0= no	+
Crop production level, continuous (X_{15})	Amount of cereal crop (maize, wheat & *teff*) produced during 2015/16 agricultural season	quintal	+
Distance to major market, continuous (X_{16})	Distance travelled by the household to reach the nearest major market	kilometer	-
Transport cost, continuous (X_{17})	Transport cost incurred to move 100kg of agricultural output over 1 km	Birr per 100 kg per km	-
Price of crops,dummy(X_{18})	Situation of crop prices	1=if attractive; 0=otherwise	+
Time spent to sell crops, continuous (X_{19})	Time spent delivering agricultural produce to the market or time spent to make a sale	hours	-
Number of market outlets, count (X_{20})	Number of market channels that a farmer has access to	number	+

Source: Author's Compilation

3.8 Model Specification

3.8.1 Smallholder Farmer Crop Output Market Participation Index

The household commercialization index (HCI) proposed by Govereh et al. (1999) was used but modified to estimate the level of smallholder farmers' crop output (Maize, Wheat, and *Teff*) market participation index (COMPI) and specified as:

$$\mathrm{COMPI_i} = \left[\frac{\text{gross value of three crop sale}_{ij}}{\text{gross value of three crop production}_{ij}}\right] * 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Where: $\mathrm{COMPI_i}$ is the i^{th} crop output market participation index of smallholder farmer for three selected major food crops (Maize, Wheat, and *Teff*); the numerator is gross value of three crop sale by the i^{th} smallholder farmer in the j^{th} year (j = 2015/16 crop production calendar) and the denominator is the gross value of three crop production by the i^{th} smallholder farmer in the j^{th} year. Therefore, smallholder farmer crop output market participation index is a ratio ranging from zero for non-participants in crop output market to one for the fully participated smallholder farmers in crop output market in the specified period.

3.8.2 Double-hurdle Econometric Model for Extent of Crop Output Market Participation

To explain output market participation behavior among smallholder farmers, this study adopted the two-tier Double-hurdle econometric technique, as originally proposed by Cragg (1971). Cragg formulated the double-hurdle model by adapting the standard Tobit model (Yen & Huang, 1996). Hence, the double-hurdle model is a parametric simplification of the tobit model, in which the decision to participate in output market and the level of participation are determined by two separate econometric approaches.

The advantage of double-hurdle model over Tobit model is that it relaxes the Tobit model assumption by allowing different mechanisms to determine the discrete or binary probability of participation and intensity or extent of participation. As compared to Tobit model, the double-hurdle model allows for separation between the first decision to participate in market or not and the second decision on the extent or degree of participation (Sigei, 2014). It also nests the tobit model and allows to test the restrictions implied in the tobit hypothesis. In the double-hurdle model specification, a smallholder farmer has to overcome two hurdles in order to report a positive quantity of crop sale. This is to mean that under this model, smallholder farmers' output market participation is modeled as two-stage decision process. The first hurdle or stage relates to whether or not a smallholder farmer takes part in the sale of crop output in the specified period, and the second hurdle or stage relates to the intensity/amount of sale by those who participated in output market. Detailed structural formulations of the double-hurdle empirical model are outlined below.

3.8.3 Probit Regression Model

The double-hurdle model estimation involves a standard probit regression analysis to identify factors affecting the binary decision to participate in output marketing by using all sample populations in the first stage, and a truncated normal regression model on the participating smallholder farmers (non-zero observations) to analyze the degree or intensity of participation, in the second stage (Gobena, 2012; Sigei, 2014). Smallholder farmer binary decision to participate in output market and the continuous decision of how intensively he/she should participate in output market on condition that he/she has decided to participate are determined by different factors.

A probit regression analysis is a type of binary classification model where the dependent (response) variable can only take two possible outcomes (dummy dependent variable). According to Gujarati (2004), Horrace and Oaxaca (2005) and Hausman (2001), the ordinary least square (OLS) estimates in case of binary dependent variable are biased, inconsistent and impose heteroscedasticity. Hence, for such binary dependent variable, a probit model is used as standard remedy to control for such effects. Therefore, probit regression model was used in the first stage of the double-hurdle model to examine the factors determining the decision to participate (probability of participation) in crop output market by using all sample population. Accordingly, binary outcome models estimate the probability that Y=1 as a function of independent variables (X). Equation 2 defines the market entry model where Y takes the value of one if a smallholder farmer made any positive sales of the crop output and zero if no sales were made.

$P = pr[y = 1|x] = F(x^{'}\beta)$……………………………………….…………….……..….(2)

$y_1^* = \beta_1 x_{1i} + \varepsilon_{1j}$ ……………………………………………………………………...(3)

Where, y_1^* is a latent discrete market participation indicator, X_1 is vector of independent variable; β_1 is vector of parameter. The error term ε_1 is independently and normally distributed such that ε_1 ~ N(0, 1). For the probit model $F(x^{'}\beta)$ is the cdf of the standard normal distribution function where the predicted probabilities are limited between 0 and 1, the functional form is given below.

$F(x^{'}\beta) = \Phi(x^{'}\beta) = \int_{-\infty}^{x^{'}\beta} \phi(z)dz$……………………………………..……………….…(4)

Marginal Effects of the Probit Model

The coefficient estimates of the probit model only show the direction of the effect of independent variable on the dependent variable (output market participation). But, it does not show the actual magnitude of the change of probabilities. Thus, the marginal effects or marginal probabilities of the probit model is used to measure the expected change in the probability of a particular choice being made with respect to a unit change in an independent variable from the mean (Greene, 1999, 2003). The marginal effects were also used to interpret the results, since the coefficient estimates of the probit model have no direct interpretation and it is given by:

$\partial p/\partial x_j = \phi(x^{'}\beta)\beta_j$……………………………………………………………...…..(5)

Where: β_j is the coefficient; ϕ is PDF (probability distribution function) of standard normal distribution and $\partial p/\partial x_j$ is the probit marginal effect.

Probit regression model denotes the functional relationship between the probability of participating in an activity (output market participation in our case) and the list of various independent variables hypothesized to affect the participation decision. These independent variables can be either continuous or categorical. The predicted probabilities are limited between 0 and 1. Therefore, the reduced functional relationship between output market participation which is the binary dependent variable and a list of independent variables for the empirical analysis of the current study can be expressed as follows using basic probit model specification:

$P(OPMP = 1) = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \beta_3 X_{3i} + \cdots + \beta_{15} X_{15i} + \mathcal{E}_i$.................................(6)

Where: P - is the probability at which smallholder farmer participated in crop output market participation in 2015/2016 production calendar represented by P(OPMP=1), β0 is the constant term; β_1 to β_{15} – are the coefficients to be estimated, X_1 to X_{15} are the different independent variables.

3.8.4 Truncated Regression Model

With smallholder farmers that did not sell crop output in the specified period being excluded from the analysis, a truncated regression model was used to explain quantity sold for participating smallholder farmers. Truncated regression as a limited dependent variable model has considerable advantage for providing consistent and unbiased estimates of the coefficients of independent variables as well as their standard errors. Hence, the extent of output market participation for participating smallholder farmers was represented by the equation:

$y_2^* = \beta_2 x_{2i} + \mathcal{E}_{2j}$ ……………………………………………………………………….(7)

Where: y_2^* is a latent or unobserved extent of market participation indicator, X_2 is vector of independent variable; β_2 is vector of parameter. The error term $\mathcal{E}_2$ is independently and normally distributed such that $\mathcal{E}_2 \sim N(0, \sigma_2)$, and $\mathcal{E}_2$ is truncated at $-X_2\beta_2$. The observed market participation extent (y_2) relates to the latent discrete market participation (y_1^*) such that

$y_2 = y_2^*$ if $y_1^* > 0$, and 0 otherwise……………………………………..…………..…(8)

Where: Y_2 is the observed amount of crop sale and y_2^* is the latent amount of crop sale; y_1^* is the latent discrete market participation variable that takes the value 1 if a farmer participated in output market and zero otherwise.

Under the assumption of independency, normally distributed and zero variance between the error terms $\mathcal{E}_1$ and $\mathcal{E}_2$, the double-hurdle model is equivalent to a combination of univariate probit model (equation 9) and the truncated regression model (equation 10). The double-hurdle likelihood function is the sum of the probit models and the truncated regression models (Woldeyohanes, 2013; cragg, 1971).

The maximum likelihood estimates of output market participation probit model or the maximum likelihood estimator (MLE) in the hurdle 1 can be obtained from probit estimator as follows:

$$logL\ pobit = \Sigma ln\left[1 - \Phi(\beta_1 x_{1i})\left(\frac{\beta_2 x_{2i}}{\sigma}\right)\right] \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.(9)$$

The maximum likelihood estimator (MLE) in the hurdle 2 can be obtained from the truncated regression model estimator as follows:

$$logL\ truncated = \Sigma \ln\left[\Phi(\beta_1 x_{1i})\frac{1}{\sigma}\ \phi\ \left(\frac{y_2 - \beta_2 x_{2i}}{\sigma}\right)\right] \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(10)$$

The log-likelihood function for the full double hurdle model is, therefore expressed as equation. 11.

$$logL\ DHM = \Sigma ln\left[1 - \Phi(\beta_1 x_{1i})\left(\frac{\beta_2 x_{2i}}{\sigma}\right)\right] + \Sigma \ln\left[\Phi(\beta_1 x_{1i})\frac{1}{\sigma}\ \phi\ \left(\frac{y_2 - \beta_2 x_{2i}}{\sigma}\right)\right] \ldots\ldots\ldots.(11)$$

Where: Φ (Greek capital letter phi) denotes the standard normal probability, ϕ(Greek small letter phi) is density functions; x_{1i} and x_{2i} represent independent variables for the probit model and the truncated model respectively; β_1, σ, and β_2 are parameters to be estimated for each case.

Truncated regression model specifies the functional relationship between the degree or extent of participating in an activity (output market participation intensity in our case, which is of course continuous dependent variable) and the list of various independent variables hypothesized to affect the participation intensity. These independent variables can be either continuous or categorical in nature. Therefore, the reduced functional relationship between the intensity of smallholder farmer output market participation and a list of independent variables for the empirical analysis of the current study can be expressed as follows using basic truncated model specification:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 \ldots + \beta_{12} X_{12} + \mathcal{E} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(12)$$

Where: Y - is the intensity of smallholder farmer crop output market participation in 2015/2016 production calendar; β_0 is the constant term; β_1 to β_{12} – are the coefficients to be estimated, X_1 to X_{12} are the different independent variables thought to influence the intensity of smallholder farmer output market participation.

3.9 Assumption Check/Diagnostic Tests

To obtain computationally and statistically efficient as well as consistent estimators of the regression coefficients for the probit and truncated linear regression models, we need to make a couple of necessary assumption.

3.9.1 Testing the Normality Assumption in Limited Dependent Variable Models

The double-hurdle model is built upon the normality assumption of residuals. The inferences in probit and truncated regression models rely on the assumption of normality (Wilde, 2007; Bera et al., 1984). The probit and truncated regression models are common linear regression models that assume error variances to be constant across observations and require normally distributed responses (Daskalakis et al., 2019; Messner et al., 2016). The consequences of violation of the normality assumption in limited dependent variable (probit and truncated regression) models can be quite problematic since, the maximum likelihood estimators (MLE) can be inconsistent under non-normal distribution (Bera et al., 1984). As a result, the asymptotic bias (inconsistency) can be quite considerable if normality is wrongly assumed.

As a commonly employed formal and popular diagnostic tool for normality test, a Jarque-Bera (JB) test was proposed by Bera and Jarque (Jarque and Bera, 1987; Brys, Hubert, & Struyf, 2004). Jarque-Bera test of normality is based on the classical measures of skewness and kurtosis coefficient and it was used to detect the normality of residuals or disturbances from a robust regression procedure and used for larger sample sizes (Urzua, 1996; Bera & Jarque, 1981; Brys, Hubert, & Struyf, 2004; Jarque and Bera, 1987). According to Bera, Jarque and Lee (1984), the normality assumption of the error term is more essential in limited dependent variables models (probit and truncated) to yield consistent parameter estimates.

In this specific study in addition to the visual inspection of the histogram of errors or residuals (appendix 3.3), the Jarque-Bera, Shapiro-wilk and Skewness/Kurtosis tests for normality of normal distribution (appendix 3.4, 3.5 and 3.6) were used to check if residuals of truncated regression model follows the normal distribution. Accordingly the probability

(p) value for Jarque-Bera, Shapiro-wilk and Skewness/Kurtosis formal tests were 0.4741, 0.57306 and 0.3821 respectively which is in all the three cases greater than the most commonly used 0.05 alpha level. So, we fail to reject the null hypothesis of normality and conclude that the data follows the normal distribution and it was drawn from normal distribution. In addition, since the calculated value for Jarque-Bera test (1.493) is less than the critical value of chi-square test statistic at 2 degrees of freedom (5.99) at 0.05 significance level, the null hypothesis of normal distribution will be accepted. Finally, the visual inspection of the histogram of errors (residuals) with normal density curve (appendix 3.7) also revealed that the error terms in the truncated regression model have approximately a truncated normal distribution. Therefore, we can conclude that there is a clear indication for the asymptotically normal distribution of the error terms in our data set.

3.9.2 The Diagnostic for Multicollinearity

This is essentially the assumption that independent variables that are going to be used in probit and truncated regression models are not too highly correlated with one another. Multicollinearity occurs when two or more independent variables in the model are correlated and provide redundant information about the dependent variable (Vatcheva et al., 2016). There are two ways of detecting multicollinearity in a data set. First, Variance Inflation Factors (VIFs) and tolerance value are used to detect collinearity (also called multicollinearity) among predictors in a truncated regression model (Wooldridge, 2013). High Variance Inflation Factors (VIFs) and low tolerance values reflect an increase in the variances of estimated regression coefficients due to collinearity among independent variables. A commonly given rule of thumb is that if VIF value exceeds 10.0, or if tolerance value becomes less than 0.1, then there is a concern with multicollinearity (Vatcheva et al., 2016; Hair et al., 2005; O'brien, 2007). In this study, the VIF values obtained were between 1 and 4 whereas the tolerance values were above 0.1 (Table 3.2). Therefore, it can be concluded that there is no serious multicollinearity symptoms among independent variables in our data set.

Table 3.2. Variance Inflation Factors (VIFs) and Tolerance used to detect collinearity among predictors in regression models

Variable	VIF	1/VIF
Production level	3.98	0.251253
Household size	2.93	0.340913
Distance to main market	2.22	0.449613
Time spent to sale crop	2.06	0.485915
Transport cost	2.01	0.497738
Off-farm income	1.95	0.511819
Livestock ownership	1.81	0.551314
Age	1.55	0.644946
Number of market outlet	1.40	0.712263
Mean VIF	2.21	

Source: Own computation, 2016

The second way of detecting multicollinearity problem in a data set is to examine the bivariate correlations between the independent variables and to look at the correlation coefficients for each pair of continuous or scale variables (Yoo et al., 2014). This assumption investigates and tests the fact that the independent variables are not too highly correlated or no independent variable is a perfect linear function of any other independent variables. The rule of thumb is that correlations of 0.8 or above (+ or -) suggest a strong relationship between pair of independent variables, hence warning signs of multicollinearity. In this study, examination of the bivariate correlations between the independent variables (Table 3.3) show that there were no big values equal to or greater than 0.80, indicating no problem of multicollinearity in the data set.

Table 3.3: Test for multicollinearity using a correlation matrix of coefficients for continuous variables

	Age	TLU	Off-farm income	House hold size	Distance to market	Trans port Cos	Time spent	Number of market outlet	Producti on level
Age	1.000								
TLU	0.412	1.000							
Off-farm income	0.220	0.289	1.000						
Household size	0.405	0.543	0.537	1.000					
Distance to market	-0.06	-0.23	-0.583	-0.510	1.000				
Transport cost	-0.099	-0.235	-0.417	-0.45	0.552	1.000			
Time spent	-0.067	-0.146	-0.402	-0.43	0.517	0.528	1.000		
Number of market outlet	0.097	0.109	0.358	0.352	-0.366	-0.459	-0.427	1.000	
Production level	0.270	0.574	0.439	0.549	-0.480	-0.409	-0.700	0.475	1.000

Source: Own computation, 2016

When dichotomous categorical independent variables are included in the model, collinearity diagnostics can be checked by the help of contingence coefficient (Baak et al., 2019; Murray et al., 2012). The contingency coefficient test, also called the phi-coefficient test of variable independence, determines if a significant relationship exists between two (or more) dichotomous variables. Specifically, the contingency coefficient test is commonly used to examine the relationship between two independent nominal variables. The contingency coefficient value ranges between -1 and 1, with values closer to -1 and 1 indicating a stronger negative and positive association or co-occurrence between the variables respectively. In this study, since the dichotomous independent variables are not so significantly correlated with each other, arguably there is no instance of multicollinearity (Table 3.4).

Table 3.4. A Contingency coefficient analysis of dichotomous independent variables

	Price of crops	Credit	Animal cart	Road quality	Sex	Education	Cooperative	extension	Radio	Mobile	Television
Price of crops	1.0000										
Credit	0.3742	1.000									
Animal cart	0.2477	0.206	1.000								
Road quality	0.2652	0.330	0.137	1.000							
Sex	0.2361	0.313	0.164	0.221	1.000						
Education	0.3395	0.286	0.188	0.289	0.468	1.000					
Cooperative	0.2097	0.196	0.251	0.133	0.132	0.216	1.00				
Extension	0.1801	0.239	0.333	0.260	0.152	0.238	0.31	1.00			
Radio	0.2920	0.328	0.193	0.330	0.236	0.323	0.30	0.34	1.00		
Mobille	0.2916	0.379	0.206	0.338	0.295	0.399	0.23	0.31	0.62	1.00	
Television	0.0698	0.229	0.054	0.182	0.146	0.142	0.28	0.23	0.39	0.25	1.00

Source: Own computation, 2016

3.9.3 The Assumption of Homoskedasticity/Heteroscedasticity Diagnostic Test

One of the standard assumptions of truncated regression analysis is homoscedasticity of errors (constant variance). According to this assumption, the errors need to be independently identically distributed across observations (Klein et al., 2016). Heteroscedasticity arises when the variance of the error terms varies across observations and is a common problem in cross-sectional data analysis (Long & Ervin, 1998). In the presence of heteroscedasticity, that is if the errors are said to be heteroscedastic, the estimated standard errors can be either too small or too large, resulting in incorrect inferences (Klein et al., 2016; Breusch & Pagan, 1979). Heteroscedasticity comes from the Greek “hetero” ('different') and “skedasis” ('dispersion') (Williams, 2015, p.1).

There are three reasons why detecting the presence of heteroskedasticity is of practical relevance (Orme, 1992; Hurd, 1979; Gelfand, 2013). First, the presence of heteroskedasticity in truncated regression models can invalidate inferences which can lead to highly misleading inferences. Second, it also leads to inconsistent parameter estimation, often resulting in inconsistent maximum likelihood estimation of truncated regression functions. Third, it reduces the predictive ability of the truncated regression model.

The Breusch-Pagan test, which is a formal and a more powerful test for heteroscedasticity was used to detect whether or not there is evidence of heteroscedasticity (non-constant variance) in the residuals of the regression following the estimation of a truncated regression model. Accordingly, there is no evidence for strong heteroscedasticity, hence error variances are constant (homoscedastic) across observations (appendix 3.8).

3.10 Results and Discussion

This section presents descriptive results of socio-economic, institutional, physical or location specific and market characteristics in relation to the binary output market participation decision and the intensity of participation. It also presents empirical results of the Double-hurdle two-stage model i.e. the probit model and truncated regression model, providing an in-depth explanation of significant variables.

3.10.1 Descriptive Statistics

3.10.1.1 Socio-economic Characteristics of Surveyed Households

Table 3.5 presents summary of descriptive statistics on selected variables used in the empirical analyses. The mean age of household heads was 34.2 and ranged from 17 to 64 years. Farm household heads in the study area can be described as relatively young and within the economically active population. About 90% of respondent household heads were male while about 10% were female. Mean family size in the study area was about 6.484 people and ranged from 2 to 12. The majority of households (76%) had formal education while only 24% had no formal education. Households had on the average 3.25626 tropical livestock units (TLU) ranging from .55 to 11.51 TLU. Households earned on the average Ethiopian birr 2416.296 from off-farm activities. The minimum and maximum off-farm incomes were 0 and 9100 Ethiopian birr respectively. The average distance to the nearest market was 20.18km and ranged between 5 and 35kms. Whereas, the average distance to all weather road was 12.958km and ranged between 0 and 27kms. The results further reveal that on average crop output market participants had a farming experience of 11 years.

The statistical summary given in table 3.5 shows that a typical household head produced food crops valued approximately birr 32293.92 ranging from birr 3697.5 to 87250. From sells dimension, a typical household head, on average, sold food crops worth birr 17002.98 ranging from birr 13932.81 to birr 20660. The average intensity of market participation which is defined as the ratio of the gross value of all crop sales to the gross value of all crop production times hundred is computed to be 26.05587% ranging from 9% to 52%.

Table 3.5: Descriptive statistics for continuous variables

Variable	Obs	Mean	Std. Dev.	Min	Max
Age	500	34.196	11.56569	17	64
Livestock ownership	500	3.25626	1.638788	.55	11.51
Off-farm income	500	2416.296	2729.998	0	9100
Household size	500	6.484	3.308722	2	12
Distance to market	500	20.18	7.870928	5	35
Distance to all weather road	500	12.958	6.746203	0	27
Transport cost	500	2.1558	.7746606	.5	3.2
Land under crops (ha)	500	1.8875	.8623666	.25	5
Output level (Q)	500	40.48244	20.33624	4.25	117.5
Crop productivity (Q/ha)	500	21.2006	3.77105	10	33.5
Sales value of crop produced (birr*)	500	32293.92	15162.83	3697.5	87250
Sales value of crop produced / ha (birr)	500	17002.98	1231.518	13932.81	20660
Quantity of crop Sold (Q)	179	12.22214	6.688916	1.2075	34.86875
Sales value of crop sold (birr)	179	14547.82	10289.49	1191.63	50136
Intensity of market participation (%)	179	26.05587	9.420704	9	52
Crop marketing Experience	179	11.20112	5.849594	0	20
Time spent to sale crops	179	7.117318	2.858593	3	12
Number of market outlets	179	2.513966	1.077646	1	4

Source: Computed from household survey, 2016

* The exchange rate at the time of the survey was 27.5 Ethiopian birr per US$.

Among 500 respondents, men accounted for 90% which was higher than the percentage of women household heads (10%). In terms of educational status, the majority of household heads (76 %) had formal education while only 24% had no formal education. The result revealed that 41% of the respondents do not have access to credit while 59% do have access to credit during 2015/16 production period. In terms of contact with extension agents, results revealed that 54.40% of the respondents had contact with extension agents. The results also revealed that 34.40% of the respondents belonged to agricultural cooperatives. With regard to local transport mode ownership, the results showed that 52.80% of the respondents owned their own local transport mode while 47.20% lack their own local transport mode. In terms of ownership of communication equipment, 46.00%, 56.40% and 29.80% of the respondents owned their own radio, mobile phone and television respectively (Table 3.6).

Table 3.6: Percentage distribution of respondents by socioeconomic characteristics (categorical variables)

Variable		Freq.	Percent
Road quality	Bad road	280	56.00
	Good road	220	44.00
Sex of household	Female	50	10.00
	Male	450	90.00
Literacy status of household head	No formal education	120	24.00
	Formal education	380	76.00
Price of crops	Not attractive	179	35.80
	attractive	321	64.20
Access to credit	No	205	41.00
	Yes	295	59.00
Animal cart ownership	no	236	47.20
	yes	264	52.80
Membership in a cooperative	No	328	65.60
	Yes	172	34.40
Access to extension service	No	228	45.60
	Yes	272	54.40
Districts	Ababo Guduru	113	22.60
	Horro	151	30.20
	Amuru	96	19.20
	Abe Dongoro	140	28.00
Agro ecology	kolla	159	31.80
	weyna dega	200	40.00
	dega	141	28.20
Output market participation decision	non-participant	321	64.20
	participant	179	35.80
Radio ownership	no	270	54.00
	yes	230	46.00
Mobile ownership	no	218	43.60
	yes	282	56.40
Television ownership	no	351	70.20
	yes	149	29.80

Source: Computed from household survey, 2016

About 92.8% of the smallholder respondents were involved in *Teff* production and 82% in maize production in 2015/16 production season. The survey results also showed that about 61.6 % of sample smallholder farmers were participated in wheat production during the stated period. On the other hand, about 35.2, 30.8 and 20.2% of maize, *teff* and wheat producers, respectively, were participated in marketing of the respective crops. At the aggregate level, about 35.8% of the smallholder respondents were participated in crop output marketing in 2015/16 production season. The mean crop output marketing index for maize, wheat and *teff* were 23, 32 and 27% of the total value of crop production, respectively. Whereas, the overall estimated average crop output marketing index for the sample respondents was 26% of the total value of crop produce (Table 3.7).

Table 3.7. Crop output market participation index for major food crops in the study area

Crop type	Sample respondents participated in crop production	Sample respondents participated in crop output marketing	Output market participation index
Maize	414 (82%)	176 (35.2%)	0.23 (23%)
Wheat	308 (61.6%)	101 (20.2%)	0.32 (32%)
Teff	464 (92.8%)	154 (30.8%)	0.27 (27%)
Aggregate cereal	500 (100%)	179 (35.8%)	0.26 (26%)

Source: Own calculation, 2016

3.10.2 Factors Influencing the Probability of Output Market Participation of Smallholder Farmers

We are interested in how some independent variables, like road quality, ownership of animal carts, being member of a cooperative association, ownership of radio, mobile and television affect the binary decision of crop output market participation. The dependent variable (output market participation decision) is a binary variable where 1 implies participation and 0 implies non-participation in output markets during 2015/16 crop production period. In the probit model, there are 15 independent variables (5 continuous and 10 dummy variables). The output shows that all 500 observations were used in the probit analysis. The Loglikelihood chi-square statistic of 431.45 with the p-value of 0.000 indicates that this model as a whole fits the data well and is statistically significant. The pseudo R^2 is 0.6615 meaning that the regressors were able to explain 66% of market participation in the study area. Therefore, this model is significant compared to the null model (a model with no independent variables).

The parameter estimates of the Probit regression model employed to identify factors influencing smallholder farmers' decision to participate in output market is presented in Table 3.8. In this probit analysis, the likelihood ratio test statistics suggest the statistical significance of the fitted regression. Results of the analyses also indicate that the decision to participate in output market was influenced by different factors at different levels of significance. Smallholder farmers who have access to good road, extension service, who own animal cart and who are members of agricultural cooperatives are more likely to participate in output markets. Similarly, Smallholder farmers who own radio, mobile and television are more likely to participate in output markets. Amount of crop produced was also found to be significant in determining the binary decision of smallholder farmers' output market participation. On the contrary, smallholder farmers with large family size and who own more tropical livestock unit are less likely to participate in crop output market.

Table 3.8: Probit model results for factors influencing probability of output market participation

OPMPD	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
Age	.00319	.0099	0.32	0.747	-.016	.022
TLU	-.18939	.0713	-2.65	0.008	-.329	-.049
Off-farm income	-.000073	.00004	-1.65	0.098	-.00016	.00001
Household size	-.08004	.04191	-1.91	0.056	-.1621	.0020
Road quality	.68164	.21783	3.13	0.002	.254691	1.10
Sex	.08049	.5736	0.14	0.888	-1.0438	1.204
Education	.1959	.3374	0.58	0.562	-.4654	.857
Credit	.40215	.2294	1.75	0.080	-.047592	.851
Animal cart	.3885	.2172	1.79	0.074	-.03720	.8142
Cooperative	.97052	.20943	4.63	0.000	.5600	1.381
Extension	.8812	.2541	3.47	0.001	.3830	1.37
Radio	1.5304	.2185	7.00	0.000	1.102	1.958
Mobile	1.0166	.2724	3.73	0.000	.4825	1.550
Television	1.434	.26938	5.32	0.000	.9062	1.962
Production level	.00986	.0047	2.08	0.037	.0005	.0191
_cons	-3.5058	.65134	-5.38	0.000	-4.7824	-2.229

Log likelihood = -110.40442 Prob> chi^2 = 0.0000

LR Chi^2 (10) = 431.45 Pseudo R^2 = 0.6615

Number of obs = 500

Source: Survey result, 2016

3.10.3 Marginal Effects of Factors Determining the Probability of Output Market Participation

To facilitate interpretation of the estimation results presented in table 3.8, the marginal effects of each variable on the predicted probability of households' market participation, evaluated at the means of the explanatory variables, are reported in table 3.9. The marginal effects report of the probit regression provides the probability that a farm household will participate in output markets.

Table 3.9: Marginal effects of the explanatory variables used to estimate probit regression

	Delta-method dy/dx	Std. Err.	z	P>|z|	[95% Conf. Interval]	
Age	.00083	.00258	0.32	0.746	-.0042	.0059
TLU*	-.04967	.01930	-2.57	0.010	-.0875	-.0118
Off farm income	-.00001	.00001	-1.6	0.10	-.00004	3.99e-0
Household size	-.0209	.01127	-1.86	0.063	-.0430	.001
Road quality	.17878	.057	3.11	0.002	.0662	.2913
Sex	.02111	.15038	0.14	0.888	-.2736	.3158
Education	.05138	.08840	0.58	0.561	-.1218	.2246
Credit	.10547	.05978	1.76	0.078	-.0116	.2226
Animal cart	.10189	.05717	1.78	0.075	-.0101	.2139
cooperative	.25455	.05852	4.35	0.000	.1398	.3692
Extension	.23114	.06634	3.48	0.000	.1011	.3611
Radio	.40142	.06750	5.95	0.000	.2691	.5337
Mobile	.26664	.06393	4.17	0.000	.1413	.3919
Television	.37616	.0855	4.40	0.000	.20849	.5438
Production Level	.00258	.00128	2.02	0.043	.00007	.005

Source: Survey data, 2016

3.10.3.1 Household Size

The predicted probability of output market participation reduces by 2.1% for every member increase in the farming household head's family, holding all other independent variables at their means (Table 3.9). This marginal effect is said to be significant at 0.1 level. This implies that, as the family size of smallholder farmer increases, the probability of participating in output market reduces. The finding satisfies *a priori* expectation, because increase in the household size would increase household's food consumption requirement and probably this reduces household's probability to participate in output market. The result perhaps suggests the subsistence, low-productivity nature of crop production among smallholder farmers in the study area. In such subsistence oriented farming system, the quantity of crop produced cannot surpass their family consumption resulting in reduced marketable surplus available for sale. Interestingly, similar to Seng (2016) and kyaw et al. (2018), we find larger family sizes are less likely than smaller family sizes to participate in sales of agricultural products. Sigei et al. (2014) found negative but statistically insignificant association between household size and probability of market participation among small-scale pineapple farmers in Kericho County, Kenya.

3.10.3.2 Livestock Ownership

The change in predicted probability for one instant change in tropical livestock unit owned by smallholder farmer is 4.9 percentage points lower in predicted probability of output market participation given that the rest of the variables in the model are at their mean values (Table 3.9). This means that as livestock ownership of the farmer's increases, the predicted probability of their orientation towards cereal crop commercialization reduces. The marginal effect of livestock ownership on the probability of output market participation is negative and significant at 0.01 level. This significant but negative effect of livestock ownership on the predicted probabilities of smallholder farmers' output market participation implies that the income earned from livestock sale might be used to solve farmers' cash constraints that in turn reduce the likelihood of their decision to participate in the crop output market.

Previous study among smallholder farmers in Bangladesh showed that the decision of smallholders to enter crop output markets is influenced by number of livestock owned (Osmani & Hossain, 2015). Accordingly, Osmani and Hossain found statistically significant and negative effect of income from livestock on market participation decision of smallholder farmers. The possible explanation for this might be the fact that, since livestock asset is considered to be the most important and alternative livelihood source for smallholder farmers, it might disperses farmers into alternative sources of income limiting the probability of cereal crop output market participation. On the contrary, Kyaw et al. (2018) found positive but insignificant association between livestock ownership and the probability of smallholder farmers ' market participation among smallholder rice farmers in Magway Region, Central Dry Zone of Myanmar.

3.10.3.3 Road Quality

Access to better road conditions showed a positive effect on the predicted probability of smallholder farmers' output market participation and it was significant at a 0.01 level (Table 3.9). In particular, the result tells us that, if we had two farmers one who has access to better road conditions, the other without having such access, the predicted probability of participating in output market would be 18 percentage points higher for the one who have access holding all other variables in the model at their means. This result reveals that smooth movement of crop outputs from rural areas to urban markets due to better road condition encourages smallholder farmers'output market participation. During the focus group discussions (FGDs), model farmers were asked about the status of road that connects rural areas with urban centers. They asserted that due to bad road condition they are not beneficiaries to access output markets. Particularly, model farmers in Abe Dongoro and Amuru mentioned poor road accessibility as one of the major factors influencing smallholder farmers' access to and participation in output markets. Key informant interviews with district agricultural office and rural kebele managers in Amuru district also complemented the focus group and survey findings.

This finding is in line with the findings of Kyaw et al. (2018), who showed that good road infrastructures facilitate the movement of agricultural products from farm to market areas that in turn reduces transactions costs encouraging the likelihood of farmers' market participation. Concerning the relationship between commercialization of smallholder farmers and quality of road transport, in another study in Ethiopia it was found that that proximity to all-weather road encourages the probability of market participation due to its effect of reducing marketing costs (Getahun, 2015). This implies that access to improved road condition to access output market is a very essential factor in the binary decision of output market participation among smallholder farmers.

3.10.3.4 Access to Credit

Smallholder farmers who have access to credit are 10.5 percentage points more likely to participate in output market as compared to those who do not have access to credit (Table 3.9). Thus, keeping other variables at their means, this 10.5 percentage point difference between the two groups of smallholder farmers is significant at 0.1 level. The moderately significant effect of access to credit for output market participation can somehow show that affordable and reliable credit availability provides incentives for farmers to make additional investments like adoption of agricultural technologies that in turn generate enormous marketable surplus.

According to Adekunle et al. (2012), more limited access to credit imposes restrictions on output market participation of smallholder farmers by limiting their capacity to access modern agricultural inputs that improve their production and productivity. Research results concerning the link between market participation and access to credit show that constrained access to credit restrain the capacity of smallholder farmers to produce surpluses for the market (Olwande & Mathenge, 2011). On the contrary, the availability of affordable and reliable credit to smallholder farmers increases their marketing capacity (Stephens & Barrett, 2011). Since credit is critical in accessing output market opportunities, therefore, increasing its access for smallholder farmers can be of great value in enhancing the households' access to markets.

3.10.3.5 Extension Visit

As farmer support services extension visit has a positive and strongly significant impact on the predicted probability of output market participation. A probit marginal effect estimates indicated that holding other variables in the model at their means, a smallholder farmer that had contacts with extension workers was about 23 percentage points more likely to participate in output market compared to a similar smallholder farmer that did not have contacts with extension workers. This effect is said to be significant at 0.001 level. The finding could be due to the fact that agricultural extension programs are expected to improve access to information and technical skills of smallholder farmers, thus improving their likelihood of output market participation.

This result is in line with Alene et al. (2008), Kahkonen and Leathers (1999), Gani and Adeoti (2011), Regasa et al. (2019) and Kyaw et al. (2018). In their study of the overall commercial transformation process of smallholder agriculture in Ethiopia, by using

Heckman's two-step estimation procedure Gebremedhin, Jaleta, & Hoekstra (2009), showed that involvement in the extension program was associated with higher smallholder market participation. In addition, Muricho (2015) by using double-hurdle regression model assessed the impact of extension contacts on household commercialization process and he found that a household that had contacts with extension workers was likely to be more market oriented than a similar household that had no contacts with extension workers. Moreover, Gebremedhin and Hoekstra (2008) found improved extension system, technical supervision and follow up as a crucial strategy to promote market-oriented chickpea production among smallholders in Ethiopia. To best address the needs of subsistence farmers, Berhanu (2008) also recommended locally compatible and economically affordable agricultural extension packages that respond to market conditions.

Contrary to our finding, Mmbando (2015), Mbitsemunda and Karangwa (2017) and Woldeyohanes (2013) found no significant influence of access to agricultural extension service on the probability of market participation. This contradictory result might be related to the nature of extension services provided by extension workers that give more emphases on provision of agricultural inputs and credit service at the expense of output marketing strategies. Since improved and specialized extension services are central to efforts to promote smallholder output market participation, extension programs the equip extension agents with tools and methods of market-oriented extension, agricultural marketing and value chains need to be in place.

3.10.3.6 Ownership of Local Mode of Transport

When all other variables are equal at their means, for two hypothetical smallholder farmers, the predicted probability of participating in output market is 10.2 percentage points greater for a smallholder farmer who own animal cart as compared to the one who do not own animal cart as a means of transport and this difference is said to significant at 0.1 level (Table 3.9). This suggests that the ownership of animal transport as an alternative means to carry farm output to the nearest market place is the key component that determines the probability of market participation. In FGDs with community elders, model farmers and extension agents, a large majority expressed that ownership of equines as a means of transport reduces costs of transporting crop produce from farm to home and from home to market place. In KII, Abe Dongoro district agricultural officials also mentioned the challenge of transporting produce to market especially for those farmers who lack local means of transport like animal carts and pack animals.

The most accepted theoretical setting that inform whether smallholder farmers participate in output market or not focuses on the transaction costs faced by smallholder farmers. As a result, asset endowments, such as the ownership of a means of transport to market (donkey, horse and mule) and animal carts all determine the cost of engaging in output market (Poole, 2017; FAO, 2014). Therefore, ownership of transport equipment such animal carts and vehicles is expected to have a positive effect on the predicted probabilities of output market participation by reducing the cost of transporting crop produce from farm to home as well as from home to the market (Melesse, 2017).

Using double hurdle model of market participation, Turaa et al. (2016) also found a positive significant effect of own transportation equipment such as animal cart and donkeys on the likelihood of participation in *teff* output markets in Bacho and Dawo districts of central Ethiopia. According to their study, animal carts and pack animals were used to transport *teff* produce from the field to homestead or home to the market in the study area. They further found a significant difference in the probability of *teff* output market participation between smallholder farmers who own their transport equipment and those who lack access to such cheaper local animal transportation. This could be due to the fact that in the absence of motorized vehicle to transport crop produce to market, ownership of local transport equipment is an important determinant of the ease of smallholder farmers' output market participation. Therefore, to encourage farm households to invest in marketable crop production, the study recommends that efforts should be made at improving rural roads and support establishment of more points of sales in local areas in order to lower transportation costs to promote output market participation. Overall, policies, and priorities that aimed at reducing the costs of physical access to local markets is a key focus to ensure smallholder farmers' participation in output markets and increase their ability to make contribution to economic growth.

3.10.3.7 Ownership of Communication Equipments

The change in predicted probability of output market participation when smallholder farmers own radio, mobile and television, as compared to those who do not own these communication equipments increases by 40, 26 and 37 percentage points respectively (Table 3.9). These marginal effects are significant at 0.001 level. The positive signs of the marginal effects of the probit regression implies that when the farmers own these communication equipments, the likelihood of participation in output market increases.

This finding corroborates that of FAO's (2014) who found that in Kenya the costs of searching for and screening trading partners had have a negative and significant effect on the probability of farmers participating in maize output markets. Also, it is consistent with the finding by Azam et al. (2012) that showed ownership of communication equipments lowers the fixed transaction costs related to information search, bargaining about the prices and best periods for selling crop produce thereby enhancing the probability of output market participation. They further revealed that fixed transaction costs tend to be higher for smallholder farmers living in remote of rural Cambodia with poor or no communication/information assets such as television, telephone and radio. Similarly, many other development literatures attribute the perceived poor probability of cereal crop output market participation in developing countries to the existing poor access to communication/information networks which in turn exacerbates the fixed transaction costs of output market participation limiting the likelihood of smallholder farmers' decision to participate in markets (Olwande & Mathenge, 2011; Amao & Egbetokun, 2018).

For example according to the study by Olwande and Mathenge, ownership of communication equipment such as television, radio, and/or telephone is positively and significantly associated with a greater probability of participating in fruits, vegetables, and milk markets among poor rural households in Kenya. In their study of market participation among leafy vegetable farmers in Nigerea, Amao, and Egbetokun (2018) further asserted that access to communication assets (ownership of radio or telephone) were found to be important in facilitating access to information that in turn is expected to improve market participation of leafy vegetable farmers by reducing search costs when seeking buyers.

3.10.3.8 Membership to Cooperative or Producer Organizations

From the probit regression model (first hurdle) result, membership to cooperative organization is found to be essential factor for output market participation with a marginal effect of 0.25 significant at 0.001probability level (Table 3.9). Accordingly, smallholder farmers who are members of producer or farmer organizations such as cooperatives are 25 percentage points more likely to participate in output market than their counterparts. This implies that agricultural cooperatives are important institutional tools that help improve output market participation of smallholder farmers. One of the possible justifications for this is that collective action by smallholder farmers can create stronger bargaining power in the market for outputs and thus contribute to greater likelihood of market participation.

In FGDs, model farmers in Horro district who are also members of *chafee buluk* farmers cooperatives, mentioned two objectives why they joined *chafee buluk* farmers cooperatives: 1) for better access to agricultural inputs and 2) to improve their access to output markets. However, during the discussion, they clearly expressed their dissatisfaction with their cooperatives failure to access both input and output markets. They also question the transparency issues on its governance (management), and performance. Throughout the FGD, model farmers frequently mentioned that board members of their cooperatives are performing below the standard. This is also further confirmed by the results from KII with rural kebele managers. During FGDs in Abe Dongoro district, non-members of *Tullu Lafto* farmer's cooperatives alike understood the advantage of being member of a farmer cooperative in overcoming barriers to input and output market participation. However, they claimed that, even though they are willing to join *Tullu Lafto* farmers cooperative, they are asked to pay initial membership fee which is not affordable to the majority of smallholders.

Different scholars have carried out extensive research on the role of membership to farmer organizations in overcoming access barriers to extension services, information and output markets (Akinlade et. al., 2013; Mmbando et al., 2015; FAO, 2014; Olwande & Mathenge, 2011). For example, according to the research conducted in Nigeria by using cross-sectional data, Akinlade et. al. (2013) identified those farmers who were members of a local institution, their market participation increased by 0.16%. They further argued that agricultural cooperative easily links smallholder farmers to buyers and this has helped them to reduce the fixed cost of market search. This finding is also in line with those of Mmbando et al. (2015), who have also shown a positive and significant relationship between membership to farmer associations and household participation in maize market in Tanzania. According to their finding belonging to a farmer association increased the predicted probability of maize market participation by 9%. By using double hurdle econometric model, Muricho (2015) found a positive and significant effect of household membership to agricultural production group on the probability of household commercialization among smallholder farmers in Kenya.

In the overall, farmer cooperative associations are good platforms for exchanging information enabling farmers in cooperatives better opportunities to participate in output market as opposed to their non-member counterparts. In order to improve the probability of smallholder farmers output market participation, producer organizations such as cooperatives as an institutional tool that help build social capital should be strengthened as it also encourages household economy by facilitating market access and competitiveness and mitigate risks and uncertainties for smallholders.

3.10.3.9 Quantity of Output Produced

Crop yield significantly and positively influenced the likelyhood of smallholder farmers' output market participation. An increase in total production of crop yield by one quintal increases the probability of participating in output market by 0.26%, all other variables held at their means (Table 3.9). This implies that as the crop yield increases, the probability of market participation also increases. In another way, this study shows that for the probability of output market participation to be increased smallholder farmers should produce a considerable yield to enable them have a marketable surplus.

During FGDs concerning about the factors affecting market participation decision of smallholder farmers, marketable surplus was emerged as a primary theme across all focus group discussions in all districts. In FGDs, participants cited that small householder farmers with more crop production would have more surpluses to sell to the market. This finding was further supported by key informant interviews with district agricultural officials and rural kebele managers as well as by survey results of the probit regression analysis (Table 3.9).

This is in line with the findings of Jaleta, Gebremedhin, and Hoekstra (2009), Kyaw et al (2018), Reyes (2012) and Mather et al. (2013) who found that an increase amount of agricultural yield augment the market supply of agricultural commodities significantly. By using double-hurdle model of factors influencing potato marketing decisions in central highlands of Angola, Reyes (2012) found that quantity of potato production had a significant and positive effect on the probability of its market participation.

In another study about factors influencing market participation among smallholder rice producers in Zambia, Moono (2015) found a substantial difference in rice output per hectare (Yield) between participants and non-participant of rice output market. In the same manner, Sigei (2014) investigated the effect of pineapple yield level on probability of pineapple market participation. Accordingly, they found statistically significant difference in the probability of pineapple market participation between market participants and non-market participants. Therefore, it can be concluded that higher crop output level greatly determine smallholder farmer's decisions regarding whether or not to sell their crop output.

While the question of how best to increase the probability of smallholder farmers' output market participation is currently the focus of much debate, it is clear that improvements in access to institutional factors (credit and extension) that increases access to necessary inputs and other productive assets will improve the ability to produce sufficient output for consumption as well as surplus for the market. Therefore, production and productivity enhancing agricultural policies and strategies should be implemented to stimulate surplus production for the market.

3.10.4 Factors Determining the Intensity of Output Market Participation of Smallholder Farmers

As already noted, of the 500 sample respondents 179 participated in crop output market in 2015/16 crop production period and the remaining (321) respondents did not participated in crop output market during the stated period. It is evident that those who participated in output market they would differ in the intensity of participation (amount sold). Therefore, the intensity of participation was estimated using the truncated regression model as presented in table 3.10.

3.10.4.1 Distance from the Nearest Market Center

The result of truncated regression model (second hurdle) revealed that distance from home to the nearest output market center (a proxy variable for proportional transaction cost) is key determinant of the intensity or degree of output market participation. For those who decided to participate (those who passed the first hurdle), the distance from farm household home to crop output market was negatively affecting the intensity of output market participation by 23.7% and significant at 0.001% probability level (Table 3.10). This means that a 1km increase in distance from the nearest market will decrease the intensity of output market participation by 23.7 percentage points setting all other variables in the model at their means. Therefore, those smallholder farmers who are far away from output market reduce their crop sale relative to those who are nearest to it. This indicates that proportional transaction costs supplemented by fixed transaction costs limit the intensity of output market participation of smallholder farmers.

Based on a qualitative analysis of the transcribed data from FGDs, long distances from output markets were among the major primary themes emerged across all FGDs. During the FGDs model farmers pointed that long distance coupled with the high transportation cost and the poor rural access roads are disincentives to agricultural output marketing. They further asserted that distance matters because of transportation costs and it is exaggerated by the inefficient modes of rural transport used to transport agricultural produce to market centers. This is also confirmed by KII and survey results that the volume of crop produce supplied to market declines as distance increases. According to some key informants, long distance the nearest output market discourages large scale production and hinders commercialization of smallholder agriculture.

Table 3.10: Truncated regression model results for the intensity of crop output market participation

	Delta-method dy/dx	Std. Err.	z	P>|z|	[95% Conf.	Interval]
Age	-.0026	.03163	-0.08	0.933	-.0646	.059
TLU	-.265156	.21280	-1.25	0.213	-.6822	.1519
Off farm income	.000897	.0001	6.70	0.000	.0006	.0011
Household size	-.366043	.14667	-2.50	0.013	-.6535	-.0785
Dist to market	-.237076	.05461	-4.34	0.000	-.3441	-.1300
Transport cost	-1.84497	.5147	-3.58	0.000	-2.85	-.836
Price crops	.173391	.74484	0.23	0.816	-1.28	1.633
Credit	-.611649	.77207	-0.79	0.428	-2.124	.901
Animal cart	1.44333	.76214	1.89	0.058	-.0504	2.937
Time to_sale	-.349245	.15667	-2.23	0.026	-.6563	-.0421
No market outlet	.16436	.3180	0.52	0.605	-.4590	.787
Production Level	.149227	.02040	7.31	0.000	.1092	.189
Lower limit= 0				Number of obs = 179		
Upper limit = +inf				Wald $chi^2(12)$ = 1000.01		
Log likelihood = -486.31749				Prob > chi^2 = 0.0000		

Source: Survey result, 2016

The finding in this study is conforming to Ademe et al. (2017); Kyaw et al. (2018); Mmbando et al. (2015); Turaa et al. (2016); Selowa et al. (2015) and Gebremedhin et al. (2009), that distance from market had negative and significant influence on intensity of smallholder commercialization. For instance, Mmbando et al. (2015) found statistically significant and negative relationship between distance to nearest market and the intensity of maize market participation among smallholder farmers in Tanzania. Turaa et al. (2016) also found that farmers located one kilometer away from the market center in Bacho and Dawo districts of Ethiopia reduces their transacted quantities of *teff* crop by 2%. Another study conducted among small-scale tomato producers in Limpopo province of South Africa indicated that the quantity of tomato transacted will decrease with more distance travelled to output markets (Selowa et al., 2015). According to another study in Kampala city, longer travel distances and time from the suburban areas to the city centre limited the range of poor people's mobility and hence their livelihood opportunities (Janusz, et al., 2019).

In studying the economic importance of small towns for rural hinterlands or surrounding smallholder farmers, G/Egizabher (2001) also argued that the availability of nearby output market reduces transportation cost and encourages smallholder farmers to bring their produce to markets. G/Egizabher further explained that if market towns are not well connected to the rural areas, commercial transformation of smallholder agriculture will be impossible and smallholders continue to experience subsistence production. As a result, our finding supports the transaction cost theory that argues economic efficiency will be gained by minimizing the proportional costs of exchange (Kherallah & Kirsten, 2002; key et al., 2000).

Our finding is also in line with findings from a study by Gebremedhin et al. (2009) in which distance negatively influenced the extent of market participation of small-scale farmers. Gebremedhin et al. (2009) further reported that an increase in a one km distance from the nearest market decreases the intensity of crop output market participation by about 1.6%. The implication for this is that the intensity of output market participation will decrease with more distance travelled to output markets.

On the contrary, in their study of the determinants of cereal market participation by sub-Saharan Africa smallholder farmers, Siziba et al. (2010) reported significant but negative association between volumes of cereal grain sold and the distance to output market center. This may be due to the fact that nearer local markets offer lower cereal prices as compared to distant markets that offer higher prices and therefore more quantities of cereal will be sent to distant markets than to nearer local markets. Overall, the results suggest that policies aimed at establishing village output market centers and improving rural road infrastructure could reduce the proportional transaction costs and enhance intensity of output market participation (marketed supply) by smallholder farmers.

3.10.4.2 Off-farm Income and Intensity of Output Market Participation

Off-farm income of the farm household head was positively related to the intensity of crop output market participation at 0.1% probability level. For those smallholder farmers who decided to participate (those who passed the first hurdle), off-farm income was positively affecting the intensity of output market participation by 0.1% (Table 3.10). This means that a 100 Ethiopia birr increase in off-farm income will increase the intensity of output market participation by 10 percentage points setting all other variables in the model at their means. The justification for this is that, engaging in off-farm activities such as *non*- agricultural wage employment, self-employment, remittances, and other income such as capital earnings and pensions can allow smallholder farmers to get more access to information and social networks. Hence, off-farm activities would influence the degree or extent of participating in output markets.

Past studies have found mixed results concerning the relationship between smallholders' off-farm income and their intensity of market participation. For example, Seng (2016) found negative and significant relationship between self-employment and participating in markets among farm households of rural Cambodia. Seng further argued that smallholder farmers involving in self-employment are likely to be discouraged from selling large volumes of produce in markets. One possible reason for Seng's finding is that, when smallholder farmers engage in such off-farm activities, they may face a shortage of labor available for farming activities that in turn reduce their production level, finally resulting in reduced intensity of market participation. Similarly, Mbitsemunda and Karangwa (2017) found negative but statistically insignificant relationship between access to off-farm activities and extent of participating in bean markets in Rwanda. This was also supported by the findings of Jaleta and Gebremedhin (2012); Mussema et al. (2013); Martey (2012) who found that the increase in off-farm income reduced the market participation intensity of cereal growers. This implies that if smallholder farmers tend to generate cash from off-farm activities that can ease their cash constraints, then their intensity of output market participation will be reduced.

But, our finding concurs with that of Siziba et al. (2010); Alkali (2017); Turaa et al. (2016) who reported that farmers' intensity of output market participation is positively and significantly related to the amount of off-farm income earned. For example, Siziba et al. (2010) observed that off-farm income is positively associated with high quantities of cereal grain sales among smallholder farmers in sub-Saharan Africa. They further revealed that conditional on the probability to participate in cereal market as a seller, a one unit additional off-farm income will brought about a 4.1% increase in the volume of crop sold. In her analysis of market participation among women soybean farmers in Nigeria, Alkali (2017) found a positive and significant influence of off-farm income on the volume of Soybean sales. She further revealed that at 0.01 level of significance, a one Naira increase in off-farm income will produce a 0.25% increase in the intensity of soybean sale.

By using a double hurdle model of market participation, Turaa et al. (2016) also found a 0.12% increase in the amount of *teff* marketed surplus for every 1% increase in off-farm income among *teff* producers in Bacho and Dawo districts of central Ethiopia. This result implies that farmers engaged in off-farm activities to earn income in addition to farm income; they tend to invest more resources to agricultural production and marketing, which possibly results in higher amounts of crop sold. This suggests that diversifying income sources such as trading and wages among others for smallholder farmers is necessary to boost crop production and quantities of marketed surplus.

3.10.4.3 Transport Cost and Intensity of Output Market Participation

Transport cost which was a proxy for proportional transaction cost is a fundamental determinant for the intensity of output market participation because it is a per-unit cost of accessing the market that can increase as the volume of transacted commodity increases. The results in Table 3.10 indicated that transport cost incurred to move farm produce to market had high negative and significant influence on the intensity of output market participation in the study area at 0.001significance level. The truncated regression results (second hurdle) showed that the increase in transport cost by one Ethiopian birr decreases the quantity of crop supplied to market by 1.8 percentage points. The negative and significant effect of transport cost underscores the adverse impact of increased transportation cost on the intensity of cereal market participation. Most cereal grain market centers are usually urban based, and prices are relatively better in these urban areas as compared to in remote villages. Therefore, smallholder farmers located in more remote villages will be discouraged from selling high volumes of crops probably because of the deterrent variable transportation costs.

As reported in FGD and triangulated with survey results of truncated regression, smallholder farmers are often constrained by transport cost. As explained by local elders and model farmers during FGD, this is specially a big challenge for remote locations and for households who do not have their own local transport means. Key informant interviews with district agricultural officials in all districts complemented the focus group and survey findings. They further identified and explained geographic isolation as a bottleneck for output market participation since it creates a wedge between market and farm gate prices. During key informant interview, rural kebele managers asserted that smallholder farmers living further away face high transportation costs hence they are forced to sale at farm gate prices. This in turn discourages smallholder farmers from selling high volumes of crops due to the low farm gate price offered by buyers.

These results are consistent to finding of Alkali (2017) who reported that transport costs per unit of distance increases with the potential marketable load size. She further argued that for women smallholder farmers in very remote rural areas of Nigeria, geographic isolation through distance creates a great price difference between market and farm gate prices. Similarly, Tolossa (2003) in his seminal article revealed that poor transport services are bottlenecks for marketing of agricultural products like fruits, vegetables and other cash crops in Munessa wereda, South-central Ethiopia. Moreover, in his seminal study, Berhanu (2009) also found low prices of major staple food grains immediately after the harvesting period in Tarmaber and Ensaro-Wayu districts of North Shewa Zone.

This implies that as transportation cost increases, the volume of crops supplied to markets decreases. Hence, smallholder farmers living further away from urban market centers face high transportation costs which further minimize the intensity of output market participation.

Moreover, Seng (2016) reported that smallholder farmers in Cambodia gain less prices from supplying produce to domestic supermarkets because they face high transportation costs. Consequently, these smallholder farmers supply their produce to traditional markets which offer them lower prices than do supermarkets. As a result, they may get stuck in subsistence farming which in turn affect the intensity of their participation in markets. In a similar fashion, Moser et al. (2006) studied the key role of reduced transport cost in promoting rice commercialization among rural localities of Madagascar. In their analysis they suggest that the existence of high proportional transaction costs, such as high transport margins between remote rural areas and urban centers are associated with lower intensity of output market participation. This implies that, as a result of proportional transaction costs (transport costs) associated with reaching urban markets that offer higher prices, some smallholder farmers are not able to sell their crop produce at these urban market centers.

Hence, access to public transportation and infrastructure, such as vehicles, road and bridge play crucial role to connect farmers to markets contributing to increased commercialization of rural agriculture. Therefore, specific policy recommendations include: subsidized transport costs for smallholders in remote areas, rehabilitation or improvement of weak road and communications infrastructure as well as investing in new transport infrastructure to reduce the costs of output marketing.

3.10.4.4 Ownership of Local Transport Assets and Smallholder Farmers' Intensity of Output Market Participation

The result of the truncated regression (second tier), which is the intensity of output market participation stage (amount sold), reveals that ownership of animal cart by respondents significantly increases the extent of output market participation. The marginal effect of 1.44 implies that holding all other variables in the model at their means, the intensity of output market participation is expected to increase by 144% when a smallholder farmer owns animal cart, which is being significant at 0.1 probability levels (Table 3.10). This demonstrates that ownership of pack animals for transporting outputs from home to market helps farmers to supply more quantities of crop to the market contributing to greater degrees of commercialization of rural agriculture.

This finding is consistent with the findings of Kabeto (2014) who found a significant difference between red bean market participants and non-participants with regard to ownership of means of transportation like pack animals and animal drawn carts in Halaba special district of Ethiopia. Kabeto also argued that in addition to smallholder farmers, urban collectors and assemblers mainly used pack animals and animal carts for transportation of red beans. Poole (2017) and Jagwe (2011) also found that the ownership of local transport equipments by smallholder farmers opened up new market opportunities in rural areas since such mode of transport is the only means of transportation for most rural households. This means that ownership of these local transport equipments could enable smallholder farmers to access niche markets thus increasing their intensity or extent of market participation.

Moreover, Gebre-Egizabher (2001), whose seminal study looked closely at the role of town markets in creating output markets for smallholder farmers, reported that significant number of farmers go to the market often on foot, with limited use of transport animals. Accordingly, he found that, of the total smallholder farmers under study, 94.4% in Robe Woreda and 67% in Limu Kossa woreda often go to market on foot, while only 2.4% in Robe Woreda and none in Limu Kossa woreda used animal back as mode of transport to go to market.

By using econometric analysis of panel data from smallholders in Kenya, Mozambique, and Zambia, Mather et al. (2013) found that ownership of local transportation assets such as pack animals and animal carts positively and significantly influenced the intensity of market participation among maize producers. Specifically, in Kenya, they reported that ownership of a cart by smallholder farmers improved the quantity of maize sold among sellers by 63%. In addition, Reyes et al. (2012) found that transportation assets ownership influenced the intensity of market participation positively and significantly among potato growers in the central highlands of Angola. Accordingly, conditional on market participation, ownership of local transportation assets increased the quantity of potatoes sold by 38.4% at 0.05 probability level (Reyes et al., 2012). This was conceivably due to the fact that ownership of transportation assets could easily be used to transport potatoes to local markets or other places for sale that further contributes to reduced market related transaction costs.

In general, our finding supports the theory of transaction cost that best explains the effect of access to transportation assets on smallholder farmers' crop sale behavior (Kirsten &

Sartorius, 2002; Kherallah & Kirsten, 2002).Thus, to boost smallholder farmers' intensity of output market participation, investments may be needed to help them own more transport assets through improving veterinary services for transport animals. Investment in rural roads and foot paths are also very imperative to promote commercialization of subsistence agriculture.

3.10.4.5 Time Spent Selling Crops and Intensity of Output Market Participation

The cost of total time spent in marketing crop output has a significant impact on quantity of marketable surplus. Holding other factors constant, for each one-hour increase in time spent on crop marketing activities (waiting for transport, going to market, dealing with buyers and returning back to home), quantity sold decreases by about 35 % significant at 0.05 probability level. This implies that due to bad roads and poor public access to output markets, considerable time was spent selling (marketing) crops that in turn causes intensity of market participation to decline. In other words, crop marketable surplus is declining with respect to increases in the amount of time spent selling (marketing) it.

The current results confirmed the hypothesis that smallholder farmers with reduced time spent crop marketing tend to supply more quantities of crop for market. This is partly because farmers need to work longer hours on agricultural activities and spend fewer hours on marketing activities. This finding confirms the assertion from transaction cost theory that selling behavior of the smallholder farmers is determined by the amount of time that it takes to move the produce to market.

Participants of the FGDs and the KIIs in this study argued that lengthy or delayed payment was one of the constraints that affect smallholder farmers' output market participation. Most model farmers in focus groups complained that they often do not receive payment for their produce on time specially when they deliver their produce to farmer cooperatives. In Ababo Guduru district, focus group discussions of extension agents, model farmers and local elders expressed an opinion that the time and cost of getting produce to market is an obstacle making it difficult for farmers to increase the quantity supplied to market. They further added that due to time constraints, farmers choose to spend more time working on their farms than on transporting and marketing produce. At the same time, KIIs in all districts of the study area displayed an awareness of the fact that if farmers get payment for their produce on time, they devote a greater proportion of their time to farm activities. They noted that ‘smallholder farmers often do not receive payment on the same day they deliver their crops to farmer cooperatives, hindering them not to continue to supply to the market’.

This result is in agreement with the findings of a great deal of the previous work in this field. For example, Holloway and Ehui (2002) found that minimizing the time required to market milk increased the number of participating producers and the level of marketable surplus. In their study they also revealed that for each one-minute increase in return time to transport milk to market center, the level or amount of marketable surplus decreased by about 0.06 litres. Using survey data from the cereal sub-sector in Guinea, Camara (2017) also reported time spent to deliver output to the market as one of the determinant factor that influence transacted volume of staple food grains among smallholder farmers.

In their study in the great lakes region of Burundi, Jagwe et al. (2010) reported time spent travelling to the nearest market center as an important determinant of intensity of participation in markets. According to Musah et al. (2014), since crop marketing activity is more costly and time consuming, smallholders choose to sell more at farm-gate to reduce the cost of time travelling to big market centers even though bigger markets offer higher prices for crops being many times greater than the average price at far gate. The possible explanation for this is that longer distances and poor transportation networks increase travel time and travel costs, which impact negatively on intensity of market participation. Thus, building roads and improving the surface of existing roads contributes a lot towards removing the geographical constraints that farmers face with regard to time cost of getting produce to market.

3.10.4.6 Crop Output Level and Intensity of Market Participation

Smallholder farmers’ crop output level (quantity produced) is associated with more sales of crops conditioned on participation in markets and is significant at 0.001 probability level. The result of truncated regression model showed that for every one quintal of cereal crop produced, the intensity of output market participation increases by 14.9% (Table 3.10). The current study is therefore implied that smallholder farmers with high level of crop production tend to participate in the output market than those with lower crop production level.

This confirms the finding of Abu (2015) that the quantity of groundnut produced is associated with a higher level of groundnut market participation. According to Abu (2015), for every extra 50kg bag of groundnut production in the upper west region of Ghana, the intensity of its market participation increases by 1%. This is due to the fact that smallholders with higher quantities of crop produced sell higher proportion of their crop produce and thus, increase the intensity of output market participation.

Our finding is also similar to the findings of Gebremedhin and Jaleta (2012); Mbitsemunda and Karangwa (2017); Ayele, Tegegne, Zemedu (2018); Moono (2015), Kyaw et al. (2018), as well as Reyes (2012). For instance, in their study of factors influencing market participation of smallholder bean farmers in Rwanda, Mbitsemunda and Karangwa (2017) found statistically significant and positive association between bean quantity produced and its level of output market participation. This is perhaps an indication that the intensity or degree of smallholder farmers' output market participation is a function of their farm productivity too. The other study by Ayele et al. (2018) found a 0.64 quintal increase in quantity of wheat marketed due to an increase in 1 quintal in quantity of wheat produced among wheat smallholder farmers of Adola Rede district of Guji zone, southern Ethiopia. Moreover, according to Moono (2015) the amount of marketed surplus of rice was increased by 69.2 kg for each one percent increases in rice output produced among smallholder rice farmers in Zambia confirming the fact that higher crop output enables smallholder farmers to have marketable surplus. Thus, boosting total production level stands out as critical to improve smallholder farmers' intensity of output market participation.

3.10.5 Distance to all Weather Road and Smallholder Farmers' Output Market Participation

A one-way between groups analysis of variance (ANOVA) was conducted to compare the effect of distance to all weather road on intensity of crop output market participation of smallholder farmers. The average distance from the nearest all weather road, measured in km for smallholder farmer respondents were divided into four distance categories (0-7; 7-14; 14-21 and 21-27kms, inclusive of the lower bound and exclusive of the upper bound). Assumptions underlying the one-way ANOVA: assumption of independence, assumption of normality and assumption of homogeneity of variance were checked one after the other prior to data analyses and found to be reasonably met for the given samples.

There was a statistically significant effect of distance to the nearest all weather road on crop output market participation intensity of smallholder farmers at the $p<.05$ level for the four distance categories $F(3, 175) = 93.83$, $p = 0.000$ (Table 3.11). In this case, after running ANOVA, the result is $F = 93.83$ with a p-value that is essentially zero, our conclusion is to reject the null hypothesis by accepting alternative (research) hypotheses and conclude that the population means for the four distance categories are significantly different.

Post hoc comparisons using the bonferroni test indicated that there are significant differences in the mean scores on the intensity of market participation across the four distance categories. The mean intensity of output market participation for 0 to 7 km distance category ($M = 38.26$, $SD = 8.80$) was significantly different from the 7 to 14 km ($M = 24.04$, $SD = 4.73$), 14 to 21km ($M = 21.19$, $SD = 4.58$ and 21 to 27 km ($M = 17.88$, $SD = 2.64$) distance categories and vice versa. Eta squared was calculated as 0.62, indicating a large effect size well above the threshold of 0.14 (Cohen, 1989). Thus the findings for the intensity of crop output market participation difference across categories of distance to all weather road represents a substantive finding, given the statistical significance and effect size reported.

The mean output market participation intensity for each distance category is computed and the output is shown in Table 3.12. Looking at the means, the results appear that, as distance to all weather road increases, the mean output market participation intensity decreases, for example the mean intensity of market participation was significantly higher for 0 to 7 km than for the other three distance categories. Taken together, these results suggest that to enable remote smallholder farmers especially those who do not own any means of local transport (animal carts, pack animals) to access output markets, investment in rural roads, and creation of output markets close to farmers is desirable to reduce unnecessary transaction costs incurred due to transportation cost.

According to Jacoby (2000), road accessibility to output markets stimulates cash-crop farming in rural areas, and it lowers transport costs promoting greater degrees of output market participation. This is partly because access to all- weather roads which give rise to improved transport services and lower transport costs, smallholder farmers with good road access are more likely to participate in output markets and they tend to sell more quantities of crop output. Using household and village level data from Tigray, Northern Ethiopia, Arethun and Bhatta (2012) found that access to roads and towns had significant impacts on several agricultural practices including higher crop productivity and the intensity of output crop commercialization. Using similar household data for Kenya, Alene et al. (2008) found access to all-weather roads to be a determinant factor to gain access to output markets and other productive assets. A World Bank-financed survey of the impacts of rural road improvements in Bihar State, India, also showed that good access to road reduces the cost and travel time of agricultural produces moving from farm to urban markets.

Similarly, by using farm survey data from Kenya, Chamberlin and Jayne (2011) found distance from the village to the nearest tarmac road to be one of the major factors influencing rural households' access to and participation in output markets. They further argued that roads that support truck and bus traffic in both the rainy and dry seasons significantly contributes to reducing in farm gate prices of agricultural inputs and increasing farm gate prices of agricultural outputs, in both case benefiting small-scale farmers. In their recent work, Stifel and Minten (2003, 2007) studied the effect of remoteness on output market participation, poverty and food crop productivity in rural Madagascar. Accordingly, by using road-based travel time and cost as proxy indicators for remoteness they reported that remoteness increases transportation-induced transactions costs hindering the commercial transformation of smallholders. In Ethiopia as well, Mussema et al. (2013) found that the average distances to the all-weather road significantly and positively influenced the demand side of market participation. Thus, since rural road accessibility is a central concern for rural communities and is considered to be one of the major factors influencing smallholder farmers' probability and intensity of output market participation, so policies integrating remote areas with urban areas through infrastructure development such as rural roads and market infrastructure are recommended.

Table 3.11: ANOVA for intensity of crop output market participation difference across distance to all weather road categories

Source	SS	df	MS	F	Prob > F
Between groups	9749.33	3	3249.78	93.83	0.0000
Within groups	6060.99	175	34.63		
Total	15810.32	178	88.82		

Source: Survey result, 2016

Table 3.12: categories of distance to all weather road for the intensity of crop output market participation

Distance to all weather road category (KM)	Mean (M)	Standard deviation (SD)	Frequency
0-7	38.26	8.8051368	46
7-14	24.04	4.7292403	50
14-21	21.19	4.5816346	66
21-27	17.88	2.6429707	17
Total	26.06	9.4245448	179

Source: Survey result, 2016

3.10.6 District wise Differences in Intensity of Crop Output Market Participation/ District Dummy Variables

A one-way between subjects ANOVA was conducted to compare the effect of district dummies or location dummies (Ababo Guduru, Horro, Amuru and Abe Dongoro) on smallholder farmers' intensity of output market participation. The table 3.13 shows a statistically significant difference in the intensity of crop output market participation across districts of the study area ($F(3,175)=15.85$, $p<0.001$), where Horro district reported the highest intensity of crop output market participation ($M=30.78$, $SD=10.93$), whilst Amuru district reported the lowest intensity of crop output market participation (M=21.86, SD=5.38).

Meanwhile, post-hoc comparisons drawing on bonferroni test indicate a major difference in mean crop output market participation intensity between Horro district (M=30.78, SD=10.93) and those of Amuru district (M=21.86, SD=5.39), Ababo guduru district (M=25.92, SD=6.49) and Abe Dongoro district (M=21.29, SD=5.67). There was also a major difference in mean crop output market participation intensity between Ababo guduru district (M=25.92, SD=6.49) and those of Abe Dongoro district (M=21.29, SD=5.67) and Amuru district (M=21.86, SD=5.39) (Table 3.14). Eta squared was calculated as 0.21, indicating a large effect size well above the threshold of 0.14 (Cohen, 1989). Thus the findings for the intensity of crop output market participation difference across districts (geographic areas) among smallholder farmers represents a substantive finding, given the statistical significance and effect size reported. Therefore, geographical locations of smallholder farmers are significant in explaining the mean difference in crop output marketed supply. This is probably because districts differ with regard to physical infrastructure, remoteness and resource endowment, which can decrease/increase transaction costs.

This finding is consistent with the findings of different previous researches. For example, Mmbando et al. (2015) reported marked difference in the likelihood of households' maize market participation between Mbulu and Karatu districts of Tanzania due to differences in infrastructure development and relative remoteness. They further argued that smallholder farmers in Kilosa district are more likely to participate in the maize market compared with those in Karatu district, because of their greater access to output markets. With regard to maize marketed supply (intensity of market participation), Mmbando et al. (2015) disclosed lower values for smallholder farmers in Mbulu, Mvomero and Kilosa districts compared with Karatu district owing to the relatively good physical infrastructure found in Karatu district.

In the study of rice market participation among farmers in western province of Zambia, Moono (2015) found market participation differences among four districts (Mongu, Kalabo, Senanga and Limulunga. As a result, 72.92 percent of smallholder farmers in Senang district sold rice as compared to 64.14 percent only in Kalabo district. In their investigation of the determinants of output market participation of smallholder farmers in four regions of Ethiopia (SNNPR, Tigray, Amhara and Oromiya), Mussema et al. (2013) also found regional differences in output market participation decision and intensity. They further reported that smallholder farmers in Tigray (9.67%), Amhara (5.41%) and Oromiya (5.27%) were less likely to participate in output markets than in the SNNPR. Such regional differences in output market participation probably arise from regional differences in transaction costs that in turn influenced by the availability and status of physical infrastructure.

Table 3.13: Intensity of crop output market participation for different districts of study area

District dummy	Mean (M)	Standard deviation (SD)	Frequency
Ababo Guduru	25.92	6.49	24
Horro	30.78	10.93	77
Amuru	21.86	5.39	21
Abe Dongoro	21.29	5.67	57
Total	26.06	9.42	179

Source: Survey result, 2016

Table 3.14: ANOVA for intensity of crop output market participation difference across districts of the study area

Source	SS	df	MS	F	Prob > F
Between groups	3378.74	3	1126.25	15.85	0.0000
Within groups	12431.58	175	71.04		
Total	15810.32	178	88.82		

Source: Survey result, 2016

3.10.7 Effect of Agro-ecological Conditions on Intensity of Output Market Participation

A one-way between subjects ANOVA was conducted to compare the effect of agro-ecological conditions (dega, woynadega and kola) on intensity of output market participation. As indicated in table 3.15, there was a significant effect of agro-ecology on intensity of output market participation at the p<.05 level for the three conditions [F(2, 176) = 44.63, p = 0.000]. Post hoc comparisons using the bartlett's test indicated that the mean output market participation intensity for the dega agro-ecology (M = 34.23, SD = 11.03) was significantly different than the kolla (M = 21.27, SD = 5.43) and woyna dega (M = 24.38, SD = 6.22). Similarly, the mean output market participation intensity for the woyna dega agro-ecology (M = 24.38, SD = 6.22) significantly differ from the the kolla (M = 21.27, SD = 5.43) agro-ecology.

These results given in table 3.16 indicated that smallholders who reside in dega agro-ecology significantly experienced higher output market participation than did smallholders that reside in kola and woyna dega. The effect size for this significant pair-wise difference was 0.34, indicating a large effect size well above the threshold of 0.14 (Cohen, 1989). Thus the findings for the intensity of crop output market participation difference across different ecological conditions among smallholder farmers represents a substantive finding, given the statistical significance and effect size reported.

Previous research by Pender et al. (2006) and Jaleta et al. (2009) confirms our finding that in addition to the underlying socio-economic circumstances under which smallholders operate, the process of smallholder commercialization emanates from the agro-ecological circumstances. This implies that smallholders can increase the quantities of staple food commodities sold depending on the agro-ecological circumstances. From the demand side of market participation, in a study conducted by Berhanu (2008), agro-ecological factors were found to influence smallholder farmers' decision to use or not to use chemical fertilizers.

The agro-ecology related major food crop development is also responsible factor for the observed difference in the intensity of output market participation across different agro-ecological conditions. For instance, wheat which is the dominant and intensively marketed crop in dega agro-ecology as compared to maize which is of course dominant in kola and woynadega agro-ecologies but less marketed brought about the variations in the intensity of output market participation across agro-ecological conditions. In general the different agro-ecological factors like soil, altitude and rainfall influence the choice of cereals and livestock within the cereal–livestock system (Pender et al., 2006).

In their analysis of a three-year panel household data set across nine agro-ecological zones of Kenya, Olwande and Mathenge (2012) assessed the extent of market participation among poor smallholder farmers and evaluated the differing agricultural potential where Lowlands, Western transitional and Marginal rain shadow and the Highlands were labeled as the lowest, medium and High potential Zones respectively. Consequently, they reported lower market participation in marginal agricultural potential zones as compared to in lowlands, and highlands. In another study of determinants of smallholder commercialization of food crops, Pender and Alemu (2007) found negative but insignificant *teff* market participation for dega (highland) and woinadega (midland) agro-ecological zones as compared to kola (lowland) agro-ecology. Taken together, these results imply that due to the agro-ecology comparative advantage, the majority of smallholder farmers in the study area produce other crops other than *teff*.

Table 3.15: ANOVA Difference for intensity of crop output market participation across agro-ecological conditions of the study area

Source	SS	df	MS	F	Prob > F
Between groups	5320.14	2	2660.07	44.63	0.0000
Within groups	10490.18	176	59.60		
Total	15810.32	178	88.82		

Source: Survey result, 2016

Table 3.16: Intensity of crop output market participation across different agro-ecologies in the study area

Agro-ecology type	Mean (M)	Standard deviation (SD)	Frequency
kolla	21.27	5.43	71
weyna deg	24.38	6.22	55
Dega	34.23	11.03	53
Total	26.01	9.42	179

Source: Survey result, 2016

3.11 Conclusions and Policy Implications

Using farm household-level cross-sectional data collected from smallholder farmers in Horro Guduru Wollega zone of western Ethiopia, the study examined the determinants of cereal crop (maize, wheat and *teff*) market participation decision and intensity of participation. The result discloses that livestock ownership, road quality, access to credit, cooperative membership, extension visit, and ownership of communication equipments like radio; mobile phone and television have significant effects on binary decisions of output market participation.

Important policy options aimed at reducing fixed transaction costs (costs of market information, costs associated with searching for a trading partner, bargaining and supervision costs) enable smallholder farmers to gain the benefits associated with cereal crop marketing. Hence, providing better access to market information by improving access to communication equipments could be an important policy option to increase the likelihood of farmers to participate in agricultural produce markets.

The study also found significant and negative effects of proportional transaction costs such as distance to all weather road, distance to the nearest market and transport cost on smallholder farmers' intensity of output market participation. Therefore, the results suggest that policies and priorities that aimed at reducing the costs of physical access to local markets is a key to ensure smallholder farmers' participation in output markets and increase the intensity of their participation. These might include establishing village output market centers and improving rural road infrastructure. The study also revealed that smallholder farmers' asset ownership such as off-farm income, ownership of local transport asset like animal carts, household size and level or quantity of crop production significantly influenced both market participation decision and intensity or extent of participation. Therefore, policies that support smallholder farmers' asset building are another priority area to increase to increase both probability and intensity of output market participation.

Public services and assets such as agricultural cooperative membership, extension services and access to credit services are also important in solving smallholder commercialization bottlenecks and improving market participation decision and quantity of marketed supply. Therefore, this calls for development of institutional innovations and improving credit delivery systems. The effects of agro-ecological conditions and geographical locations on output market participation and marketed supply should not be under estimated. To do so, special attention should be given to the balanced distribution of transport and market infrastructure to ensure equal benefit of smallholder farmers across all districts of a region. Agro-ecology based output market development through comparative advantage is also equally important to increase the intensity of output market participation among smallholder farmers.

References

Abu, B. M. (2015). Groundnut market participation in the Upper West Region of Ghana. *GJDS, 12*(1 & 2). doi//http://dx.doi.org/10.4314/gjdsv12i1&2.7.

Ademe, A., Legesse, B., Haji, J. & Goshu, D. (2017). Smallholder farmers' crop commercilization in the highlands of eastern Ethiopia. *Review of Agricultural and Applied Economics*, *XX* (2), pp.30-37. doi: 10.15414/raae/2017.20.02.30-37

Admassie, A., Berhanu, K., & Admasie, A. (2016). Employment Creation in Agriculture and Agro-industries in the Context of Political Economy and Settlements Analysis. Partnership for African Social and Governance Research Working Paper No. 016, Nairobi, Kenya.

AESE [Agricultural Economics Society of Ethiopia] (2006). Commercialization of Ethiopian Agriculture. Proceedings of the 8th Annual Conference of the Agricultural Economics Society of Ethiopia, February 24-26, 2005, Addis Ababa.

Akaranga, S. I., & Makau, B. K. (2016). Ethical considerations and their applications to research: A case of the University of Nairobi. *Journal of Educational Policy and Entrepreneurial Research, 3* (12), pp. 1-9.

Akinlade, R. J., Balogun, O. L., & Obisesan, A. A. (2013). Commercialization of Urban Farming: The Case of Vegetable Farmers in Southwest Nigeria, Invited paper presented at the 4th International Conference of the African Association of Agricultural Economists, September 22-25, 2013, Hammamet, Tunisia.

Alemu, D., & Berhanu, K. (2018). The political economy of agricultural commercialisation in Ethiopia: discourses, actors and structural impediments. Working paper number 14.

Alene, A. D., Manyong , V. M., Omanya, G., Mignouna, H.D., Bokanga, M., & Odhiambo, G. (2008). Smallholder market participation under transactions costs: Maize supply and fertilizer demand in Kenya. *Food Policy, 33,* pp. 318–328. doi:10.1016/j.foodpol.2007.12.001

Alkali, H. M. (2017). Analysis of Market Participation by Women Soybean Farmers in Hawul Local Government Area of Borno State, Nigeria, Master thesis, University of Maiduguri, Nigeria.

Amao, I. O., & Egbetokun, O. A. (2018). Market participation among vegetable farmers. *International Journal of Vegetable Science, 24* (1), pp. 3-9, doi: 10.1080/19315260.2017.1346030.

Arethun, T., & Bhatta, B. P. (2012). Contribution of rural roads to access to- and participation in markets: Theory and results from northern Ethiopia. *Journal of Transportation Technologies, 2,* pp. 165-174. doi:10.4236/jtts.2012.22018.

Ayele, T., Tegegne, B., & Zemedu, L. (2018). Analysis of market decisions and intensity of market participation of smallholder wheat farmers in Adola Rede district of Oromia Regional State, Ethiopia. *International Journal of Research Studies in Agricultural*

Sciences (IJRSAS), 4 (8), PP. 1-11. dOI: http://dx.doi.org/10.20431/2454-6224.0408001

Azam, M. S., Imai, K. s, & Gaiha, R. (2012). Agricultural Supply Response and Smallholders Market Participation: The case of Cambodia, Discussion Paper Series, Kobe University, Japan.

Baak, M., Koopman, R., Snoek, H., & Klous, S. (2019). A new correlation coefficient between categorical, ordinal and interval variables with Pearson characteristics.

Barnes, T. J. (2008). American pragmatism: Towards a geographical introduction. *Geoforum 39*, pp. 1542–1554. doi:10.1016/j.geoforum.2007.02.013.

Barrett, C. B. (2008). Smallholder market participation: Concepts and evidence from eastern and southern Africa. *Food Policy 33*, pp. 299–317. doi:10.1016/j.foodpol.2007.10.005

Baumol, W. J. (1986). Williamson's the economic institutions of capitalism. *The RAND Journal of Economics, 17(* 2), pp. 279-286.

Bera A., & Jarque. C. (1981). *Efficient tests for normality, heteroskedasticity and serial independence of regression residuals: Monte Carlo evidence*. *Economics Letter*, ***7***, pp. 313 – 318.

Bera, A. K., Jarque, C. M. & Lee, L. (1984). Testing the normality assumption in limited dependent variable models. *International Economic Review, 25* (3), pp. 563-578.

Berhanu, A. (2008). Matching extension service with farmers' needs: Towards combining social and agro-ecological approaches in Ethiopian extension. *Eastern Africa Social Science Research Review/EASSRR*, *24*(2), pp. 1-25. doi: 10.1353/eas.0.0004

Berhanu, A. (2009).The Ethiopian Extension and the Farmer: A View from the Farm. In: Proceedings of the 16th International Conference of Ethiopian Studies, ed. by Svein Ege, Harald Aspen, Birhanu Teferra and Shiferaw Bekele, Trondheim, pp. 751-760

Berhanu, K. (2013). CAADP Ethiopia: A New Start? Working Paper 060, Future Agricultures, www.future-agricultures.org

Berman, J. (2013). Utility of a conceptual framework within doctoral study: A researcher's reflections. *Issues in Educational Research*, *23*(1)

Bishop, F. L. (2015). Using mixed methods research designs in health psychology: An illustrated discussion from a pragmatist perspective. *British Journal of Health Psychology, 20 (5–2)*. DOI:10.1111/bjhp.12122.

Bridge, G. (2019). Habit, experience and environment: A pragmatist perspective. Environment and Planning D: Society and Space file.

Brys, G., Hubert, M., & Struyf , A. (2004). A Robustification of the Jarque-Bera test of Normality, COMPSTAT'2004 Symposium, pp. 253-760.

Buitelaar, E. (2004). A transaction-cost analysis of the land development process. *Urban Studies, 41*(13), 2539–2553, DOI: 10.1080/0042098042000294556

Camara, A. (2017). Market participation of smallholders and the role of the upstream segment: evidence from Guinea, MPRA Paper No. 78942, International Food Policy Research Institute, Cheikh Anta Diop University, Dakar. https://mpra.ub.uni-muenchen.de/78942/

Chamberlin, J. (2007). Defining smallholder agriculture in Ghana: who are smallholders, what do they do and how are they linked with markets? Ghana Strategy Support Program (GSSP), Background Paper No. GSSP 0006.

Chamberlin, J., & Jayne, T. S. (2011). Unpacking the Meaning of Market Access, Staff Paper 2011-10, Michigan State University.

Coase, R. H. (1937). The nature of the firm, *Economica, 4*, pp. 386–405.

Cooke, E. (2007). Peirce's Pragmatic Theory of Inquiry: Fallibilism and Indeterminacy, London: Bloomsbury.

Cragg, J. G. (1971). Some statistical models for limited dependent variables with applications to the demand for durable goods. *Econometrica 39*, pp. 829-44.

Creswell, J. W. (1999) Mixed method research: Introduction and application. In G. J. Cizek (Ed.), Handbook of educational policy (pp. 455-472). San Diego, CA: Academic Press.

Creswell, J. W. (2009). *Research design: Qualitative, quantitative, and mixed methods approaches* (3rd ed.). Thousand Oaks, CA: Sage.

Creswell, J. W. (2012). Planning, Conducting, and Evaluating Quantitative and Qualitative Research (4th ed.). Thousand Oaks, CA: Sage.

Creswell, J. W., & Plano Clark, V. L. (2011). Designing and Conducting Mixed Methods Research (2nd ed.). Thousand Oaks, CA: Sage.

Creswell, J. W., Plano Clark, V., Gutmann, M., & Hanson, W. (2003). Advanced mixed methods designs. In A. Tashakkori & C. Teddlie (Eds.), Handbook of mixed method research in the social and behavioral sciences (pp. 209-240). Thousand Oaks, CA: Sage.

CSA [Central Statistical Authority] (2006). Statistical Abstracts. CSA, Addis Ababa, Ethiopia.

CSA [Central Statistical Authority] (2011). Federal Democratic Republic of Ethiopia Central statistical Agency Statistical Abstract, Addis Ababa, Ethiopia.

CSA [Central Statistical Authority] (2018). Agricultural sample survey: Report on area and production of major crops for private peasant holdings, meher season, Vol. 1. Addis Ababa, Ethiopia.

Daskalakis, C., Gouleakis, T., Tzamos, C., & Zampetakis, M. (2019). Computationally and Statistically Efficient Truncated Regression. *Proceedings of Machine Learning Research vol 20*:1–31.

Demeke, L., & Haji, J. (2014). Econometric analysis of factors affecting market participation of smallholder farming in Central Ethiopia.

FAO [Food and Agriculture Organization of the United Nations] (2010). Food Security in Africa: Market and Trade Policy for Staple Foods in Eastern and Southern Africa, Food and Agriculture Organization of the United Nations, Rome, Italy.

FAO [Food and Agriculture Organization of the United Nations] (2015). The economic lives of smallholder farmers: An analysis based on household data from nine countries, Food and Agriculture Organization of the United Nations, Rome, Italy.

FAO [Food and Agriculture Organization of the United Nations](2014). Understanding smallholder farmer attitudes to commercialization –The case of maize in Kenya. Rome.

Fouka, G., Mantzorou, M. (2011). What are the major ethical issues in conducting research? Is there a conflict between the research ethics and the nature of nursing?, *Health Science Journal*, *5*(1), pp:3-14.

Gebre-Egizabher, Tegegne. (2001). Rural-Urban Linkages under Different Farming Systems: The Cases of Coffee and Non-Coffee Growing Regions in Ethiopia. Social Science Research Report Series, no.21, Addis Ababa: OSSREA.

Gani, B.S., & Adeoti, A.I. (2011). Analysis of market participation and rural Poverty among farmers in northern part of Taraba state, Nigeria. *Journal of Economics, 2* (1), pp. 23-36. doi: 10.1080/09765239.2011.11884934.

Gaudin, O. (2018). Pragmatist views of urban experience: Sensorial perception in urban studies. *Pragm atism Today 9 (1)*

Brierley, J.A. (2017). The role of a pragmatist paradigm when adopting mixed methods in behavioural accounting research. *International Journal of Behavioural Accounting and Finance, 6* (2), pp. 140-154. ISSN 1753-1969 https://doi.org/10.1504/IJBAF.2017.10007499

Gebremedhin, B., Jaleta, M., & Hoekstra, D. (2009). Smallholders, institutional services, and commercial transformation in Ethiopia. *Agricultural Economics 40* (supplement) , pp. 773–787. doi: 10.1111/j.1574-0862.2009.00414.x.

Gebremedhin, B., & Hoekstra, D. (2008). Market orientation of smallholders in selected grains in Ethiopia: Implications for enhancing commercial transformation of subsistence agriculture. IPMS (Improving Productivity and Market Success) of Ethiopian Farmers Project Working Paper 11. ILRI (International Livestock Research Institute), Nairobi, Kenya. 44 pp.

Gebremedhin, B., & Jaleta, M. (2012). Market Orientation and Market Participation of Smallholders in Ethiopia: Implications for Commercial Transformation, paper presented at the International Association of Agricultural Economists (IAAE) Triennial Conference, Foz do lguacu, Brazil, 18-24 August, 2012.

Gebreselassie, S., & Sharp, K. (2006). Commercialization of smallholder agriculture in selected *teff*-growing areas of Ethiopia, *Ethiopian Journal of Economics, 15 (1),* pp. 55-86.

Gelfand, S. J. (2013). Understanding the Impact of Heteroscedasticity on the Predictive Ability of Modern Regression Methods, Master thesis, University of Calgary.

Gobena, G. K. (2012). Analysis of Smallholder Farmer's Participation in Production and Marketing of Export Potential Crops: The Case of Sesame in Diga District, East Wollega Zone of Oromia Regional State, Master thesis, Addis Ababa University.

Goetz, S.J. (1992). A selectivity model of household food marketing behavior in Sub-Sahara Africa. *Amer. J. Agr. Econ. 74*, pp. 444–52.

Goldkuhl, G. (2012). Pragmatism vs interpretivism in qualitative information systems research. *European Journal of Information Systems*, (21), 2, pp. 135-146, http://dx.doi.org/10.1057/ejis.2011.54.

Gorringe, P. (1987). A review article: The economic institutions of capitalism: Firms, markets and relational contracting by Oliver E. Williamson. *Australian journal of Management, 12*(1), pp. 125-143.

Govereh, J., Jayne, T.S. & Nyoro, J. (1999). Smallholder Commercialization, Interlinked Markets and Food Crop Productivity: Cross-Country Evidence in Eastern and Southern Africa.

Gray, P. S., Williamson, J. W., Karp, D. A., & Dalphin, J. R. (2007). The Research Imagination: An Introduction to Qualitative and Quantitative Methods. Cambridge: Cambridge University Press.

Greene, W. (1999). Marginal effects in the censored regression model. *Economics Letters, 64*, pp. 43–49.

Greene, W. (2003). 5th ed, Econometric Analysis, Prentice Hall, Saddle River.

Gujarati, D. N. (2004). Basic Econometrics, 4th ed., McGraw-Hill, New York.

Gurmessa, K., Tolemariam, T., Tolera, A. & Beyene, F. (2016). Production and Utilization of Crop Residues in Horro and Guduru Districts, Western Ethiopia. *Food Science and Quality Management (48)*.

Hair, J. F. Jr., Anderson, R. E., Tatham, R. L. & Black, W. C. (1995). Multivariate Data Analysis (3rd ed.). New York: Macmillan.

Hammersley, M. (2008). Troubles with triangulation. In: Bergman, Manfred Max ed. Advances in Mixed Methods Research. London: Sage, pp. 22–36.

Harney, L., McCurry, J., Scott, J., & Wills, J. (2016). Developing 'process pragmatism' to underpin engaged research in human geography. *Progress in Human Geography*, 1–18. DOI: 10.1177/0309132515623367.

Hausman, J. (2001). Mismeasured variables in econometric analysis: Problems from the right and problems from the left. *Journal of Economic Perspectives, 15* (4), pp. 57–67.

Hazell, P., Poulton, C., Wiggins, S., & Dorward, A. (2006). The future of small farms: synthesis paper. Latin American Center for Rural Development to the preparation of the World Development Report 2008 "Agriculture for Development"

Hellin, J., Lundy, M., & Meijer, M. (2009). Farmer organization, collective action and market access in Meso-America. *Food Policy 34*, pp. 16–22. doi:10.1016/j.foodpol.2008.10.003.

Hildebrand, D. L. (2008). Dewey: A Beginner's Guide. Oxford: One world Publications.

Holloway, G. & Ehui, S. (2002). Expanding market participation among smallholder livestock producers: A collection of studies employing Gibbs sampling and data from the Ethiopian highlands, 1998–2001. Socio-economics and Policy Research Working Paper 48. ILRI (International Livestock Research Institute), Nairobi, Kenya. 85 pp.

Horrace, W. C. & Oaxaca, R. L. (2005). Results on the bias and inconsistency of ordinary least squares for the linear probability model. *Economics Letters, 90*, pp. 321–327, doi:10.1016/j.econlet.2005.08.024.

Hurd, M. (1979). Estimation in Truncated samples when there is Heteroskedasticity. *Journal of Econometrics, 11*, pp. 247-58.

ILO [International Labour Organization] (2009). Sampling methodology, International Labour Organization, Geneva.

Imenda, S. (2014). Is there a conceptual difference between theoretical and conceptual frameworks?, *Journal of Social Sciences*, *38* (2), pp. 185-195. doi: 10.1080/09718923.2014.11893249.

Jacoby, H. G. (2000). Access to markets and the benefits of rural roads. T*he Economic Journal, 110*, pp. 713-737.

Jagwe, J. N. (2011). The impact of transaction costs on the participation of smallholder farmers and intermediaries in the banana markets of Burundi, Democratic Republic of Congo and Rwanda. PHD dissertation, University of Pretoria, Pretoria, South Africa.

Jagwe, J., Machethe, C., & Ouma, E. (2010). Transaction costs and smallholder farmers' participation in banana markets in the great lakes region of Burundi, Rwanda and the Democratic Republic of Congo. *AfJARE, 6* (1).

Jaleta, M., & Gebremedhin, B. (2012). Interdependence of smallholders' net market positions in mixed crop-livestock systems of Ethiopian highlands. *Journal of Development and Agricultural Economics*, *4*(7), pp. 199-209. doi: 10.5897/JDAE11.099.

Jaleta, M., Gebremedhin, B., & Hoekstra, D. (2009). *Smallholder commercialization: Processes, determinants and impact.* Discussion Paper No. 18. Improving Productivity and Market Success (IPMS) of Ethiopian Farmers Project, ILRI (International Livestock Research Institute), Nairobi, Kenya. 55 pp.

Janusz, K., Kesteloot, C., Vermeiren, K., & Van Rompaey, A. (2019). Daily mobility, livelihoods and transport policies in Kampala, Uganda: A Hagerstrandian analysis. *TIJDSCHRIFT VOOR ECONOMISCHE EN SOCIALE GEOGRAFIE, 110* (4), pp. 412- 427. doi: 10.1111/tesg.12349

Janvry, A., & Sadoulet , E. (2006). Progress in the Modeling of Rural Households' Behavior under Market Failures.

Jarque, C. M., & Bera, A. K. (1987). A test for normality of observations and regression residuals. *International Statistical Review, 55*, pp. 163–172.

Kabeto, A. J. (2014). An Analysis of Factors Influencing Participation of Smallholder Farmers in Red Bean Marketing in Halaba Special District, Ethiopia, Master Thesis, University of Nairobi.

Kahkonen, S. & Leathers, H. (1999). Transaction Costs Analysis of Maize and Cotton Marketing in Zambia and Tanzania. Technical Paper No. 105, IRIS Center, University of Maryland.

Kalolo, J. F. (2015).The Drive towards application of pragmatic perspective in educational research: Opportunities and Challenges. *Journal of Studies in Education, 5(*1). doi:10.5296/jse.v5i1.7145

Kaushik, V. & Walsh, C. A. (2019). Pragmatism as a research paradigm and its implications for social work research, *Soc. Sci, 8,* (255). doi:10.3390/socsci8090255.

Key, N., Sadoulet, E., & de Janvry, A. (2000), Transaction costs and agricultural household supply response. *American Journal of Agricultural Economics 82*, pp. 245–259.

Kherallah, M. & Kirsten, J. F. (2002): The new institutional economics: applications for agricultural policy research in developing countries. *Agrekon: Agricultural Economics Research, Policy and Practice in Southern Africa, 41* (2), pp. 110-133.

Kilpinen, E. (2009). The Habitual Conception of Action and Social Theory. Semiotica *173 (1/4)*, pp. 99-128.

Kirsten, J., & Sartorius, K. (2002). Linking agribusiness and small-scale farmers in developing countries: Is there a new role for contract farming? *Development Southern Africa, 19* (4), pp. 503-529. doi: 10.1080/0376835022000019428

Klein, A. G., Gerhard, C., Büchner, R. D., Diestel, S., & Schermelleh-Enge, K. (2016). The detection of heteroscedasticity in regression models for psychological data. *Psychological Test and Assessment Modeling, 58* (4), pp. 567-592.

Kostov, P., & Davidova, S. (2013). A quantile regression analysis of the effect of farmers' attitudes and perceptions on market participation. *Journal of Agricultural Economics, 64* (1), pp. 112132. ISSN 0021857X.

Kyaw, N. N., Ahn, S., & Lee, S. H. (2018). Analysis of the factors influencing market participation among smallholder rice farmers in Magway Region, Central dry zone of Myanmar. *Sustainability, 10* (4441). doi:10.3390/su10124441.

Long, J. S., & Ervin, L. H. (1998). Correcting for Heteroscedasticity with Heteroscedasticity Consistent Standard Errors in the Linear Regression Model: Small Sample Considerations, Indiana University, Bloomington, IN 47405.

Madhok, A. (2002). Reassessing the fundamentals and beyond: Ronald Coase, the transaction cost and resource-based theories of the firm and the institutional structure of production. *Strategic Management Journal, 23*, pp. 535–550. doi: 10.1002/smj.247

Madushani, H. D. P. (2016). Ethical issues in social science research: A review. *Journal of Social Statistics 2016,* pp. 26-33.

Majeed, M. H. (2018). Pragmatist Inquiry in to consumer behaviour research, philosophy of management https://doi.org/10.1007/s40926-018-0103-4.

Martey, E., Al-Hassan, R. M., & Kuwornu, J. K. M. (2012). Commercialization of smallholder agriculture in Ghana: A Tobit regression analysis. *African Journal of Agricultural Research*, *7*(14), pp. 2131-2141. doi: 10.5897/AJAR11.1743.

Martins, R. A., Serra, F. R., Leite, A. da S, Ferreira, M. P., & Li, D. (2010). Transactions cost theory influence in strategy research: A review through a bibliometric study in leading journals. XXXIV Encontro da ANPAD.

Mather, D., Boughton, D., & Jayne, T.S. (2013). Explaining smallholder maize marketing in southern and eastern Africa: The roles of market access, technology and household resource endowments. *Food Policy, 43*, pp. 248–266. http://dx.doi.org/10.1016/j.foodpol.2013.09.008

Mbitsemunda, J. P. K., & Karangwa, A. (2017). Analysis of Factors Influencing Market Participation of Smallholder Bean Farmers in Nyanza District of Southern Province, Rwanda. Journal of Agricultural Science, 9 (11), pp. 99-111. doi:10.5539/jas.v9n11p99.

Melesse, T. M. (2017). Agricultural Intensification and Market Participation under Learning Externality: Impact Evaluation on Small-scale Agriculture, Maastricht University and UNU-MERIT.

Messner, J. W., & Mayr, G. J., & Zeileis, A. (2016). Heteroscedastic censored and truncated regression with crch. *The R Journal Vol. 8*/1, pp.173-181. Migiro S. O., & Magangi B. A. (2011). Mixed methods: A review of literature and the future of the new research paradigm. *African Journal of Business Management Vol.5 (10)*, pp. 3757-3764, DOI: 10.5897/AJBM09.082.

Mmbando, F. E., Wale, E. Z., & Baiyegunhi, L. J. S. (2015). Determinants of smallholder farmers' participation in maize and pigeonpea markets in Tanzania. *Agrekon*, *54* (1), pp. 96-119. doi: 10.1080/03031853.2014.974630.

MoARD [Ministry of Agriculture and Rural Development] (2010). Ethiopia’s agriculture sector policy and investment framework: Ten year road map (2010–2020) draft. Addis Ababa, Ethiopia: Ministry of Agriculture and Rural Development.

MOFED [Ministry of Finance and Economic Development] (2010). *Ethiopia’s Growth and Transformation Plan: 2010-2015,* MOFED, Addis Ababa, Ethiopia.

Moono, L. (2015). An Snalysis of Factors Influencing Market Participation among Smallholder Rice Farmers in Western Province, Zambia, Master Thesis, University of Nairobi.

Morgan, D. L. (2014b). Pragmatism as a paradigm for social research. *Qualitative Inquiry 20*, pp. 1045–53.

Moser, C.M., Barrett, C.B., & Minten, B. (2006). Spatial integration at multiple scales: rice markets in Madagascar, Cornell University Working Paper, Ithaca, NY.

Muricho, G. S. (2015). Determinants of Agricultural Commercialization and its Impacts on Welfare among Smallholder Farmers in Kenya, PHD dissertation, University of Nairobi.

Murray, L., Nguyen, H., Lee,Y., Remmenga, M. D., & Smith, D. W. (2012). Variance inflation factors in regression models with dummy variables, Conference on Applied Statistics in Agriculture. https://doi.org/10.4148/2475-7772.1034

Musah, A. B. (2013). Market participation of smallholder farmers in the upper west region of Ghana, Phd dissertation, University of Ghana, Legon.

Mussema, R., Kassa, B., Alemu, D., & Rashid, S. (2013). Analysis of the determinants of small- scale farmers' grain market participations in Ethiopia: The contribution of transaction costs. *Ethiop. J. Agric. Sci., 23*, pp. 75-94.

Muthyalu, M. (2013). The Factors that Influence the Participation of Cooperative Members in the Agricultural Input and Output Marketing –A Case Study of Adwa District, Ethiopia. *Journal of Business Management & Social Sciences Research (JBM&SSR), 2(*4).

Nijhawan, L. P., Janodia, M. D., Muddukrishna, B. S., Bhat, K. M., Bairy, K. L., Udupa, N., … Musmade, P. B (2013). Informed consent: issues and challenges. *Journal of Advanced Pharmaceutical Technology & Research, 4*(3). doi: 10.4103/2231-4040.116779.

Nikolaeva, E., & Pletnev,. D. (2016). The role of the transaction costs in the business success of small and medium sized enterprises in Russia. *Procedia - Social and Behavioral Sciences 221*, pp. 176 – 184. doi: 10.1016/j.sbspro.2016.05.104.

North, D. C. (1990). A Transaction cost theory of politics. *Journal of Theoretical Politics 2* (4): 355-367.

O'brien, R. M. (2007) A caution regarding rules of thumb for variance inflation factors [J]. *Quality and Quantity, 41*(5), pp. 673-690.

OECD [Organisation for Economic Co-operation and Development] (2002). Impact of Transport Infrastructure Investment on Regional Development, the OECD Programme of Research on Road Transport and Intermodal Linkages.

Olwande, J., & Mathenge, M. (2011). Market Participation among Poor Rural Households in Kenya, Tegemeo Institute of Agricultural Policy and Development, Nairobi, Kenya.

Olwande, J., Smale, M., Mathenge, M. K., Place, F., & Mithofer, D. (2015). Agricultural marketing by smallholders in Kenya: A comparison of maize, kale and dairy. *Food Policy 52*, pp. 22–32. http://dx.doi.org/10.1016/j.foodpol.2015.02.002

Orme, C. (1992). Efficient score tests for heteroskedasticity in microeconomics. *Econometric Reviews, 11* (2), pp. 235-252. doi: 10.1080/07474939208800233.

Osmani, A. G., & Hossain, E. (2015). Market participation decision of smallholder farmers and its determinants in bangladesh. *EP 2015 (62) 1 (163-179).*

Palys, T. (2008). Purposive sampling. In L. M. Given (Ed.) The Sage Encyclopedia of Qualitative Research Methods. (Vol.2). Sage: Los Angeles, pp. 697-8.

Pender, J., Ehui, S., & Place, F. (2006). Conceptual framework and hypothesis. In: Pender J, Place F and Ehui S (eds), Strategies for sustainable land management in the East African highlands. IFPRI (International Food Policy Research Institute), Washington, DC, USA.

Pender, J., & Alemu, D. (2007). Determinants of Smallholder Commercialization of Food Crops Theory and Evidence from Ethiopia, IFPRI Discussion Paper 00745, International Food Policy Research Institute (IFPRI), Washington, DC.

Poole, N. (2017) Smallholder Agriculture and Market Participation, Rugby, UK: Practical Action Publishing, http://dx.doi.org/10.3362/9781780449401

Pratt, S. F. (2016). Pragmatism as Ontology, Not (Just) Epistemology: Exploring the Full Horizon of Pragmatism as an Approach to IR Theory, *International Studies Review 0*, (1–20). doi: 10.1093/isr/viv003.

Regasa , G., Negash, R., Eneyew, A., & Bane, D. (2019). Determinants of smallholder fruit commercialization: Evidence from southwest Ethiopia. *Review of Agricultural and Applied Economics, 22* (2), pp. 96-105. doi: 10.15414/raae.2019.22.02.96-105.

Reyes, B. (2012). Market participation and sale of potatoes by smallholder farmers in the central highlands of Angola: A Double Hurdle approach. Paper presented at the International Association of Agricultural Economists (IAAE) Triennial Conference, Foz do Iguaçu, Brazil, 18-24 August, 2012.

Rios, A. R., & Masters, W. A., & Shively, G. S. (2008). Linkages between Market Participation and Productivity: Results from a Multi-Country Farm Household Sample, Prepared for presentation at the American Agricultural Economics Association Annual Meeting, Orlando, Florida, July 27-29, 2008.

Roberts, P., & Thum, C (2005).Transport Core Measures and Indicators: A Users Guide, Transport Core Measures and Indicators Users Guide, Transport and Urban Department, World Bank.

Selowa, L., Lefophane, M.H., & Belete, A. (2015). Market participation in formal agricultural output markets: A case study of small-scale tomato producers in Limpopo province, South Africa. *Journal of Human Ecology, 50* (2), pp. 161-167. doi: 10.1080/09709274.2015.11906870.

Seng, K. (2016). The Effects of Market Participation on Farm Households' Food Security in Cambodia: An endogenous switching approach, MPRA Paper No. 69669, https://mpra.ub.uni-muenchen.de/69669/

shane J. Ralston (2011). Pragmatism in international relations theory and research, EIDOS N° 14 (2011), PÁGS. 72-105

Shenton, A. K. (2004). Strategies for ensuring trustworthiness in qualitative research projects. *Education for Information, 22*, pp. 63–75.

Sigei, G. K. (2014). Determinants of Market Participation among Small-scale Pineapple Farmers in Kericho County, Kenya, Master thesis, Egerton University.

Silcock, D. (2015). Marketing Pragmatism: a Constructive Review of Pragmatic Philosophy and Implications For Consumer Research, in NA - Advances in Consumer Research Volume 43, eds. Kristin Diehl and Carolyn Yoon, Duluth, MN : Association for Consumer Research, Pages: 212-217, http://www.acrwebsite.org/volumes/1019940/volumes/v43/NA-43

Siziba, S., Nyikahadzoi, K., Diagne, A., Fatunbi, A.O., & Adekunle A.A. (2010). Determinants of cereal market participation by sub-Saharan Africa smallholder farmer. Learning *Publics Journal of Agriculture and Environmental Studies,2* (1), pp.180-193.

Skorobogatova, O., & Kuzmina-Merlino, I. (2017). Transport infrastructure development performance. *Procedia Engineering 178*, pp. 319 – 329. doi: 10.1016/j.proeng.2017.01.056.

Snieska, V., & Simkunaite, I. (2009). Socio-economic impact of infrastructure investments. *Economics of Engineering Decisions (3)*, pp. 16-25.

Stehman, S. V. (1992). Comparison of systematic and random sampling for estimating the accuracy of maps generated from remotely sensed data. *Photogrammetric Engineering & Remote Sensing, 58 (*9), pp. 1343-1350.

Stifel, D., & Minten, B. (2003). Transactions Costs and Agricultural Productivity: Implications of Isolation for Rural Poverty in Madagascar, Cornell University.

Stifel, D., & Minten, B. (2007). Isolation and agricultural productivity, IFPRI Research Report, IFPRI, Washington, DC.

Tesfaye Berhanu Woldeyohanes (2013).Off-farm Income and smallholder Commercialization: evidence from Ethiopian rural household panel data, Master thesis, Rheinische Friedrich – Wilhelms–Universität Bonn

Teshome, A. (2006). Agriculture, Growth and Poverty Reduction in Ethiopia: Policy Processes around the New PRSP (PASDEP), Research Paper 004.

Tobi, H., & Kampen, J. K. (2017). Research design: the methodology for interdisciplinary research framework, *Qual. Quant*. doi: 10.1007/s11135-017-0513-8.

Tobi, H., Kampen, J.K. (2013). Survey error in an international context: an empirical assessment of cross cultural differences regarding scale effects. *Qual. Quant., 47*(1), pp. 553–559.

Tolossa, D. (2003). Issues of land tenure and food security: The case of three communities of Munessa wereda, south-central Ethiopia, Norsk Geografisk Tidsskrift - Norwegian Journal of Geography, 57 (1), pp. 9-19. DOI: 10.1080/00291950310000785

Tongco, M. D. C. (2007). Purposive sampling as a tool for informant selection. *Ethnobotany Research & Applications, 5*, pp. 147-158.

Turaa, E. G., Goshub, D., Demisiec, T., & Kenea, T. (2016). Determinants of market participation and intensity of marketed surplus of *teff* producers in Bacho and Dawo districts of Oromia state, Ethiopia. *Journal of Economics and Sustainable Development, 7* (1), pp.13-24.

Urzua, C. M. (1996). On the correct use of omnibus tests for normality, *Economics Letters, 53,* pp. 247-251.

Vatcheva, K. P., Lee, M., McCormick, J. B., & Rahbar, M. H. (2016). Multicollinearity in regression analyses conducted in epidemiologic studies. *Epidemiology (Sunnyvale), 6*(2). doi:10.4172/2161-1165.1000227.

Vo, L. (2012). Pragmatist Perspective on knowledge and knowledge management in Organizations. *International Business Research, 5* (9), doi:10.5539/ibr.v5n9p78.

Wilde, J. (2007). A Simple Representation of the Bera-Jarque Lee Test for Probit Models, IWH Discussion Papers, No. 13/2007, Leibniz-Institut für Wirtschaftsforschung Halle (IWH), Halle (Saale), http://nbn-resolving.de/urn:nbn:de:gbv:3:2-6272

Williams, R. (2015). Heteroskedasticity, University of Notre Dame, https://www3.nd.edu/~rwilliam/

Williamson, O. (1985). The economic institutions of capitalism: Firms, markets, relational contracting, New York: Free Press.

Williamson, O. (2002). The theory of the firm as governance structure: from choice of contract. *Journal of Economic Perspectives, 16*(3), pp. 171-195.

Williamson, O. E. (1975). Markets and hierarchies, analysis and antitrust implications: A study in the economics of internal organization, New York: Free Press.

Wood, N., & Smith, S. J. (2008). Pragmatism and geography, *Geoforum 39*, pp. 1527–1529. doi:10.1016/j.geoforum.2008.06.003.

Wooldridge, J. M. (2013). Introductory Econometrics: A Modern Approach (5th ed.). SouthWestern, Cengage Learning.

Worku, I. (2011). Road sector development and economic growth in Ethiopia. Ethiopia Support Strategy Program II, International Food Policy Research Institute, Addis Ababa, Ethiopia, 101–146.

Yefimov, V. (2004). On pragmatist institutional economics, MPRA Paper No. 49016, https://mpra.ub.uni-muenchen.de/49016/

Yen, S. T., & Huang, C. L. (1996). Household demand for finfish: A generalized double-hurdle model. *Journal of Agricultural and Resource Economics 21*(2), pp. 220-234.

Yoo, W., Mayberry, R., Bae, S., Singh, K., Peter, Q., & Lillard, J. W. (2014). A Study of effects of multi-collinearity in the multivariable analysis. *International Journal of Applied Science and Technology, 4* (5), pp. 9-19.

CHAPTER 4: RURAL TRANSPORT AND STORAGE INDUCED POST-HARVEST LOSSES OF MAJOR FOOD CROPS AMONG SMALLHOLDER FARMERS OF HORRO GUDURU WOLLEGA ZONE, WESTERN ETHIOPIA

Abstract

Understanding the main factors affecting cereal crop post-harvest loss during different stages of the post-harvest chain will help with better design of intervention steps to reduce cereal loss. Therefore, the objective of this study is to investigate the main factors affecting post-harvest cereal loss at different stages of the post-harvest chain. Post-harvest loss index, Likert scale assessment, and Tobit regression model were used to analyze the data obtained from randomly selected 500 smallholder farmers across 16 rural kebeles in 4 districts of Horro Guduru Wollega Zone, western Ethiopia. Farm-level cereal crop post-harvest loss of 37% was identified as the highest percentage of losses. The maximum post-harvest loss was found to be 20.4% for maize followed by teff (13.8%) and wheat (11%). Home storage, harvesting, and transportation are the hotspot links for post-harvest losses of cereal crops in the chain. Using the Likert scale assessment, farmer level cereal crop post-harvest loss causing factors were identified in order of severity where Pests (52%), traditional storage facilities (45%), insufficient transportation (38%), bad weather condition (30%), wild animals (21%) and poor marketing coordination (17%). Using the Tobit model, family size, sex, educational status, access to credit, labor reciprocity, crop price condition, storage facilities, and tropical livestock unit were found negatively and significantly affecting farm-level crop post-harvest losses. Whereas, distance to the nearest market center, transport cost, distance to all-weather road, distance to farm plot, and crop production level were found positively and significantly affecting farm-level crop post-harvest losses. Taken together, the result of our research calls for policies and strategies that encourage investment in transport infrastructure and improved rural transport services, formation and strengthening of farmers' cooperative organizations, farm labor exchange arrangements as a form of indigenous knowledge system, better endowments of livestock resources, development of local market centers and improved storage facilities towards the effort of reducing farm-level post-harvest losses.

***Key words**: Post-harvest loss; Rrural transport; Smallholder farmer; Storage facility, Tobit model.*

4.1. Introduction

Post-harvest loss of major food crops is increasingly becoming a global problem. Post-harvest loss is responsible for substantial damage to food and cash crops worldwide. In recent years, high international food prices have caused great concern about the post-harvest loss of food crops (Amentae, 2016). According to the Food and Agriculture Organization of the United Nations (FAO), approximately one-third of the total annual food production is lost every year worldwide (Martins, 2013). Such an amount of annual food loss represents a loss of 1.3 billion tons of food per year in a world where over 870 million people go hungry (Affognon et al., 2014; Ridolfi, Hoffmann, & Baral, 2018).

Rapidly increasing urban populations and changing consumption patterns in developing countries are creating major opportunities for small-scale farmers by driving vital growth in domestic and regional market demand for food (Chapoto, Demeke, Onumah, & Ainembabazi, 2016). But, because of post-harvest losses caused by inappropriate transport, ineffective storage, and market-related constraints, resource-poor smallholder farmers in Africa in general and in sub-Saharan Africa (SSA) in particular are not in a position to take the advantage of such existing and emerging opportunities (Chapoto et al., 2016). Therefore, this requires critical attention from all agricultural stakeholders, including governments of African countries.

Post-harvest losses in Africa are often estimated to be between 20 and 40%, with a value estimated at over US$ 2 billion annually (Abass et al., 2013). Such losses are a combination of those which occur during harvesting, drying, threshing, winnowing, processing, bagging, storage, transportation, and marketing activities.

Despite the low total agricultural productivity, post-harvest loss of food crops remains the greatest threat to increased food production in sub-Saharan Africa. A recent report by the World Bank (Affognon et al., 2014) revealed that, between harvest and consumption, significant volumes of food are lost in sub-Saharan Africa, the value of which is estimated at USD 4 billion for grains alone. The report demonstrates that this proportion of food loss is greater than the value of total food aid received in SSA over the last ten years, and further equates to the annual value of grain imports to SSA. In Eastern and Southern Africa alone, post-harvest losses are valued at the US $1.6 billion per year, or about 13.5% of the US $11 billion total value of grain production (Abass et al., 2013).

Ethiopia has a short, medium and long term vision to become a food self-sufficient country. To achieve such food self-sufficiency, the country has implemented several measures toward maximizing agricultural production by mitigating pre- and post-harvest losses. Under Agricultural Development Led Industrialization (ADLI) development strategy, Ethiopia has planned a lot in the post-harvest sector (Prabhakar & Alemu, 2013). To attain high nutritional status, some of the targets set to be achieved under ADLI were improvement of post-harvest management, production of value-added products, and reduced post-harvest losses. Finally, strengthening and promoting effective and efficient research programs in the post-harvest sector were also recommended under this agricultural development strategy of the country (Hussen, Beshir, & W/Hawariyat, 2013).

Next to ADLI, the agriculture sector of Ethiopia has held the core strategic position within the medium and long-term plans as outlined in the Plan for Accelerated and Sustained Development to End Poverty (PASDEP) implemented from 2005/06 to 2009/10. The Growth and Transformation Plan (GTP-I & II), is under implementation since 2010/11 after PASDEP. Consequently, in these two development strategies, Ethiopia established the special action program to ensure smallholder farmers' food self-sufficiency, through increased agricultural productivity and commercialization by addressing some of the key constraints to agricultural growth like post-harvest losses (Federal Democratic Republic of Ethiopia Ministry of Agriculture, 2015). According to the Growth and Transformation Plan, post-harvest loss related awareness creation and training, extension package preparation were envisioned with an aim to minimize smallholder farmers' post losses. Zero loss of food is one of the eight pillars of the Seqota Declaration that represents a strong commitment to ending malnutrition in Ethiopia (Gebru et al., 2018).

In the Plan for Accelerated and Sustained Development to End Poverty, the country targeted reducing losses of grain by 6%. Whereas in the Growth and Transformation Plan (GTP-I &

II) Ethiopia targeted to reduce cereal crop post-harvest losses by 8% (the Federal Democratic Republic Ethiopia Ministry of Agriculture and Natural Resources, 2018). However, no account of progress has been achieved towards both Post-harvest loss reduction targets. Moreover, despite these action plans and other subsequent initiatives, food crop post-harvest loss still remains a pressing problem in Ethiopia (Minten, Engida, & Tamru, 2016; Hengsdijk & Boer, 2017).

Ethiopia's economy is dominated by agriculture, contributing 38.8% to the GDP (Ethiopian Institute of Agricultural Research, 2016). Of this total contribution of agriculture, the crop sub-sector contributes 30% of agricultural GDP and 67.3% of the export earnings in Ethiopia.

Household food insecurity in Ethiopia is still a critical issue. The situation is being exacerbated by huge post-harvest losses, a growing population, decreasing the carrying capacity of the land and recurring droughts in the country. Reduction in post-harvest losses is, therefore, one of the sustainable solutions to enhance future food availability in the country (Parmar, Hensel, & Sturm, 2016). For rural households in Ethiopia, cereal grains are important food crops and accounts for approximately 60% of rural employment and 80% of total cultivated land (Schneider & Anderson, 2010). Despite the economic and food security importance of cereal grains, major food crop losses are evident in Ethiopia and may range from 30 to 50% of the total produce depending on the crop type (Temesgen, 2016).

Cereal grain production in Ethiopia, as in other developing countries, suffers from a substantial post-harvest loss. In Ethiopia, the total post-harvest loss of cereal is estimated to be 2.04 million tons, whereas the cereal import requirement of the country was 1.16 million tons (Ethiopian Institute of Agricultural Research, 2016; Befikadu, 2018). According to the estimates of USAID, the post-harvest loss for cereals was 30% in Ethiopia (Temesgen, 2016). Therefore, Post-harvest food loss is one of the principal causative factors to food insecurity in the country. The loss mainly associated with Poor infrastructure for transport, ineffective storage, and marketing, bad weather as well as traditional grain harvesting methods and the subsequent handling processes.

At present, small-scale cereal crop farmers account for most of the domestic production in Ethiopia. By 2012, the magnitude of cereal loss in Ethiopia for maize, wheat, and *teff* was used to be 16.8, 9.9 and 12.3% respectively, whereas, by 2013 the loss for maize and wheat increased to 18 and 12% respectively (the Federal Democratic Republic of Ethiopia, Ministry of Agriculture and Natural Resources, 2018). Hence, the losses showed an increasing trend over a year.

Postharvest losses in these three staple crops, which are considered major food crops in Ethiopia, occur throughout the country because all farmers grow at least one or two of these crops for their consumption as well as for source of household income. While the post-harvest challenge has many facets which vary from crop to crop, Postharvest losses of these major food crops are particularly severe when the rainy seasons extend and coincide with harvesting periods.

In addition, the consistent lack of access to good quality road networks and improved storage facilities (plastic silos, and metal silos) by smallholder farmers is a major contributor to post-harvest loss of major food crops in Ethiopia. Thus, access to such post harvest infrastructure facilities would contribute considerably to reducing associated losses.

The population of Ethiopia is rising at alarming rate and expected to reach more than 130 million by the year 2030 (Ethiopian Institute of Agricultural Research, 2016). To feed such fast growing population, a proper post-harvest handling (drying, threshing, shelling, winnowing, and sorting), transport, storage, processing and marketing program needs to be in place as soon as possible.

Among smallholder farmers of Horro Guduru Wollega Zone, major food crop post-harvest losses are one of the most pressing issues. The need for this study arose due to post-harvest losses of major food crops experienced by smallholder farmers in HGWZ, Western Ethiopia after harvesting. The survey assessed the post harvest losses of three different staple crops, maize, *teff* and wheat in four districts of HGWZ namely Horro, Hababo Guduru, Amuru and Abe Dongoro. In the study area, crop postharvest losses occur at different stages such as harvesting, drying, threshing, winnowing, transporting, storage, and marketing. The causes of postharvest losses in HGWZ are multiple; however, the most significant losses are caused by bad weather, pests (insects and rodents), delay in harvesting, and lack of appropriate storage facilities, inappropriate packaging, and inadequate means of transportation.

While research on the improvement of agricultural production and productivity of smallholder farmers have received much attention, until recently post-harvest activities have not attracted considerable attention from national and international research organizations. Even though, the prevention of crop postharvest loss is major agricultural concern in Ethiopia too, it has not received the attention that it deserves. On the other hand, post-harvest loss studies in Ethiopia emphasized on perishable horticultural crops like fresh fruits and vegetables (Banjaw, 2017; Bantayehu, Alemayehu, Abera, & Bizuayehu, 2017; Hailu & Derbew, 2015; Sebeko, 2015; Emana, Afari-Sefa, Nenguwo, Ayana, Kebede, & Mohammed, 2017; Kasso & Bekele, 2016), roots and tubers (Parmar, 2018; Ametataw, 2016). But, the attention given to cereal crop post-harvest loss has been minimal.

The overall postharvest loss figure i.e losses occurring across the entire agricultural value chain are not considered in this research. Hence, the pre-harvest losses (losses due to weeds, insects or disease), wholesale-level, processor-level, retailer-level losses and consumer level losses lies outside the scope of this paper. Therefore, it needs to be studied in the future. Another most important limitation of this paper lies in the fact that the post-harvest estimates of cereals are based on subjective self reported information from smallholder farmers. Indeed, it would have been better to use measured loss data (expert estimates of post-harvest losses incurred during different stages of the post-harvest chain). Hence, this calls more in-depth research of post-harvest losses by using measured loss data than subjective self estimates.

In Horro Guduru Wollega Zone, post-harvest losses are of major agricultural concern. HGWZ has cereal production potential and multiple suitable agro-climates. But, there is no official detailed quantitative study of postharvest losses in major food crops (*teff*, maize and wheat). This is an obstacle to provide a better understanding of the problem along the different stages of post-harvest system. So far, no more research was done on the postharvest losses assessment of cereal crops especially in western part of Oromia region. Thus, the main aim of this research is to create awareness on the post-harvest loss of cereal crops in Horro Guduru Wollega Zone.

The lack of scientific and consistent information on major food crop postharvest losses needs to be addressed in the study area. As a result, this study attempts to fill an important gap in the crop post-harvest loss literature by providing a better understanding of the nature, magnitude, and causes of such losses among smallholder food crop farmers at different stages of post-harvest chain. This study also attempts to evaluate smallholder farmer's perceptions on causes of crop post-harvest loss. This in turn would help develop strategies and policies to intervene and minimize these losses in different stages of post-harvest systems right from harvesting to marketing. This information is important for agriculturalists, administrators, technologists and policymakers. The specific objectives of the present study were:

1) To identify Percentage losses of cereal crops at different stages of post-harvest loss and locate loss hotspot point within the post-harvest chain

2) To investigate the main factors affecting post-harvest cereal crop loss at different stages in the post-harvest chain

3) To examine smallholder farmers' attitude or beliefs about severity of factors that causes cereal crop postharvest losses

The remainder of the paper contains four sections. Section 2 presents the theoretical and conceptual framework as well as the philosophical underpinnings of the study. Section 3 is all about methodology. The findings and discussions are presented in section 4 while section 5 concludes the paper.

4.2. Theoretical and Conceptual Frameworks

It is indispensable that common ground should be established as issues of smallholder farmer, smallholder farming, post-harvest losses, transport infrastructure, storage infrastructure and other similar terms have oftentimes been confused with each other or are given diverse meanings within the concept of agricultural value chain management.

4.2.1. Philosophical Underpinnings of the Research

Before carrying out the empirical analysis of the effect of rural transport infrastructure on smallholder farmers' crop post-harvest losses, identification of the paradigm and philosophical approach on which the research is based is necessary.

According to our research questions that we are seeking to answer and research objectives set to be addressed, positivist research paradigm is considered to be more logical to be adopted over other research paradigms for this specific research. Furthermore, positivist paradigm fits to our thesis statement. According to Elshafie (2013), the first and most crucial step in any research journey is to identify the kind of research paradigm to be adopted. Shah and Al-Bargi (2013) also pointed out that in order to be successful in their research career; researchers should be familiar with the basic research paradigms and their philosophical characteristics. The term paradigm has its roots in the work of Thomas Kuhn "the structure of scientific revolutions" (Kuhn, 1962 in Shah & Al-Bargi, 2013:253). This term is best described as a lens or a world view that guides the whole system of thinking and action. On the whole, the concept paradigm stands for the established research traditions, theories and models in a particular discipline that affects every single decision made in a research (Creswell, 2007; 2009).

Before clarifying the type of ontological and epistemological stances used in this specific study, it is essential to define what ontology and epistemology mean. First and foremost, ontology refers to the nature of reality (Grant & Giddings, 2002; Morgan, 2007). As Grant and Giddings (2002) point out, the ontological lens of realism essentially refers to the real features and phenomena within the world around them. Having given these definitions of ontology, it is now worth clarifying the ontological stance of this study. Ontologically, our study favors more towards realist ontological stance for a number of reasons. First, quantitative methodology was adopted to examine the relationship between rural transport infrastructure and extent of post-harvest losses. Second, the goal of this research was to discover the nature of post-harvest losses (effects) as subjected to different observable demographic, socio-economic and physical factors (causes). Third, in order to identify causal relations between post-harvest losses and the different observable demographic, socio-economic and physical factors (causes) deduction research approach was used.

It is also vital to clarify what is meant by epistemology in research before identifying the epistemological position of this particular research. Crotty (2003:3) defined epistemology as "a way of understanding and explaining how we know what we know". Furthermore, Creswell (2014) considered epistemology as how knowledge is formed and most notably how we get an adequate and legitimate knowledge of our world. Having a particular ontological stance constrains the epistemological stance we can logically hold (Grant & Giddings, 2002). Therefore, our study is well-established within objectivist epistemology. This can be justified by the following reasons: first, in this research, data were measured numerically and analyzed statistically. Second, realist ontological philosophical assumption by itself will dictate objectivist epistemology. Third, we have chosen to conduct tobit regression analysis on primary data gathered from 500 smallholder farmers in order to establish how demographic, socio-economic and physical factors affect smallholder farmers' cereal post-harvest losses. Fourth, the investigator investigated the observable facts (rural transport infrastructure and post-harvest loss) without influencing them and maximum care was also taken by investigator not to impede (subjective bias) the research process.

Objectivism is defined by Crotty (2003:10) as an epistemological position that asserts "meaning exists in objects independently of any consciousness". Scotland (2012) added that the investigator and what going to be investigated are independent entities, indeed the investigator should go forth into the world impartially to know about objective reality. Thus, according to objectivist epistemology, reality is external of us waiting to be discovered through objective measurements, but not constructed.

4.2.2. Theoretical Framework of the Study

In response to the crop post-harvest loss problem, many disciplines have proposed corresponding theories or models. This study was based on the broad framework of the theory of constraints. Theory of constraints best explain farmers' crop post harvest loss. This theory has been developed by an Israeli physicist Dr. Eliyahu Moshe Goldratt at the beginning of 1980s and was initially applied to production scheduling. Goldratt defines a Constraint as, 'anything that limits a system from achieving higher performance versus its goal' (Goldratt, 1990:5). The core idea of the theory of Constraints is that every real system such as a profit-making enterprise must have at least one constraint in a production process that limits its output. Therefore, the theory of constraints assumes that optimal management of these bottlenecks (constraints) in the entire production system is essential for resolving problems and increasing profitability.

This production management theory calls into question several principles about how we manage our businesses and our firms. The theory of constraints is based on the hypothesis that localized management is the main cause of many of the problems that we encounter today in firms (Goldratt & Cox, 1992). The applicability of the theory of constraints has been tested in different companies and found to be successful in explaining their overall system performance. The theory of constraints encourages the firm to identify the constraint (the bottleneck) along the chain and exploit the constraint by subordinating all resources to the constraint to improve productivity. According to theory of constraints, an organization can be seen as a chain composed of several links with strong interdependencies.

Even though the theory of constraints is so little known in the agricultural sector, since the beginning of the 21st century, many academic and professional researchers tried to apply this theory in the field of agriculture. For example, Taylor & Esan (2012) used Goldratt's theory of tonstraints and thinking process to explain quantitative and qualitative food losses at all stages in the post-harvest chain of harvesting to the final delivery to the consumer. In the same manner, Kanchanasuwan (2018) applied Theory of Constraints to explain the importance of adopting cold chain to overcome existing constraints in the fruit supply chain and help increase performance in developing countries, the case of Thailand. In another study, Theory of Constraints has been used by Tutuba and Vanhaverbeke (2018) to identify and understand constraints that limit beekeepers from commercializing the sector in Tanzania.

Smallholder farmers expect that today's investments will yield a higher rate of return over a shorter timeframe. Yet, to meet this goal, efficient and effective Post-harvest management is important. The Theory of Constraints (TOC) can be applied to explain the cause-and-effect thinking processes between the determinants of post-harvest loss at different stages of the post-harvest system and farmers' productivity. The theory of constraints encourages smallholder farmers within their small farm enterprises to identify as soon as possible the factors that are responsible for post-harvest losses at farm level and further help them to anticipate potential solutions. The objective of the theory of constraints in smallholder agricultural sector is therefore to promote the efficiency of farmers in managing their farms, to avoid bottlenecks and to promote the realization of higher productivity.

4.2.3. Conceptual Framework

This section gives the conceptual framework of the study developed from our knowledge of theoretical and empirical literature. To do so, we sketch out a conceptual framework for understanding the effects of transport infrastructure and storage facilities on smallholder farmers' cereal crop post-harvest losses. Such conceptual framework helps to clarify key concepts and definitions around the notion of post-harvest loss and rural infrastructure. The conceptual framework defines important terminologies used in the research and shows how dependent variable is being influenced by independent variables of interest. No consistent definitions, concepts, and measurement methods have been used in different studies concerning post-harvest loss. This makes difficult to explain the concept of post-harvest losses in the cereal crop sub-sector.

4.2.4. Operational Definitions of Selected Concepts

The following are operational definitions of a selected few common terms and key concepts used in this research.

A) Post-harvest Loss

Post-harvest losses have been variously defined by several authors in so many ways. They may be referred to as measurable quantitative and qualitative food loss through the value chain, starting at the time of harvest till the crop reaches the consumer (Kimiywe, 2015; Taherzadeh & Hojjat, 2013; Suleiman, 2015; African Union Commission, 2018; Ambler, Brauw, & Godlonton, 2017). For example, Kimiywe (2015, p. 490) defined post-harvest loss as 'measurable qualitative and quantitative food loss along the supply chain, starting at the time of harvest until its consumption or other end uses'. Kimiywe stated that a significant share of crop output never reaches the consumer due to post-harvest losses across different stages of the post-harvest chain.

In this definition the quantitative food loss refers to the loss in mass (kg) reduction while the qualitative loss refers to the reduction of nutritional and economic value. Post-harvest losses in the view of Saba and Ibrahim (2018) refer to the degradation in both quantity (physical) and quality of food produced from time of harvest to the point it is consumed. Post-harvest losses at farm level are, therefore, the extent of crops lost at various points in the post-harvest value chain. Temesgen (2016) and Chen, Wu, Shan, and Zang (2018) further stated that post-harvest losses are caused by constraints in harvesting, threshing, winnowing, storage, transport, road infrastructures, and market integration system.

In the views of Dominguez (2003), there are direct and indirect post harvest losses. To him, a direct loss refers to the disappearance of food by spillage or consumption by rodents, birds and insects. On the other hand, according to Dominguez, the indirect loss of post harvest refers to the losses caused by a lowering of nutritional quality and loss of seed viability, leading to its refusal as food and lowers the eventual sales price. The author argued further that post harvest losses are associated by economic reductions of the product, and they occur in any of the stages of the postharvest system contributing to total post-harvest loss.

B) Post-harvest Loss Measure

Quantitative measurement and evaluation of crop post-harvest loss is the basic premise of post-harvest loss research. The overall cumulative loss figures in different cereal grains can be obtained by summing or cumulating the losses along the different stages of the chain (Chen et al., 2018). Since the actual physical weighting of the losses throughout the entire post-harvest chain is difficult and time consuming, this research used survey data gathered from smallholder farmers by asking them opinions of quantity harvested and lost at each stages of post-harvest chain. Farmers self reported postharvest loss assessment methods have been used by a number of researchers in different countries to get aggregate loss figures at farm household level. In this research, for quantifying cereal crop harvest losses, farmers self reported post-harvest loss estimates were used. This study used questionnaire to indicate subjective estimated losses by smallholder farmers experiencing the losses in post-harvest value chains.

C) Smallholder Farms

Definitions of small farms or smallholder agriculture differ among scholars. Most of the literature defines small farms based on the sizes of farm land holdings of less than two hectares. But, Gatzweiler and Braun (2016) and Kirsten and Zyl (1998) argued that the conceptualization of small farm based on the criteria of land holding size is quite deficient, non-inclusive and is not a good criterion for defining small farms. As farm land holding sizes are often divergent among countries, a comparison among countries becomes problematic. The author continue to argue that, using farm size alone as a basic criteria to define small farm may distort our understanding of smallholder agriculture and may lead to misguided agricultural policy actions. According to Gatzweiler and Braun (2016) the same amount of farm size but different sustainability (well managed or highly degraded) or with different locations with respect to market (remote or near urban market) may provide different income for smallholder farmers. Therefore, it is important to consider the technical and institutional characteristics in the definition of small farm.

Hazell, Poulton, Wiggins, and Dorward (2006) describe small farms as those with ‘limited resources', a definition that includes land, labor, capital, technology, and skills (p. 48).

Others like Kirsten and Zyl (1998) define small farms based on primary aim of the farm (household's consumption or commercialization). Smallholder agriculture is a source of employment, food and sustenance for most sub-Saharan African households and most agriculture in Africa, in turn, is carried out by smallholder households (Gollin, 2014). According to Alliance for a Green Revolution in Africa (AGRA) (2017) study, 500 million smallholder farmers around the globe supply livelihoods for more than two billion people and produce about 80 percent of the food in sub-Saharan Africa and Asia. Large proportion of what is produced by these smallholders is consumed within the household. In addition, household surveys from many African countries revealed that most African smallholder farming systems use family labor in contrast to hired labour (Gollin, 2014).

D) Cereal Crops

Cereal crops are interchangeably named grain crops. In most of the cases, they are simply referred as cereals or grains.The term may also refer to 'edible seed of the grass family' that represents the principal component of human diet (Gani, Wani, Masoodi, & Hameed, 2012 p. 1). similarly, in their seminal article, Sarwar et al. (2013) define the concept of cereal crops as plants of the grass family yielding an edible grain which are utilized as staple food and animal feed. According to Awika (2011), in some less developed countries of the world up to 90% of the total diet may be cereal crop.

According to FAO statistics, the top three basic cereal crops in the world ranked on the basis of production tonnage are maize (corn), wheat and rice (paddy) (FAO, 2018). These crops make up the bigger part of cereal production and continue to be the most important source of food for human consumption. Cereal crops continue to be by far the key source of total food consumption in the developing countries where direct consumption of cereal crops provides 53 percent of total calories and 49 percent for the global calorie intake as a whole (FAO, 2012). FAO continue to state that maize and wheat are by far the most widely consumed cereal crops throughout the world. Rice [*Oryza sativa*], wheat [*Triticum spp.*] and maize [*Zea mays*] constitute approximately 85 percent of the world's production of cereal crops and are part of the daily diet of the majority of the world population (FAO, 2008). As to the projections for the year 2050, global cereal production will continue to be indispensable for food security and global survival. The projections are grounded on a growing population that is expected to reach more than nine billion people in 2050 (Martins, 2013). Cereal crops go through a number of processing stages between harvest and consumption and such chain of process is referred to as the post-harvest cereal system (Abass et al., 2013; Pasetto, 2018; Mada, Hussaini, Medugu, & Adams, 2014).

The cereal crops that were surveyed in this study include *Teff*, wheat, and maize. These crops are the most produced and consumed staple cereal crops in Ethiopia in general and in the study area in particular. In addition these Crops were selected on the basis of importance and area of production in the study area.

E) Rural Transport Infrastructure

There are no clear and agreed upon meanings for rural transport infrastructure. Rural transport infrastructures, according to Donnges (2001), are the underlying structures that support the movement of people and goods in rural area. It also helps in delivery of agricultural inputs, goods and services to rural communities and evacuates agricultural outputs to market places. Rural transport infrastructure within this concept takes into account feeder road, walking, human portage, motorized transport, animal transport (i.e animal pack and cart) and paths and footbridges. The Cambridge Advance Learner's Dictionary and Thesaurus (2016) generally defined rural transport infrastructures as the set of interconnected structural elements that provide a framework supporting an entire activity in the rural setting. Connerley and Schroeder (1996) also defined rural transport infrastructure as public goods provided by governments which is one important part of a broader concept of rural access. Consequently, Connerley and Schroeder explained the benefits of rural transport infrastructure as access to markets, public services, labor opportunities, and household consumption.

Rural road systems consist predominantly roads of gravel or earth construction. In rural areas of developing countries, much of these rural road networks remain unsealed. In Ethiopia, for example, only 15% of the total road network is asphalt (Anega & Alamirew, 2013). Rural roads are often considered to be a lifeline for small-scale farmers. Studies carried out in SSA by World Bank (2011) found inadequate rural connectivity as a cause for increased post-harvest loss. Conversely, villages provided with all-weather access and regular transport services produced more than they did before (Popova, 2017). According to Satish (2007), a well functioning rural transport infrastructure lowered transportation costs, increased farmers' access to markets, and led to substantial reduction in cereal crop post-harvest loss and higher crop productivity.

There are, of course, many other ways a poor road connectivity can affect agricultural productivity and marketing by increasing the cost of inputs and reducing their accessibility to their product market. Therefore, general social and economic improvement of smallholder farmers cannot be considered without such influential factor as transport and transport infrastructure. It is quite natural to take for granted that rural transport infrastructure facilitates agricultural production processes. Rural transport provides the fundamental conditions for active functioning of rural economy and society. At the same time, poor transport system in the rural areas can be a constraint of the rural economy (Popova, 2017). Cereal crop losses may occur when moving the harvested produce from field to threshing floor, when transporting the produce from threshing floor to home storage and when transporting the produce from home storage to market place (Basavaraja, Mahajanashetti, & Udagatti, 2007). In summary, improved rural transport can ease the introduction of improved post-harvest practices by lowering the costs of modern post-harvest implements such as improved harvesting and storage facilities.

F) Grain Storage

In rural areas, the availability of effective grain storage infrastructure is considered to be vital to reduce post-harvest losses. Secure post-harvest storage facilities also play an important role in improving farm incomes and food security for smallholder farmers. According to Chen et al. (2018), grain storage conditions have the greatest effect on post-harvest cereal loss, followed by transportation. By using multinomial logit model, Okoruwa et al. (n.d.) studied the effectiveness of traditional, semi-modern and modern storage facilities in reducing post-harvest losses in South West Nigeria and they found that farmers who stored under the traditional system usually suffer great post-harvest losses.

Smallholder farmers in Ethiopia use conventional grain storage structures and handling systems such as *gotara* and *gumbi* to store grain. However, these storage practices are ineffective against mold and insects. Different chemical storage protectants such as malathion, Actellic, and DDT dusts or Phostoxin tablets are also mixed with grain to protect post-harvest loss and quality deterioration. Modern storage practices like metal silos and hermetic bags are said to be effective in grain storage, but they are cost-prohibitive to most smallholder farmers in Ethiopia. Such modern storage practices will help reduce smallholder farmers' cereal crop storage losses and maintain grain quality.

4.2.5 Conceptual Framework for Estimating Cereal Crop Post-harvest Losses

In this section, we present a conceptual framework to show how cereal crop post-harvest loss can be estimated across the stages of post-harvest system along with factors driving the loss. The current study adapted Morris and Kamarulzaman's (2014) commodity system approach as a conceptual framework towards estimating crop postharvest losses and identifying causative factors across the different stages of the postharvest loss value chain.

Cereal crop post-harvest activities could be performed along the value chain from harvest to marketing. Losses occur at each stage along the chain and contribute to the total post-harvest loss. The loss at any stage along the post-harvest value chain is driven by different socio-economic, institutional, natural, technical and infrastructural factors, examples of which are described in the conceptual framework presented in figure 4.3. The relative significance of a particular factor or stage toward contributing to the total cereal post-harvest loss will vary across smallholder farmers and cereal type. In this study, crop losses at wholesale, and retail and consumer levels were not included in the estimation of post-harvest loss.

The agricultural sector in many developing countries faces a lot of challenges such as low productivity and postharvest grain losses (Kannan, 2014). In several African countries, the postharvest grain losses have been estimated to range between 20% and 40%, which is highly significant considering the existing low agricultural productivity in these regions of Africa (Abass et al., 2013). Late harvesting, insect infestation in field and rain during drying causes crop post-harvest losses, which in turn decrease farmers' crop productivity. Therefore, low farm productivity starts with high post-harvest loss rates. Farmers' crop productivity is to a large extent can also be influenced by contamination with foreign matter during threshing stage of post-harvest chain (Sawicka, 2019; Kumar & Kalita, 2017).

Other reasons for the formation of farming cooperatives and collective action groups include: market failure (due to costly information and transaction costs), promotion of self-help, a desire to enhance bargaining strength with input suppliers and buyers of farm products, Ortmann and King (2007) contented that some of the reasons for the formation of farming cooperatives and farmer group organisations include: market failure due to costly information and transaction costs, promotion of self-help, a desire to enhance bargaining strength with input suppliers and buyers of farm products, operational costs, income enhancement, reduction of transaction costs with trading partners, provision of missing services such as inputs and/or product marketing, assurance of input supplies and/or product markets.

In many areas of the developing world, where crop productivity is already minimal and the means of mitigating post harvest losses of agricultural crops are limited, weak marketing knowledge and limited collective marketing arrangements are expected to reduce productivity to even lower levels and make crop production more inconsistent (Hodges et al., 2010; Garikai, 2014). In addition to enhancing bargaining power of smallholder farmers, the formation of farming cooperatives and collective action groups minimize market failure that may arise due to costly information and transaction costs (Garikai, 2014). In summary, reducing smallholder farmers' post-harvest losses at different stages of the post-harvest stages will increase productivity, profitability and secure access of food crops to local, regional, national and international markets.

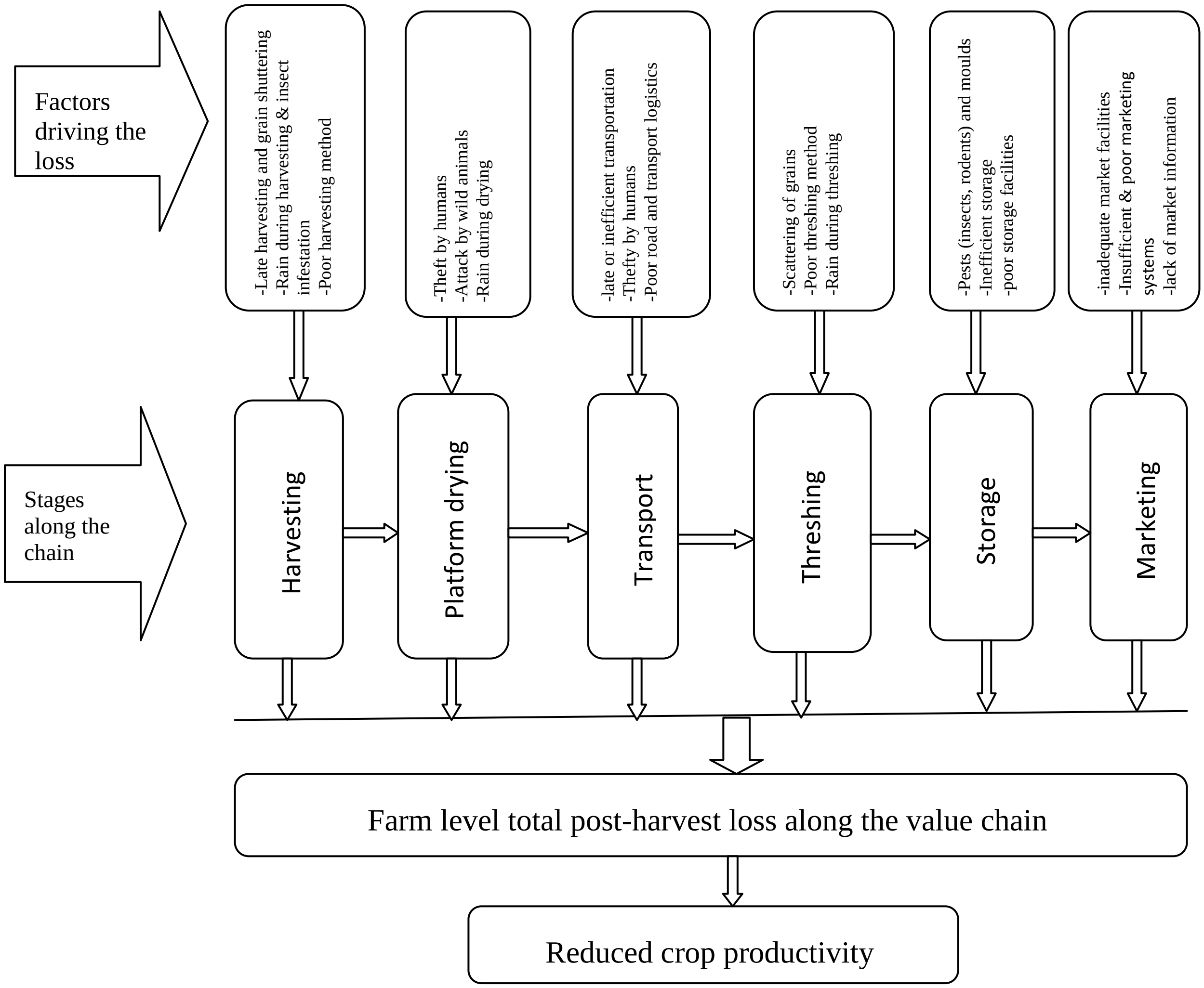


Figure 4.1. Conceptual Framework for Postharvest Losses

Source: Author’s conceptualization

4.3. Research Methods

4.3.1 Study Sites

The study took place in four districts of Horro Guduru Wollega Zone: Horro, Amuru, Abe Dongoro and Habobo Guduru (Figure 4.2). This zone is one of Ethiopia's largest major food crop producing areas of the country. The loss of post-harvest links of major food crops (wheat, maize and *teff*) in Horro Guduru Wollega Zone were collected, and the characteristics of post-harvest loss of major food crops were systematically analyzed and quantified. In 2017 /18 (2010 E.C) crop production calendar, wheat, maize and *teff* production in Ethiopia's main food crops accounted for 54.02% of total cereal crop area and 59.86% of the total cereal crop production (CSA, 2018), which basically reflected the overall situation of post-harvest losses in Ethiopia. The post-harvest links of major food crops in this study mainly include the stages of crop harvesting, threshing, winnowing, transportation, drying, storage, and marketing. Data at each stage of post-harvest losses were obtained primarily from smallholder farmers self-report. Therefore, we estimate the post-harvest loss of major food crops based on farmers' self reported data for 2015 /16 crop production calendar.

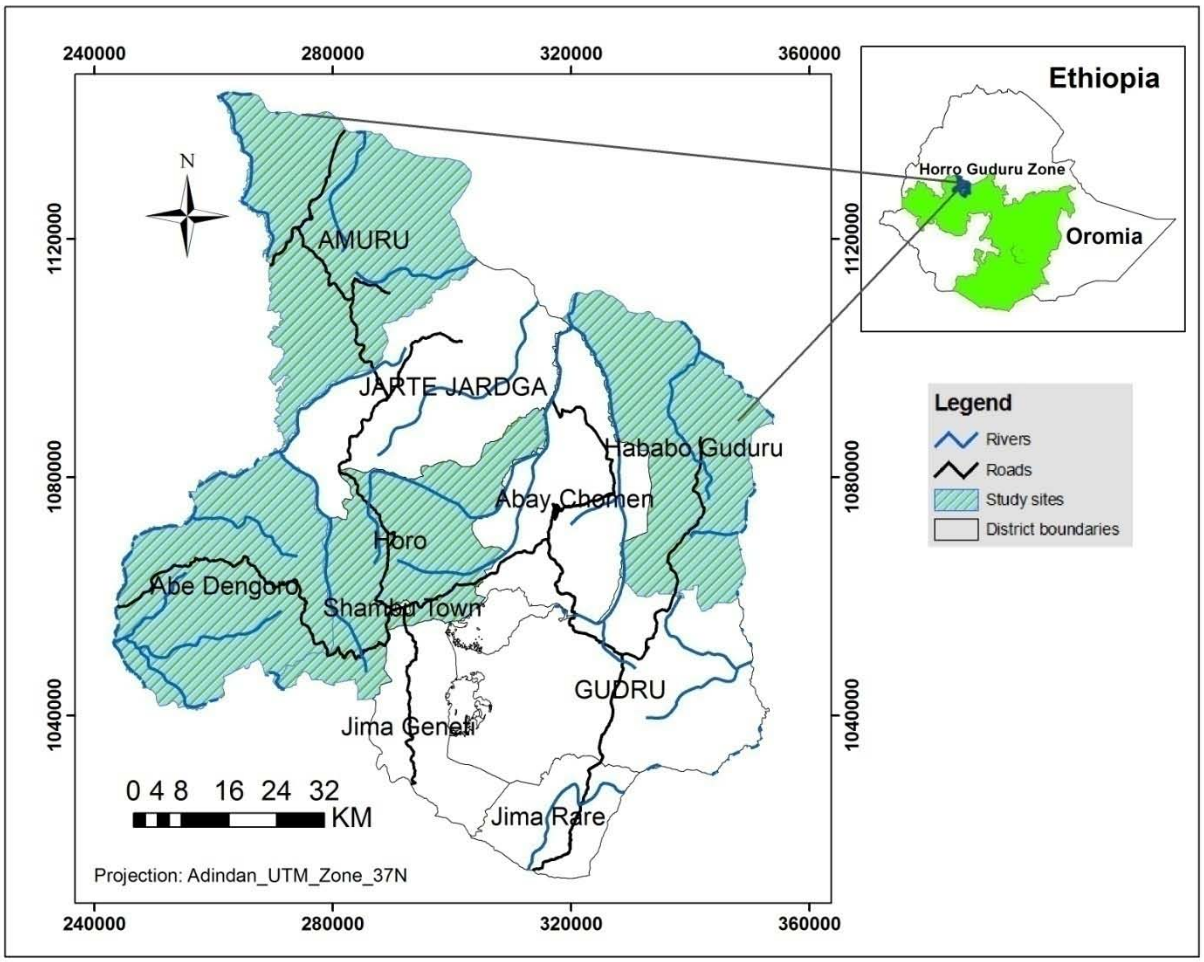


Figure 4.2. Location map of Horro Guduru Wollega Zone.

Source: Adapted from Finance and Economic Development Bureau of Oromia, 2016.

4.3.2. Sampling Techniques

A multi-stage sampling design was adopted for the ultimate selection of food grain-growing farmers. A three-stage simple random sampling design was adopted to draw a sample size of 500 major food crop growing smallholder farmers. The three stages involved the selection of the four districts (Horro, Amuru, Abe Dongoro, and Habobo Guduru), the selection of the 16 rural kebeles and the selection of the 500 smallholder farmers. The final selection of farmer respondents was made from a comprehensive list of smallholder farmers from each selected rural kebeles with the help of agricultural development agents and rural kebele managers. For selection of smallholder farmer respondents, simple random sampling formula by Gray et al. (2007) was employed with confidence level of 95%.

4.3.3. Methods and Instruments of Data Collection

The study has utilized cross-sectional data obtained from the survey of sample smallholder farmers. The data for this research was collected from February to June 2016. A total of 16 rural kebeles from four different cereal crop growing districts of Horro Guduru Wollega Zone were included in the study. The data for this research were from primary source. The household questionnaire was the main tool used for primary data collection. The questionnaire was intentionally structured to elicit information needed from the sample smallholder farmers. The questions were made short, simple and clear to avoid non-responses and missing variables as much as possible.

The data collected from the farmer respondents included general information about the current level of post-harvest losses of the selected crops at different stages of the post-harvest chain (methods of harvesting, and drying, place of drying, threshing, winnowing/cleaning, mode of packaging, transportation condition, storage system and marketing). The questions also included the most susceptible food crop to post-harvest loss, the causes of postharvest cereal losses, rural transport infrastructure and storage facility related factors causing post-harvesting losses in the study area. In addition, the structured questionnaire was set to collect data on the socio-economic and demographic characteristics of smallholder farmers such as gender, marital status, household size, farming experience, farmland size, level of education, mode of transportation often used for transporting produce from the farm to the collection point, from collection point to threshing floor, from threshing floor to storage and from storage to market.

The questionnaire has been refined by a preliminary test carried out on three smallholder farmers in the study area in order to adapt it to the reality of the field and has been translated into vernacular language (Afaan Oromo). The actual survey took place from February to June, 2016 through interviews at the home or work place of each respondent farmer. A total of 500 copies of structured questionnaires were distributed in this survey, and the sample effective rate was 100% (zero non-response). The primary data collection exercise took five months and involved the researcher and trained data collectors in each selected sample rural kebeles.

4.3.4. Data Processing and Analysis

Statistical Package for Social Sciences (IBM SPSS) software program version 20 was used in computing descriptive statistics (mean, standard deviation, frequencies, and percentages). Descriptive analysis was used to identify percentage losses of cereal crops at different stages of post-harvest loss and locate loss hotspots within the post-harvest chain. The collected post-harvest loss, socio-economic and demographic data were first analyzed descriptively, in order to understand the general characteristics of smallholder farmers' profiles. The descriptive analysis involved the use of frequency tables and percentages to categorize smallholder farmers under the different demographic and socio-economic characteristics. The summary measures used included the standard deviation and mean.

Data on factors affecting post-harvest losses were analyzed by the help of Tobit regression using STATA 12.1 software. Since the dependent variable (the proportion of cereal crop lost at different stages of post-harvest loss system) was censored at both right and left sides to be within the (0-100%) range, the conventional ordinary least squares (OLS) is inconsistent and no longer applied to estimate regression parameters. Therefore, in such limited dependent variable case a Tobit regression model best fits or is a better choice (Amentae, 2016; Tobin, 1958). The use of the Tobit model in this study is consistent with other previous studies. For example, according to Kaminski and Christiaensen (2014) and Chen et al. (2018), a Tobit model is appropriate to describe censored data in the interval [0, 1]. In their study, Kikulwe, Okurut, Ajambo, Nowakunda, Stoian, and Naziri (2018) also employed a tobit model to get robust estimates of the factors affecting postharvest losses at the farm level. Therefore, we run a Tobit regression of the proportion of cereal crop post-harvest loss as a function of all the independent variables to investigate factors affecting smallholder farmers' post-harvest losses. The parameters of the Tobit model were derived using the Maximum Likelihood Estimation method in the STATA 12.1 software.

In addition to Tobit model, smallholder farmers' attitude about the severity of factors that causes cereal crop postharvest losses was assessed by using a 5-point Likert scale (Likert, 1932 in Warmbrod, 2014). This scale used the following perception indices: 1 = not at all influential, 2 = slightly influential, 3 = somewhat influential, 4 = very influential and 5 = extremely influential. The Likert scale was used by a number of researchers to assess the severities of post-harvest loss causing factors (Amentae et al., 2016; Meena, Prasad, & Singh, 2009; Kong, Nanseki, & Chomei, 2015).

4.3.5 Variable Definition and Measurement

Our variables of interest (both dependent and independent) used in this study and their levels of measurement is shown in table 4.1. These variables are supposed to capture the influence of the potential independent variables on smallholder farmers' post-harvest losses.

Table 4.1: Descriptions of variables used and their measurements

Variable name and type	Description	Measurement	Expected sign
Total post-harvest loss (Y)	A dependent variable expressed as a rate (apercentage) of post-harvest loss for major food crops	% of total post-harvest loss for major food crops	NA
Family size (continuous) (X_1)	Total family size of the household head	Number	+
Distance to major market (continuous) (X_2)	Distance travelled by the household to reach the nearest major market	kilometer	-
Transport cost (continuous) (X_3)	Transport cost incurred to move 100kg of agricultural output over 1 km	Birr per 100 kg per km	-
Distance to all weather road (continuous) (X_4)	Distance travelled by the household to reach the nearest all weather road	kilometer	-
Distance to farm plot (continuous) (X_5)	Average farm plot distance from the homestead	kilometer	-
Sex, Dummy(X_6)	Sex of household head	1=if male; 0=otherwise	-
educational status of the household head, Dummy (X_7)	Literacy status of the household head	1=if attended any formal education; 0= otherwise	-
Access to credit, Dummy (X_8)	Whether farmers get access to credit facility or not	1=if access credit; 0=otherwise	-
Labor reciprocity, dummy (X_9)	A form of social capital which entails mutually helping or working on each others' farm by turn	1= Yes; 0= No	-
level of output (continuous) (X_{10})	Amount of cereal crop produced during the last completed agricultural season	quintal	+
Price of crops, dummy (X_{11})	Situation of crop prices	1= attractive; 0= otherwise	-
Status of storage facility, dummy (X_{12})	storage facility used to store cereals	1= traditional storage method; 0= otherwise	-
Livestock ownership (X_{13}) (continuous)	Total livestock ownership of the household	Total livestock unit (TLU)	-
Age of household head (continuous) (X_{14})	Age of household head	Number of years	-

Source: Author's Compilation, 2016

4.4. Model Specification

Following Gogo, Opiyo, Ulrichs, and Huyskens-Keil (2017); Walker (1983) and Kasso and Bekele (2016), loss in yield (PHL) due to different causal factors at a given post-harvest operation is best expressed as the reduction in the maximum, potential or attainable yield in the absence of the causal factors (W_1), expressed as a percentage of it. The yield in the presence of post-harvest loss causal factors is (W_2), hence the estimated percent post-harvest loss was calculated by the formula:

$$\text{PHL (\%)} = \frac{W_1 - W_2}{W_1} \times 100 \qquad (1)$$

Where: W_1 is the estimated original weight (kg) of given crop at a given stage of post-harvest chain and W_2 is estimated weight (kg) of the same crop after loss.

Post-harvest loss at smallholder farmers' level can occur anywhere between harvesting and marketing. Following Yeboah (2015), farm level cumulative or aggregate post-harvest losses across all stages of the post-harvest chain can be found by summing up all the losses that occurred along these chains i.e between harvesting and marketing. This was calculated using the formula below:

$$\begin{aligned}\text{Cumulative postharvest loss (CPHL)} &= \text{Harvesting} + \text{Platform drying} + \text{transport from field to threshing floor} \\ &+ \text{Threshing} + \text{Winnowing} + \text{Transport to home} + \text{Home Storage} \\ &+ \text{Transport to market} + \text{Marketing}\end{aligned} \qquad (2)$$

A) Tobit Model

A tobit model is most easily defined as a limited dependent variable regression model, originally developed by the Nobel laureate Israel economist, James Tobin (1958). Censored samples usually require censored regression model and a frequently used censored regression model is the Tobit model. A Tobit model which is also called censored normal regression model is appropriate when the dependent variable is censored at an upper bound, a lower bound, or at both an upper and a lower bound (Leclere, 1994; Khaledi, Weseen, Sawyer, Ferguson, & Gray, 2010; Amentae et al., 2016). In our case, since the dependent variable (smallholder farmers' post-harvest loss) has a lower limit of 0% and an upper limit of 100%, we estimate the model using Tobit regression. While the natural upper limit is 100%, no smallholder farmer reported a post-harvest loss higher than 37%. However, as at least 71 smallholder farmers reported the lowest score of post-harvest loss that is 0%, we use Tobit model with lower limit (censored from below at zero). In the present study, a lower-limit Tobit model (left-censored at zero) was applied to obtain robust estimates of the factors affecting post-harvest losses at different stages of the post-harvest chain.

The dependent variable "smallholder farmers' post-harvest loss" is defined as the proportion of cereal crop loss to the total harvested yield. Following Amentae et al. (2016) and Martey, Al-Hassan and Kuwornu (2012), such limited dependent variable model can be mathematically represented as indicated in equation 3.

$$Y^* = \beta_0 + X_i\beta_i + \varepsilon, \varepsilon|X \sim Normal\,(0, \sigma^2) \quad i = 1,2 \ldots . n \tag{3}$$

Where: Y* is the latent (unobserved) dependent variable, the subscript i=1,…, n indicates the observation, β_0 is an intercept, β_i is coefficient of i^{th} independent variable, X_i represents a vector of independent variables and ε is an error or disturbance term, assumed to be independently and normally distributed with mean zero and common variance of σ^2.

The latent dependent variable that we don't observe Y* is related to the actual (observed) dependent variable Y as follows:

$Y = Y^*$ if $Y^* > 0$; and $Y = 0$ if $Y^* \leq 0$

Therefore, the observed dependent variable Y can also be expressed as:

$$Y = \max(Y^*, 0) \tag{4}$$

B) Maximum Likelihood Estimates of the tobit Model

The parameters β_0, β_i and ε under equation 3 are unknown and must be estimated. This estimation can be performed using the method of maximum likelihood estimates of the tobit model in such a manner that the probability of observing the actual response variable (Y) is as maximum as possible. The main idea behind the maximum likelihood is the likelihood function. Therefore, maximum likelihood estimates of the unknown parameters are calculated by maximizing the log-likelihood. According to Gujarati (2004), MLE is a large sample method that can be applied to regression models that are non-linear in the parameters. The maximum likelihood estimates of the tobit model can statistically be expressed according to the following equation, where β, σ are parameters whereas Φ and ϕ are standard normal cumulative distribution function and standard normal probability distribution function respectively:

$$\ell_i(\beta,\sigma) = 1(Y_i = 0)log\left[1 - \Phi\left(\frac{X_i\beta}{\sigma}\right)\right] + 1(Y_i > 0)log\left\{\left(\frac{1}{\sigma}\right)\phi\left[\left(\frac{Y_i - X_i\beta}{\sigma}\right)\right]\right\} \tag{5}$$

If one is using maximum likelihood technique to estimate the regression coefficients (parameters), a likelihood ratio test is quite convenient for this purpose. Following Greene (2012), regardless of the number of variables in the model, maximum likelihood estimator of σ^2 can be written as:

Likelihood ratio test statistic can be calculated by the following formula

$$\boldsymbol{LR = 2\left(Log\ L|\hat{\theta}_{ML}\right) - (Log\ L[\theta_{H_o}])} \tag{6}$$

Where, Log $L|\hat{o}_{ML}$ is a maximum likelihood estimates of a particular parameter (Log likelihood of unrestricted model), Log $L(\theta_{Ho})$ is the Log likelihood obtained under null hypothesis (Log likelihood of the restricted model). Similarly, Likelihood ratio test for unknown parameters (μ, σ^2) follows chi-square distribution with q degree of freedom. Likelihood ratio test can further be expressed as:

$$\boldsymbol{LR = \left[\ell(\hat{\theta}) - \ell(\theta_0)\right]} \tag{7}$$

C) Marginal Effect in the Tobit Model

A tobit analysis permits estimation of the effects of a given explanatory variable on both kinds of dependent variables (latent and observed). In our case, the marginal effect takes into consideration that a change in an explanatory variable will affect the probability of post-harvest loss as well as the amount of loss across all farm level post-harvest chain. Therefore, the marginal or partial effects of independent variables on the latent variable (Y*) can be expressed as:

$$\boldsymbol{\beta_j = \frac{\partial E(Y^*|X)}{\partial X_j}} \tag{8}$$

But, the tobit model parameters do not directly relate to changes in the dependent variable brought about by the variations in independent variables. Instead, following Greene (2012), the marginal or partial effects of independent variables on the observed or actual dependent variable (Y) was given as follows:

$$\frac{\partial E(Y|X)}{\partial X_j} = \beta_j \Phi\left(\frac{X\beta}{\sigma}\right) \tag{9}$$

Following from the aforesaid discussion, the empirical model for computing the factors which affect the extent of smallholder farmers' post-harvest loss is specified as follows:

$$Y^* = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \cdots + \beta_{14} X_{14} + \Sigma \tag{10}$$

Where: Y* is the proportion of smallholder farmers' post-harvest loss, β_0 is an intercept and to be estimated, β_1 to β_{14} are a vector of parameters to be estimated which measures the effects of independent variables on the smallholder farmer's post-harvest loss, X_1 to X_{14} are a vector of hypothesized to affect smallholder farmer's post-harvest loss. Whereas, Ɛ is normally distributed error term with mean zero and constant variance and captures all unmeasured variables. The specific variables in the model are described under variable definition and measurement section in Table 4.1.

4.5. Preliminary Analyses and Assumption Testing

When using Likert-type scales, it is very important to calculate and report Cronbach's alpha coefficient for internal consistency reliability of scales. Cronbach's alpha, a psychometric statistics was used to check the internal reliability or internal consistency of psychometric instrument like Likert-type scales. Most of the time Cronbach's alpha ranges from .00 to 1.00, where .00 indicates no consistency in measurement whereas, 1.00 indicates perfect consistency in measurement. In most of the cases, Values of .7 or higher of Cronbach's alpha is an indication that the scale will be acceptable and will be internally consistent (Gliem & Gliem, 2003, p. 87; Dessalegn et al., n.d., p. 21). Since in our data set the Cronbach's alpha (scale reliability coefficient) calculated using STATA 12 software program was 0.9331, which was greater than the threshold value .7, indicates an internal consistency among the 15 Likert items in this scale. This result indicates that 93% of the variance of the aggregate score to rate the severity of post-harvest loss causing factors at farm level is consistent internally. Therefore, only 7% is error variance.

The usual checks for multicollinearity, Variance inflation factor (VIF) and Tolerance were computed to see if multicollinearity exists among independent continuous variables in our dataset. The variance inflation factor (VIF) for each and every continuous variable was less than the rule of thumb i.e 10 (Gliem & Gliem, 2003; Gujarati, 2004). On the other hand, the tolerance values are all greater than 0.1 (Appendix 4.1). Therefore, there is no problem of multicollinearity in our dataset ensuring that there are no perfect linear relationships among the independent variables.

The three basic assumptions underlying the tobit model: homoscedasticity (constant variance), normality of residuals and independence of residuals were checked. Testing the homogeneity of variances is the most important assumptions in tobit regression model (Gujarati, 2004). To check whether the residuals are heteroscedastic or not, we run the Breusch-Pagan statistical test for heteroscedasticity (appendix 4.2). In addition to the statistical test, graphical method of checking heteroscedasticity (plotting residuals against fitted values) was also carried out (appendix 4.3). From both statistical and graphical outputs, we can conclude that there is no problem of heteroscedasticity in our dataset and hence is homoscedasic (the residuals exhibit constant variance).

Another important assumption related to the residuals in tobit regression analysis is normality test of residuals. Both Graphical inspection and formal test statistics (Shapiro-Wilk test) of residual normality check were used to see the distribution of disturbance term across our independent variables. From the visual indications of histogram (appendix 4.4) and Shapiro-Wilk test output (appendix 4.5), we can conclude that the residuals appear to be approximately normally distributed.

The last but not the least tobit model diagnostics is the assumption of independent residual. All the residuals are assumed to be independent of each other (uncorrelated for the population). For the detection of this assumption of independent residuals, Durbin-watson statistic was used (Chen, 2016). The Durbin-watson statistic can range from 0 to 4, but a value of approximately 2 indicates that there is no correlation between residuals (Chen, 2016). In our dataset, since the Durbin-Watson statistic was 1.64 which is close enough to 2, we can assume that there is no worry for some level of correlation between residuals and hence the residual series can be regarded as free of autocorrelation (appendix 4.6). Visual inspection of the scatter plot of standardized predicted value against standardized residual also showed the absence of autocorrelation between residuals (appendix 4.7).

4.6. Ethical Considerations

Ethics in research are the norms for conduct that distinguish between wrong and right. Hence, it differentiates between acceptable and unacceptable behaviors on the part of the researcher. Adherence to ethical principles is so important in research, because it increases the reliability, integrity, generalizability and validity of the research findings (Akaranga & Makau, 2016; Manti & Licari, 2018). According to Sobocan, Bertotti, and Strom-Gottfried (2018) and Nijhawan, et al. (2013), keeping an eye on ethical considerations in the research process is the obligation of every social science investigator to make sure that the cultural, legal, economic, and political rights of the respondents is respected. Having discussed the meaning and importance of research ethics in all kinds of research, it is vital to explain the ethical standards followed in this specific research. Informed consent is the major ethical issue in conducting research that involves human subject. Accordingly, in this research an introduction to the study and its purpose as well as the principle of voluntary participation was explained to the respondents prior to data collection. Respondents were also informed that they may choose whether or not to participate in the study and had the right to withdraw from the study at any time.

4.7. Results

4.7.1. Socio-economic Backgrounds of Smallholder Farmer Respondents

General information of smallholder farmers in the study area was presented in Table 4.2. The result showed the average self-reported cereal post-harvest loss at farm household level was 16.73%. The age of the respondent smallholder farmers were between 17 and 64 with 34 years as an average age of respondents. The family size of households is on average 6 individuals. Smallholder farmers live far from the nearest markets, on average 20 km. The average distances to the nearest all weather roads and to farm plots were 12.96 and 6.41 km respectively. The average tropical livestock unit owned by smallholder farmers was 3.26, whereas the average cereal crop production was 40.48 quintals with a minimum and maximum production level of 4.25 and 117.5 quintals respectively. The descriptive statistical result also showed that on average smallholder farmers incur a transportation cost of 2 Ethiopian birr for one kg of cereals per 100 km of distances.

Table 4.2: Socio-economic information of respondent farmers

Variable	Obs	Mean	Std. Dev.	Min	Max
Post harvest loss (%)	429*	16.76	11.75	1	37
Age (years)	500	34.2	3.31	17	64
Household size (number)	500	6.48	3.31	2	12
Tropical livestock unit (TLU)	500	3.26	1.64	.55	11.51
Distance to market (km)	500	20.18	7.87	5	35
Distance to all weather road (km)	500	12.96	6.75	0	27
Distance to farm plot (km)	500	6.41	3.38	.4	13
Transport cost (ETB)**	500	2.16	.77	.5	3.2
Cereal Output (quintal)	500	40.48	20.34	4.25	117.5

*descriptive statistics for the dependent variable (Post-harvest loss) was computed only for farmers who experienced (incurred) post-harvest loss.

** The exchange rate at the time of the survey was 27.5 Ethiopian birr per US$.

Source: Survey result, 2016

4.8 Percentage Post-harvest Cereal Losses by Smallholder Farmers

Farm level post-harvest loss characteristics of the three major food crops (wheat, maize and *teff*) of the study area across the different post-harvest chain in 2015/16 crop season was presented in Figure 4.3. The results showed that the post-harvest loss rate of major food crops was higher. Farm level average post-harvest loss rates of wheat, maize and *teff* were 11%, 20.4% and 13.8%, respectively (see also appendix 4.8). The average loss rate of the three was 16.76%, which was higher than the post-harvest loss level of Sub-Saharan African countries. Among the post-harvest chains or stages, the percentage of loss in the home storage chain was high, the average loss ratio reached 3.45%, followed by the harvesting chain, which was 3.14%, and the loss in transportation and threshing, which were 3% and 1.91% respectively. Therefore, home storage, harvesting and transportation are the hotspot links for post-harvest losses of cereal crops in the study area. On the other hand, the losses in platform drying and marketing stages were small, 1.21 % and 0.46% respectively. The survey also showed that the post-harvest loss rate at storage stage for wheat, maize and *teff* were 3.4%, 6.1% and 0.9% respectively.

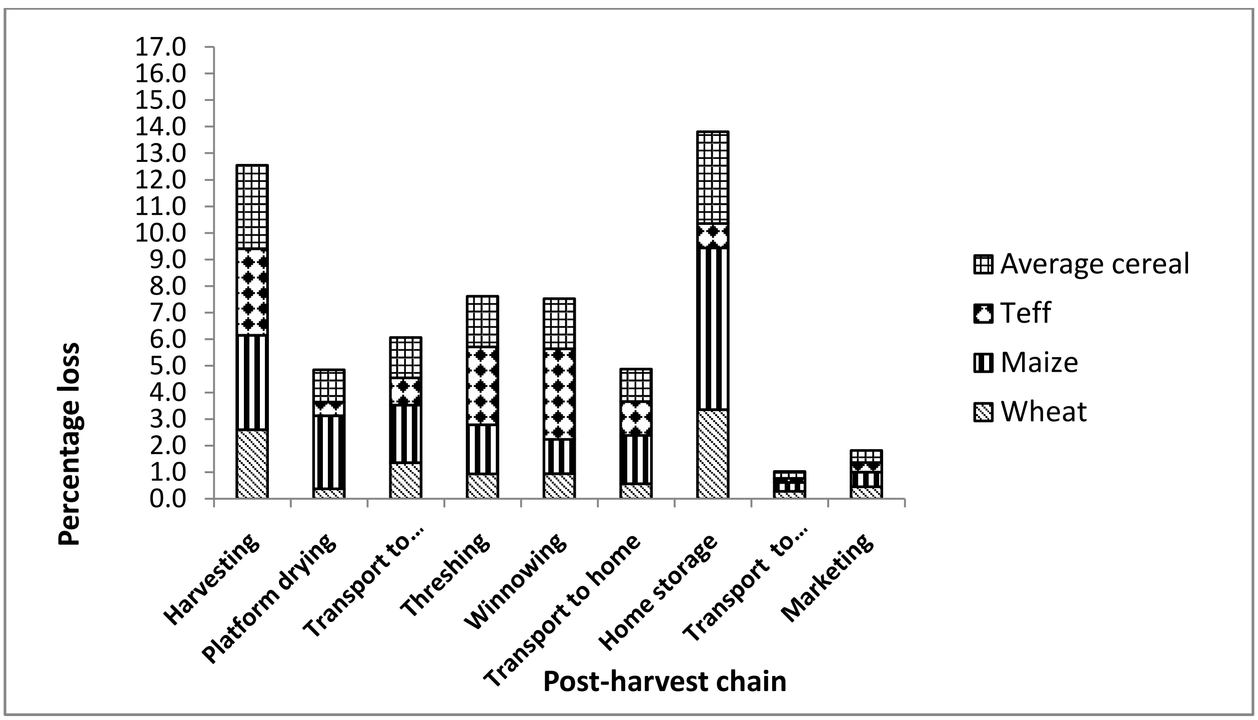


Figure 4.3. Extent of cereal crop post-harvest loss at different post-harvest chain

Source: Survey result, 2016

4.9 Likert Scale Assessment of Farmers Perception on the Severity of Post-harvest Loss Causing Factors

Farmers were asked to rate farm level post-harvest loss causing factors on a five point Likert scale where these factors were assessed as extremely influential (5) to not at all influential (1). Accordingly, smallholder farmers' perceived severity of factors causing post-harvest losses of cereals in the study area were presented in Figure 4.4. According to the result, insect pests and insufficient transportation were rated as extremely influential and very influential factors causing crop post-harvest losses respectively.

The study revealed that causes of postharvest losses at various stages of post-harvest system are diverse. The major physical, socio-economic and technical factors causing losses of cereals in the study area, expressed in order of severity as extremely influential factors in causing cereal post-harvest losses, included: Pests (52%), traditional storage facilities (45%), insufficient transportation (38%), bad weather condition (30%), wild animals (21%) and poor marketing coordination (17%). Whereas, smallholder farmers considered bad weather (30%), insufficient transportation (29%), traditional harvesting and threshing methods (28%), and traditional storage facilities (27), wild animals (25) and pests (24%) as the six very influential factors causing post-harvest losses (see also appendix 4.9).

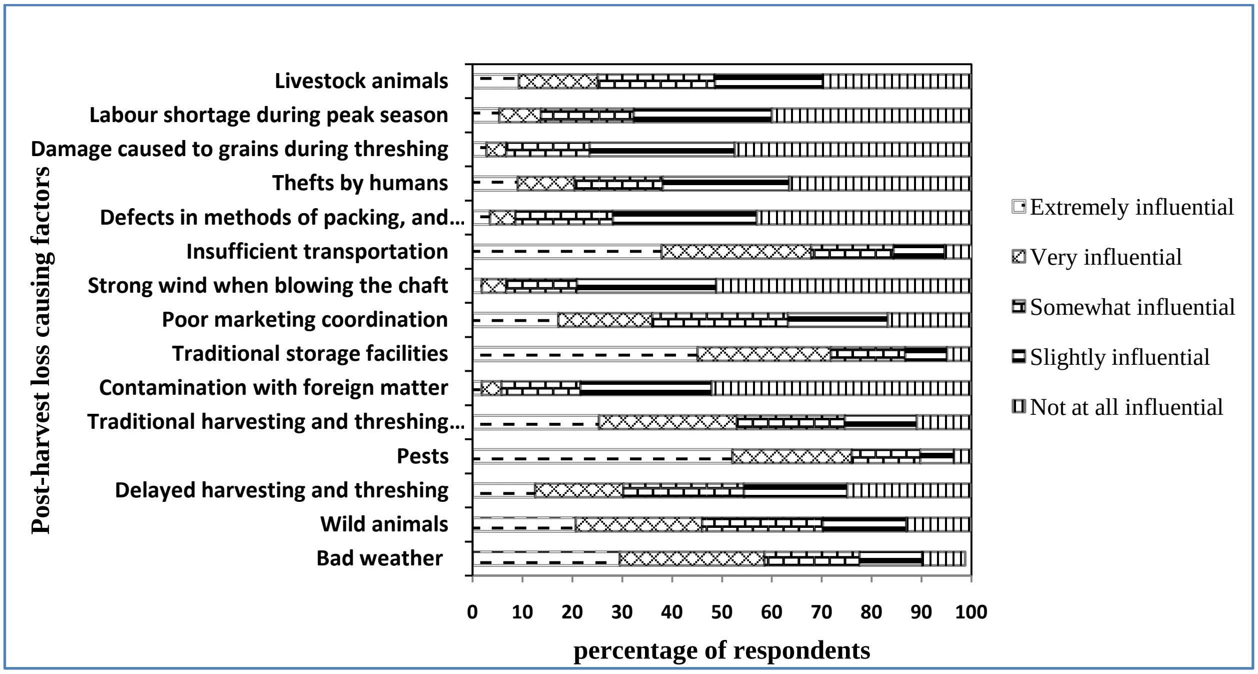


Figure 4.4. Severity of factors perceived by Smallholder farmers as causing cereal post-harvest losses across the different post-harvest stages

Note, Rating scale: 1 = not at all influential; 2 = slightly influential; 3 = somewhat influential; 4 = very influential; 5 = extremely influential

Source: Survey result, 2016

4.10. Tobit Regression Results of Factors Affecting Smallholder Farmers' Post-harvest Losses

Table 4.3 presents factors affecting smallholder farmers' post-harvest losses of cereals in the study area. The Tobit model estimated results of the variables that are expected to influence the amount of cereal post-harvest loss at farm-level. With the exception of age and crop output level variables, all independent variables were found to significantly influence the amount of cereal post-harvest loss at the 0.01 level. The STATA 12.1 software was used to estimate the beta coefficients for expected value of the uncensored latent dependent variable and marginal effects of the potential independent variables (covariates) that were assumed to determine the actual amount of cereal post-harvest losses of farmers (observed outcome). The Tobit regression result showed that most of the coefficients are consistent with hypothesized relationships that mean the signs of all of these independent variables are according to *a priori* expectations (see Table 4.1), and their tests of significance help to indicate their importance in determining farm level post-harvest losses. The variables used in Tobit regression analysis were included based on *a priori* theoretical considerations. The Likelihood Ratio Chi-Square test i.e., $\chi2(14) = 946.05$; Prob > $\chi2 = 0.000$) revealed that at least one of the predictors' regression coefficient is not equal to zero.

The amount of smallholder farmers'post harvest loss is significantly determined by educational status, labour reciprocity, price of crops, credit availability, gender, storage facility, tropical livestock unit, distances to market, and distance to all weather road.

As can be seen in Table 4.3, participating in local labour arrangements like labour exchange or labour reciprocity tends to decrease the probability of incurring post-harvest loss by 3.7 percentage points. Smallholder farmers with formal education can decrease the amount of post-harvest loss by 3.8 % as compared to their counterparts with no formal education. The tobit regression result also indicated that having a male headed household resulted in a decrease of 2.3% in post-harvest losses. Getting an attractive price for crops decreases the probability of PHL by 2.7%. Access of smallholder farmers to credit facilities found to decrease the probability of PHL by 2.5%. Modern storage facilities also found to decrease the probability of PHL by 2.1%. The tobit regression coefficients also indicated that increasing distances to the nearest market, to all weather road and to farm plot increased cereal post-harvest losses of smallholder farmers by .31%, .37% and .33% respectively. Confidence interval of variables used in the tobit model is presented in appendix 4.10 for tobit coefficients and in appendix 4.11 for marginal effects.

Table 4.3. Results of Tobit model and marginal effects of factors influencing crop post-harvest loss.

	Tobit model		Marginal effects (dx/dx)	
Post-harvest loss (dependent var.)	Coef.	s. e.	Coef.	s. e.
Household size	-.268*	.102	-.267*	.101
Distance to market	.305*	.049	.304*	.048
Transport cost	3.074*	.428	3.067*	.426
Distance to all weather road	.368*	.066	.367*	.066
Distance to farm plot	.336*	.078	.335*	.077
Sex	-2.265*	.835	-2.259*	.832
Educational status	-3.831*	.652	-3.821*	.651
Access to credit Credit	-2.533*	.541	-2.526*	.539
Labour Reciptocity	-3.688*	.549	-3.678*	.548
Output level	.051**	.019	.050**	.019
Price of crops	-2.750*	.554	-2.742*	.552
Storage facility type	-2.119*	.513	-2.114*	.511
Livestock ownership	-.922*	.247	-.919*	.246
Age	.016	.023	.016*	.022
_cons	6.997	1.720		
/sigma	4.873	.166		
Number of obs = 500				
LR chi2(14) = 946.05				
Prob > chi2 = 0.0000				
Pseudo R2 = 0.2634				
Log likelihood = -1323.0009				
Obs. summary: 71 left-censored observations				
429 uncensored observations				
0 right-censored observations				

** and * *statistically significant at 5% and 1% probability level*, respectively.

Source: Survey result, 2016

4.11 Discussion

4.11.1 Farmers' Perception on Major Causes of Farm Level Post-harvest Losses

Post-harvest loss as caused by pests was further separated into different categories of causes; (i) bird damage, (ii) fungal damage, (iii) mouse and rats damage, and (iv) insect damage. Pests are a key constraint to effective crop production and further complicates smallholder farmers' food self sufficiency efforts in sub-Saharan Africa (SSA), with damage caused by these pests due to lack of appropriate storage facilities is of particular concern. These pests are considered very destructive to stored food crops especially in tropical and sub-tropical regions of the world (Midega, Murage, Pittchar, & Khan, 2016). For instance, in their study, FAO (1994) and Champ & Highley (1986) reported that the larger grain borer, maize weevil and lesser grain borer as major pests of stored maize in Tanzania.

On top of this, the prevailing bad weather conditions stimulates the reproduction of the main insect pests, which are multiplying at high speed, as well as the development of micro-organisms such as yeasts and molds. Indeed, the speed at which insect pests multiply can be influenced by prevailing bad weather conditions. According to Martin (2016), fungi attack on cereal crops, for example, results in fungible stored grain.

In the developing countries the availability of arable land and water is decreasing. Indeed, to cope with the growing food demand for populations living in these countries, addressing the issue of post-harvest loss and hence food insecurity is of paramount important. Even though there are many possibilities to address the problem of food insecurity (slowing down population growth and increasing agricultural production by increasing yields or the cultivable areas), reducing post-harvest losses is said to be the easiest and forward solution in this regard (Amentae, 2016; Affognon et al., 2014). Therefore, establishing effective pest management systems that are adapted to smallholder farmers' situations is a priority.

4.11.2 Farm Level Cereal Post-harvest Losses at Home Storage Stage

The study found that between harvest and marketing, more than 16.76% of production was lost across different stages of the post-harvest system. This post-harvest loss proportion is higher in Sub-Saharan African countries. For instance, Ambler et al. (2017) reported farm level postharvest loss averages between 5 and 12 % of farmer’s total harvest in Malawi. On the contrary, by using panel household data collected in Ethiopia, Hengsdijk and Boer (2017) observed an average self-reported cereal post-harvest loss of 24%. This study found that cereal loss during home storage is a high proportion of post-harvest losses (Figure 4.3). The loss during storage chain is mainly due to the reduction in quantity and quality caused by insect pests and traditional grain storage (ordinary equipment, without any protective measures) (Figure 4.5).

Figure 4.5: Field storage/field drying, maize, Horro district

Source: Photo taken during field survey

The storage loss of *teff* was found to be lower than wheat and maize. This is probably because of the small grain size of *teff*, which makes it more resistant to insect attacks than other cereals (Hengsdijk & Boer, 2017). In terms of causes of storage cereal losses, 52% and 24% of respondents believed that pests (insects, mites, ants, termites, rodents, rats and molds) had extremely influential and very influential impact respectively (Figure 4.4).

Different scholars have carried out extensive research on safe grain storage for farmers that help them reduce post-harvest losses of grains. In the research of *Teff* post-harvest losses in Bacho and Dawo districts of central Ethiopia, Amentae et al. (2016) compared the efficiency of traditional and modern *teff* storage facilities. In their study, Amentae and his Colleagues found that the traditional *teff* storage equipments (*Gumbi/ Gotara*-traditional granaries) are the causes for *Teff* post-harvest losses. According to their finding Post-harvest loss of *Teff* could decrease by 6.9% when the smallholder farmers use good storage facilities like metal silos and Plastic sacks as opposed to the traditional facilities. In another Scholarly work, Abass et al. (2013) studied the effects of different kinds of grain storage infrastructures on maize post-harvest losses in semi-arid savannah area of Tanzania. Accordingly, he found significant variations in the proportions of maize post-harvest loss among users of polypropylene storage facilities (metal silos and other hermetic storage devices) and traditional granaries made with mud and plant materials.

Even though the post-harvest loss of cereals cannot be completely eliminated, it can be reduced by improving storage conditions. Furthermore, according to action research conducted in Uganda and Burkina Faso by Costa (2014), new storage technologies enabled food losses to be reduced by more than 98% as compared to traditional storage units. Therefore, smallholder farmers' access to appropriate crop storage technology is a critical need to reduce farm level Post-harvest loss.

4.11.3. Farm Level Cereal Post-harvest Losses during Harvesting Stage

As can be seen from figure 4.3, average cereal post-harvest losses during harvesting stage were estimated to be 3.14%. These losses were mainly due to natural conditions such as bad weather, harvesting methods, harvest timing, awareness and technical inadequacies of smallholder farmers, as well as some socio-economic factors. Prior studies have shown that natural factors such as weather and climate can affect cereal harvest losses. As noted by Amentae et al. (2016), the occurrence of abnormal weather condition increased the loss of *teff* harvest through shattering during harvesting. According to Amentae and his coworkers, the occurrence of abnormal weather during different post-harvest operations continues to increase harvest losses of selected food commodities by 1.53% in Ethiopia. Studies of post-harvest losses in Brazilian soybean-maize producers have also shown negative effects of unfavourable weather (Goldsmith, Martins, & Moura, 2015). Another study made in nine provinces of China also found that extreme weather events such as heavy rainstorms and prolonged exposure to strong sunlight during loading and unloading increased cereal post-harvest losses (Chen et al., 2018).

This is probably because heavy precipitation and strong sunlight during harvesting may cause grain rotting and shuttering respectively. On the other hand, Chegere (2018) found positive and significant relationships between timely harvesting at maturity and lower post-harvest losses of maize in Kilosa district, Morogoro region of Eastern Tanzani. When maize was harvested during more favorable dry conditions its post-harvest loss will be reduced.

Extreme weather events, such as prolonged exposure to strong sunlight and heavy rainstorms during harvesting not only causes post-harvest losses but also increases the difficulty of mechanical and manual operations.

Field management during harvest, harvesting methods and availability of manpower during peak harvesting seasons can also have a significant impact on the amount of post-harvest losses. Late harvesting results in increased natural threshing (shattering) and crop loss due to attack by rodents, birds and other pests. Cereal losses at harvesting stage occur when the harvest is delayed and pods began to split and fall onto the ground (Alliance for a Green Revolution in Africa, 2014). For example, according to the estimates of Alliance for a Green Revolution in Africa, 4% of groundnut lost during harvesting as a result of rotting, over drying or late harvesting. Mechanical harvesting as opposed to manual harvesting sought to reduce post-harvest losses; in the same manner it reduces labour requirements of smallholder farmers for harvesting operations (Hodges, Buzby, & Bennett, 2011). Thus, in order to reduce post-harvest losses at farm level, the introduction of some labour saving technologies may now is a viable option.

4.11.4 Factors Influencing the Extent of Farm-level Crop Post-harvest Losses

4.11.4.1 Education Status

The study used tobit regression model to analyze and quantify post-harvest losses of major food crops in the study area. Using tobit regression model, attendance of formal education was identified as the most influencing factor for farmers' to reduce the extent of farm level post-harvest loss. According to the result (Table 4.3) at 1% statistical significance, access to formal education decreases smallholder farmer's post-harvest loss by 3.82 kg per quintal. It was the most influencing factor as compared to the other variables used in the tobit regression analysis.

This may be attributable to the fact that more education may contribute to smallholder farmers' willingness and readiness to take post-harvest loss prevention training, to adopt improved crop storage facilities, which may lead to more effective implementation of post-harvest loss mitigation strategies. This result is similar to Chegere (2018) that found significant negative association between educational status of household head and pre-storage losses. According to Chegere, education of head of household may help to use effective and safer application of post-harvest procedures, which may finally contribute to the reduction of post-harvest loss. Previous research by Martins (2013) also showed that the more educated the farmer is, the greater is his or her perception on post-harvest loss.

4.11.4.2 Family Size

It is apparent from table 4.3 that family size was found significantly affecting farm level post-harvest losses. Family size was found to have a significant negative relationship with the extent of cereal post-harvest losses that occurred at farm level at 1% statistical significance. This study found that when family size increases by one individual the extent of cereal post-harvest losses decrease by 0.27kg per quintal. This is because since labor availability for different post-harvest activities within the household is proxied by family size, an increase in family size is expected to reduce Post-harvest losses.

The finding of the current study is consistent with those of Amentae et al. (2016) who found that more available labour force was vital to reduce *Teff* postharvest losses. Our finding is also in agreement with Amentae's (2016) findings which showed that due to the labour intensive farming practice of *Teff*, lesser family size leads to higher postharvest losses. However, our finding is not consistent with the findings of Kikulwe et al. (2018), who claimed that larger households are more likely to experience higher post-harvest losses. Their explanation was that larger family produces more yields, and often times more yields will be susceptible to more post-harvest loss. Although the findings of Kikulwe et al. (2018) are somewhat logical, their generality need more tests and hence it can be a potential future research into this area. Overall, our results indicated that smallholder farmers with less family size (a proxy for farm labor) are more likely to experience higher post-harvest losses.

4.11.4.3 Sex of Household Head

The results, as shown in Table 4.3, indicate that sex of household head affects the amount of post-harvest loss at farm level significantly and negatively at 1% statistical significance. From tobit regression result, it can be seen that having a male household head resulted in a decrease of cereal post-harvest losses of about 2.26 kg per quintal as compared to female headed households. This gender differential post-harvest loss results may be ascribed to: men generally have more access than women to transportation and services which help reduce losses (The Rockefeller Foundation, 2015; Chen et al., 2018). The other possible reason for observed gender differential post-harvest loss results may be due to the fact that relative to women, men have more access to post-harvest productive assets and finance (Alliance for a Green Revolution in Africa, 2014); due to their greater mobility, males in male-headed households can easily search markets for their produces when compared to females in female-headed households (Kikulwe et al., 2018). Furthermore, as opposed to their male headed household heads, female headed household heads have additional tasks or family responsibilities at home which results in lesser time available for post-harvest activities, leading to higher postharvest losses (Amentae et al., 2016). Another previous study in Ethiopia has found female headed households to be more resource poor than male headed households which make them more susceptible to post-harvest losses (Dessalegn et al., undated).

In contrast to our findings, however, previous findings by Kaminski and Christiaensen (2014) reported substantially lower maize post-harvest losses for female headed households in Sub-Saharan Africa. A possible explanation for their results might be that fewer alternatives available to female-headed households in terms of access to other sources of incomes such as livestock sales and off-farm income. This makes them susceptible to instant crop sales right after harvesting season, which in turn tends to reduce post-harvest losses especially at home storage stage. Taken together, the results of our research call for opportunities for public investment into gender specific post-harvest loss interventions and gender-responsive post-harvest loss reduction strategies.

4.11.4.4 Access to Credit

The study found access to credit as statistically significant factor influencing smallholder farmers' post-harvest loss. Access to credit is statistically significant at 1% statistical significance, which means farmer's access to credit decreases crop post-harvest loss by 2.53kg per quintal (Table 4.3). Because access to credit increases the economic power of smallholders, it increases the tendency to adopt post-harvest technologies. This might also be the reason why credit or liquidity constrained smallholder farmers would not be able to adopt the technology that might help reduce their post-harvest losses.

This result is consistent with prior studies that indicated that lack of access to credit is a constraint to reducing post-harvest loss (McNamara & Tata, 2015; Chegere, 2018; Affognon et al., 2014). Martins (2013) and Alliance for a Green Revolution in Africa (2014) also argued that difficulty in accessing credit facilities is the main reason why farmers do not invest on improved storage facilities. The major barriers that impede smallholder farmers from getting access to credit as stated by African Union Commission (2018) are higher loan repayment, complicated laws towards credit arrangement, and risks associated with small-scale farming.

Therefore, lack of access and/or limited access to appropriate and affordable credit facilities must be effectively addressed in order to successfully reduce post-harvest losses. To promote credit accessibility for smallholder farmers, formation and strengthening of farmers' cooperative organizations is necessary as well.

4.11.4.5 Labour Reciprocity

As shown in Table. 4.3, the study found statistically significant and negative marginal effect of labour reciprocity on post-harvest loss. To that end, being a participant in mutual aid associations marginally decreases cereal post-harvest loss by 3.68kg per quintal holding all other variables at their means. The observed decrease in crop post-harvest loss for farmers who have participated in indigenous mutual aid associations can be contributed to the possibility of pooling additional farm labor, so that the combined work output is greater than the amount of labor that each farmer could accomplish individually. Due to the labor intensive nature of post-harvest agricultural activities (harvesting, threshing, and transporting of produce), smallholder farmers in the study area used non-monetized mutual labor exchange system to reduce post-harvest losses. These non-monetized mutual labor exchange groups were known as *Dabo* or *Dugda*, meaning labor exchange group. Such farm labor exchange arrangements reflect a form of social capital that persisted among smallholder farmer communities in the study area.

Thus, to overcome the problem of labor shortage during peak periods of post-harvest activities, farmers of the study area have an indigenous labor exchange arrangement which is also common in other parts of Ethiopia (Leta, 2008; Demissie, 2009; Ewonetu, 2012) as well as in different agricultural communities throughout the world (Suehara, 2006; Gilligan, 2004; Shiraishi, 2006).

Many previous researches found success stories of reciprocal labor exchange in raising farm and firm productivity. For example, Tokuori (2006) and Bhattarai's (2006) findings indicate that farmers make use of various forms of labour exchange practices to acquire labour. Under this labor exchange systems, farmers form a work team that performs a task such as plowing, planting, weeding, harvesting, threshing crops on each team member's farm in sequence. Other previous studies by Panpakdee and Limnirankul (2018), Jana, Bandyopadhyay and Choudhuri (2013) and Gilligan (2004) also looked at the importance of mutual labor exchange in harnessing productivity gains of agriculture. Our finding is also consistent with the results obtained in the Ecuadorian highlands where by labour exchange agreements are considered to be the most determinants of production of agricultural exportable commodities (Vasco, 2014). These distinct sources demonstrate that farmers took turns working in each other's fields on a reciprocal basis in order to pool human capital so that the combined work output is greater than the amount of labor that each farmer could accomplish individually. To put it another way, a reciprocal labor exchange practice is a way of exchanging labor for labor as a gift.

From the outcome of our investigation it is possible to suggest that the reciprocal farm labor exchange arrangements as a form of indigenous knowledge system should be used in collaboration with scientific knowledge towards the effort of reducing post-harvest losses. Future study is also warranted to explore the potential contribution of farm labor exchange as an indigenous knowledge system (social capital) in reducing post harvest losses.

4.11.4.6 Distance to the Nearest Market and Post-harvest Loss

As we can see from Table 4.2, the average distance from sample smallholders to the nearest market center, where cereal produce sold was about 20.2 Km, with the minimum and maximum distances of 5 and 35 km respectively. The Tobit regression analysis revealed distance to the nearest market as the most determinant factor for smallholder farmers' cereal post-harvest losses. The result from the model showed that as distance of farmers' homestead to the nearest market increases by one kilometer, the amount of cereal post-harvest loss increases by 0.3kg per quintal at 1% statistical significance.

The positive coefficient for distance to the nearest market may signify that long distance between cereal production areas and marketing centers causes post-harvest loss and quality deterioration. This could be due to three possible reasons. First, smallholder farmers located farther from market centers might be less likely to get access to information about improved storage facilities. Second, as the travel distance to the closest market center increases, smallholder farmers will be restrained from participating in output market due to the associated increase in transport costs. In doing so, they prefer to store cereals for home consumption, suggesting an increase in storage post-harvest loss. Third, when distant farmers decide to take their crop to market these crops may need to be transported from home storage to market over long distances which may require multiple loading and unloading resulting in spillage or pilferage losses.

Different previous findings in the area confirm to the present study. For example, Amentae et al. (2016) and Shah (2014) reported higher and significant post-harvest losses when distance between farmers' residence and market center increases. Their analysis showed that the magnitude of post-harvest loss increases with long distance travel to market center and poor transport infrastructure. The same holds in Malawi, where FAO (2011) found significant positive relationship between increased distance to selling points and post-harvest losses among small to medium scale tobacco farmers in Malawi. FAO further argued that long physical distances to selling points, poor roads and long time period before sale are responsible for the existing higher post-harvest losses of tobacco.

This provides further evidence that distance and poor road infrastructures from farm to market reduces produce quality and increases post-harvest losses. Eventually, to enable smallholder farmers to overcome their distance or time travelled to markets, and thus ensure fewer post-harvest losses, adequate transportation networks should be developed. The post-harvest losses incurred due to greater distance to markets could also be mitigated by the development of village or rural markets.

4.11.4.7 Distance to All-weather Road

The average walking distance to reach all weather road in the study area was about 13 km, with a minimum and maximum distance of 0 and 27 km respectively (Table 4.2). The coefficient of distance to reach all weather road (a proxy for road accessibility) had the expected positive sign and was significant at 1% statistical significance for intensity of post-harvest losses (Table 4.3). In doing so, increase in the distance to all weather road increases the quantity of crop loss of 0.37 kgs per kilometer of distance.

Proximity of farmers to all weather road is essential for timely labour input delivery during peak harvesting season and output disposal and results in less transport cost for crop surpluses. Another advantage of being near all weather road might be access to extension services on time (Maganga, Mehare, Ngoma, Magombo, & Gondwe, 2011). Distance of household from all weather road influence households' participation in formal credit markets because of more or less similar reasons discussed in the case of proximity to the nearest market. A final point to note is that decreased walking distance to the nearest all weather road help smallholder farmers to access key public social services like health and education. A final point to note is the probability of using improved storage technologies decreases with distance from all weather road.

Our results are in good agreement with World Bank (2011) who found that geographic characteristics like distance from farmers' home to all-weather access roads played a vital role in ensuring that crops do not have to spend longer periods in home storage and in helping to reduce the high transport costs. The World Bank further asserted that lack of access to all-weather roads caused extended delays and prevented transport to market among smallholders of Sub-Saharan Africa contributing to higher post-harvest losses. Distance to all weather road also influence access to agro-chemicals like insecticide and pesticide in general and adoption of improved post-harvest technologies in particular that would help mitigate crop post-harvest loss. In its recent post-harvest loss management strategy, African Union Commission (2018) also underlined the role of rural road networks that are linked to the national network of all-weather roads towards the effort of reducing the current levels of post-harvest losses in Africa.

4.11.4.8 Storage Facility and Post-harvest Loss

Storage facility used by smallholder farmers also affected the extent of crop post-harvest loss at farm level at 1% statistical significance. It can be observed that post-harvest loss of crops could decrease by 2.11kg per quintal when the farmers use good storage facilities as opposed to the traditional storage facilities. This gives the impression that inefficient and inadequate crop storage facilities cause deterioration leading to quantity or quality losses.

Several previous studies found a significant role of improved storage facilities in reducing farm level post-harvest losses. For instance, in their review about the effect of grain storage technology in reducing maize post-harvest losses in developing countries, Tefera et al. (2011) confirmed that traditional storage practices were responsible for 20-30% maize losses and deterioration of maize quality in developing countries. This is also asserted by Tolosa (2005) who found substantial crop losses among smallholder farmers of Erenssa and Garbi communities in Oromiya Zone, Amhara National Regional State due to the use of traditional granaries for harvest storage. This calls attention to policies that target at improving crop storage structures to mitigate postharvest losses at farm level. Moreover, according to action research conducted in Uganda and Burkina Faso by Costa (2014), new storage technologies made food losses to be reduced by more than 98% as compared to traditional storage systems.

4.11.4.9 Tropical Livestock Unit (TLU)

The result showed that smallholder farmers' ownership of livestock affects the amount of post-harvest loss at farm level negatively at less than 1% statistical significance. The marginal effect of livestock ownership on the extent of cereal post-harvest loss was -0.919 kgs per quintal among smallholder farmers (Table 4.3). This might be due to the following reasons. First, the significance of having considerable number of livestock helps smallholder farmers to generate income from the sales of livestock and dairy products (principally milk and cheese) that further used to purchase improved post-harvest technologies. Second, livestock animals such as donkey, horse, and mule are intensively used to transport harvest from field to threshing ground, from threshing ground to home and from home to market that would farther reduce post-harvest losses to a greater extent. Third, livestock animals such as ox, horse, mule, and donkey are used for threshing/shelling of crops.

This finding is in agreement with that of Nambiro (2008), who indicated that household resource endowment such as livestock ownership may affect households' participation in purchase of improved storage facilities and recruitment of labor force for post-harvest activities. Nambiro further argued that because of the lender's evaluation of household's creditworthiness, asset rich households may have access to both formal and informal credit markets as compared to asset constrained households. Similarly, The Royal Society (2009) and Heshmati (2017) also revealed the complementarity nature of livestock ownership and reduced post-harvest losses among smallholder farmers. For example, Heshmati reported that, in Ethiopia smallholder farmers who own more livestock units were more likely to buy modern storage facilities that prevent and reduce post-harvest losses as compared to those who own less livestock units. Therefore the results suggest that since the asset possessions of the households such as livestock could decrease their post-harvest losses, better endowments of livestock resources in general and transport animals in particular should be encouraged.

4.11.4.10 Transportation Cost

Referring to Figure 4.4, we can see that next to insect pests and traditional storage facilities smallholders rated insufficient transportation as the third extremely influential cause for farm level post-harvest loss. In fact, further analysis of our data by tobit regression model (Table 4.3) indicated that at 1% statistical significance, a one kilometer increase in transport costs for the evacuation of crops from field to home and then to market increased farmers' cereal post-harvest loss by 0.304 kg per quintal. This result may be explained by the fact that reduced transport costs play a significant and positive role in creating stronger market integration, creating additional economic opportunities and reducing rural isolation which in turn contributes to a reduction in post-harvest loss at farm level. It is also interesting to note that reduced transport costs will contribute to lower post-harvest losses through cheap labor transport from labor surplus area to labor shortage area during peak harvest season.

Increased transportation cost during evacuation of the annual yield can limit any increase in agricultural production and productivity of smallholders (Bonsu, 2014). Transport costs for the evacuation of crops from field to home and then to market depends on distance to farm plot, distance to market as well as on road conditions and loading capacity of transport mode used. Sieber (1999) studied the impact of insufficient transport services on crop yield loss or damage in Sub-Saharan Africa. According to Sieber, walking, head-loading and back-loading as the dominant modes of on-farm transport increases transport costs and time and can increase the probability of smallholder farmers' post-harvest loss due to higher pest damage and spoilage. Sieber further emphasized the role of IMT in enabling farmers to reduce high crop losses that occur due to low carrying capacities of traditional mode of transport.

Another study by Birachi et al. (2013) reported that traditional mode of transport like human head as a major cause of higher transport losses (spillage and theft) for bean crop marketing in Burundi. This is also confirmed by Gogo et al. (2017), who reported that in three counties of Kenya poor rural road and inadequate transport services caused increased losses of African nightshade leaves. In their study of the extent of rice market integration in Madagascar, Moser, Christopher, and Minten (2005) also identified the prohibitively high transport costs incurred by more remote areas as a cause for rice post-harvest losses. In their study, Moser and his associates found that owing to prohibitively high transport costs, significant portion of rice produce would be lost to spoilage, shrinkage, and pests.

In another study in Ethiopia, Gebre-Egziabher (2007), who is a seminal researcher in the regional and local development studies, looked at status of rural-urban linkages in Ethiopia, and argued that the existing higher transport cost and loss of travel time hampered the movement of goods and people in Ethiopia.

Therefore, since more people in the rural area use a footpath to travel to a farm plot, a local market and other service giving centers, public investment in footpath improvement is necessary. In addition, since pack animals which are used to transport small volumes over short distances can operate on footpaths, a footpath improvement project was found to be very important to reduce travel times and increase transport loads. At the same time, the IMT can improve the efficiency of on-farm agricultural transports by reducing transport costs and time which in turn reduces post-harvest losses. Hence, public investment in transport infrastructure and improved rural transport services would reduce the opportunities for cereal post-harvest losses.

4.11.4.11 Crop Output Prices

From the survey, it was found that, an ideal and remunerative price of cereals leads to a 2.74 kg per quintal decrease in the extent of cereal post-harvest loss at farm level (Tables 4.3). A possible explanation for this might be that in situations of discouraging current output prices, smallholder farmers prefer to store their cereals either for expectation of increase in prices or consumption at the later time instead of selling at throwaway prices. This in turn causes storage post-harvest losses. On the other side, to avoid the potential post-harvest losses caused by pest infestations and pathogens during storage stage, smallholder farmers are forced to sell soon after harvest at low market prices for any surplus cereals they produce, a second loss. What is more disappointing is that those smallholder farmers who end up selling their cereals soon after harvest, buy it back at an expensive price just a few months after the harvest period, a third loss.

This finding confirms the assertion from economic theory that remunerative output prices are an encouragement for farm households to supply produce for market. This finding corroborates the ideas of Amentae et al. (2016), who suggested that, rather than accepting low prices at early harvesting season households store their produce for extended periods expecting high price in the future. The present finding also seem to be consistent with

Njoki’s (2018) findings which showed that a sharper fall in the market prices caused greater absolute post-harvest loss during plentiful harvests in Kitui county of Kenya.

In their prominent work, Kaminski and Christiaensen (2014) further elaborated the impact of higher seasonal price differences on the post-harvest loss status of farmers in Sub-Saharan Africa. This combination of findings provides some support for theory of Constraints that every real system such as a profit-making enterprise must have at least one constraint in a production cycle that limits its output (Goldratt, 1990). This finding has important implications for the need to develop public and cooperative agencies that provide price support scheme so as to help farmers fetch better prices for their produce while minimizing post-harvest losses.

4.11.4.12 Output Size or Level of Crop Production

As can be seen from the results in Table 4.3, total quantity of cereals harvested was identified as statistically significant factor influencing the extent of smallholder farmers’ post-harvest loss at 5% statistical significance. The increases of cereal crop production by one quintal increases the amount of post- harvest loss by 0.05 kg per quintal. There are several possible explanations for this positive association. First, when the amount of the harvest is large, it became problematic for smallholder farmers to harvest the whole production on time due to labor constrained nature of family farms. Second, the yield loss increases with increase in amount or size of production, because smallholders cannot afford to have adequate storage facilities that can accommodate the bountiful produce, resulting in huge storage losses. Third, whenever there is a devastating weather conditions, smallholders with large harvest are more susceptible than those with small harvest size.

This finding is consistent with the finding of Amentae et al. (2016) who showed positive relationship between the production levels of *teff* and its post-harvest losses extent in Bacho and Dawo districts of central Ethiopia. In another study in the Volta region of Ghana, Taiwo and Bart-Plange (2016), observed strong positive association between post-harvest rice losses and rice farmers’ bountiful harvest. Their result may be explained by the fact that, in production seasons of favorable weather farmers tend to harvest and store more rice in terms of volume and percentage. But, it became difficult for them to harvest on time due to lack of manpower and unable to store due to storage constraints. In the same way, Basavaraja et al. (2007) in their noble work of post-harvest losses in food grains in India found that losses in rice increased with increase in output.

Overall, a great deal of the previous work in this field (Kaminski & Christiaensen, 2014; Gabriel & Hundie, 2006; Amentae, 2016; Kikulwe et al., 2018) confirmed the positive association between size of total harvest and levels of post-harvest loss. Thus, efforts should be geared towards improving storage facilities and marketing arrangements to ensure smallholder farmers' increased production and reduced cereal postharvest losses.

4.12 Conclusion, Recommendations, Policy Options, and Future Research Directions

Post-harvest food grain losses are the greatest threat to increased food production and productivity among smallholder farmers in the study area. Analysis of the survey data obtained in this research shows that efficient transport and storage systems are critically important to reduce farm level cereal crop post-harvest losses. If rural transport services are of poor quality, infrequent, or unaffordable then smallholder farmers will be at a disadvantage when they attempt to transport their agricultural produce from farm to home and from home to market. Lack of all-weather roads, infrequent transport services coupled with traditional storage facilities, can lead to greater crop post-harvest losses.

Besides Under-developed rural transportation infrastructure and inefficient storage systems, other factors that can account for greater farm level post-harvest losses include labor shortage during peak harvesting season, large volumes of production, lack of awareness or training on how to minimize post-harvest losses, poor access to credit, lack of local labor exchange arrangements, low farm gate crop prices, an inadequate supply of vehicles at harvest time and unaffordable price to transport produce to markets.

Given the limited or constrained agricultural production factors (technology, land, capital, labor) among smallholder farmers, policy interventions that attempt to mitigate the post-harvest losses through holistic approaches are in need. As a result, expanding access to post-harvest infrastructure and post-harvest service centers are vital as they contribute considerably to post-harvest loss reduction. For example, post-harvest service centers provide postharvest loss prevention training on pest control methods, standards related to post-harvest handling, packing, transporting and storage of products to reduce postharvest losses. Furthermore, smallholder farmers need to be encouraged on the adoption of improved metal storage facilities and plastic storage products like metal silos and plastic silos. Recognizing the significance of attaining food self-sufficiency, It is also important for the public sector at different levels to improve transportation, marketing, and storage infrastructure as these are the potential solutions to reduce postharvest losses in the study area. To mitigate post-harvest losses caused by extreme weather events, village-level meteorological information networks that create early warnings should also be promoted as the majority of smallholder farmers do not have access to modern communication channels.

There are a number of gaps in our knowledge around smallholder farmers' post-harvest loss mitigation strategies that follow from our findings. Hence, it would be helpful to further explore the role of locally-produced tools and technologies that help reduce post-harvest losses. Further research would also be helpful to capture qualitatively the experiences and perspectives of smallholder farmers on post-harvest causing factors and mitigation strategies.

References

Abass, A. B., Ndunguru, G., Mamiro, P., Alenkhe, B., Mlingi, N., & Bekunda, M. (2013). Post-harvest food losses in a maize-based farming system of semi-arid savannah area of Tanzania. *Journal of Stored Products Research Vol. 57*, pp 49-57, http://dx.doi.org/10.1016/j.jspr.2013.12.004

Affognon, H., Mutungi, C., Sanginga, P., & Borgemeister, C. (2014). Unpacking postharvest losses in Sub-Saharan Africa: A meta-analysis. *World Development Vol. 66*, pp. 49–68, http://dx.doi.org/10.1016/j.worlddev.2014.08.002

African Union Commission (2018). Post-Harvest Loss Management Strategy

Akaranga, S. I., & Makau, B. K. (2016). Ethical considerations and their applications to research: A case of the University of Nairobi. *Journal of Educational Policy and Entrepreneurial Research, 3* (12), 1-9.

Alliance for a Green Revolution in Africa. (2014). Establishing the status of postharvest losses and storage for major staple crops in eleven African countries (Phase II). AGRA: Nairobi, Kenya.

Alliance for a Green Revolution in Africa. (2017). Africa Agriculture Status Report: The Business of Smallholder Agriculture in Sub-Saharan Africa (Issue 5). Nairobi, Kenya: Alliance for a Green Revolution in Africa (AGRA). Issue No. 5.

Ambler, K., Brauw, A., & Godlonton, S. (2017). Measuring postharvest losses at the farm level in Malawi. *Australian Journal of Agricultural and Resource Economics, 60*, pp. 1–22, doi: 10.1111/1467-8489.12237

Amentae, T. K. (2016). Evaluation of supply chains and post-harvest losses of selected food commodities in Ethiopia. Licentiate Thesis Report 088, Swedish University of Agricultural Sciences, Uppsala, Sweden.

Amentae, T. K., Tura, E. G., Gebresenbet, G., & Ljungberg, D. (2016). Exploring value chain and post-harvest losses of *Teff* in Bacho and Dawo districts of central Ethiopia. *J. Stored Prod. Postharvest Res., 7*(1), 11-28.

Ametataw, E. (2016). Economic Analysis of Postharvest Losses along the Supply Chain of Potato in Kombolcha Woreda, Eastern Hararghe Zone, Ethiopia (PhD dissertation, Haramaya University), Haramaya, Ethiopia.

Anega, N. M., & Alamirew, B. (2013). Is public investment on rural road transport sector in Ethiopia pro-poor? Evidence from the Ethiopian rural socio-economic–living standard measurement survey panel data (LSMS).

Awika, J. M. (2011). Major cereal grains crop production and use around the world. In: Awika, Joseph M., et al (eds) Advances in Cereal Science: Implications to Food Processing and Health Promotion. American Chemical Society Symposium Series; American Chemical Society: Washington, DC.

Banjaw T. D. (2017). Review of post-harvest loss of horticultural crops in Ethiopia, its causes and consequences and mitigation strategies. *Journal of Plant Sciences and*

Agricultural Research, 2 (1): 006, http://www.imedpub.com/plant-sciences-and-agricultural-research/

Bantayehu, M., Alemayehu, M., Abera, M., & Bizuayehu, S. (2017). Postharvest losses assessment of tropical fruits in the market chain of North Western Ethiopia. *Food Science and Quality Management*, Vol.66.

Basavaraja, H., Mahajanashetti, S. B., & Udagatti, N. C. (2007). Economic analysis of post-harvest losses in food grains in India: A case study of Karnataka. *Agricultural Economics Research Review, Vol. 20* January-June 2007 pp 117-126.

Befikadu, D. (2018). Postharvest Losses in Ethiopia and Opportunities for Reduction: A Review. *International Journal of Sciences: Basic and Applied Research (IJSBAR), 38*(1) 249-262.

Bhattarai, S. (2006). The Bola or Parma of the Newar in Manamaiju village: The significance of a farm labor exchange system among indigenous peasants in Nepal. Master of Philosophy in Indigenous Studies, University of Tromso, Norway.

Birachi, E.A., Ochieng, J., Wozemba, D., Ruraduma, C., Niyuhire, M.C., & Ochieng, D. (2013). Factors influencing smallholder farmers' bean production and supply to market in Burundi. *African Crop Science Journal, 19* (4), 335 – 342.

Bonsu, D. (2014). Road transport and agriculture: A comparative study of the implications of road access for subsistence agriculture in the Northern Ghana (Master's Thesis, University of Bergensis).

Champ, B. R., & Highley, E. (1986). Pesticides and humid tropical grain storage systems: proceedings of an international seminar, Manila, Philippines, 27-30 May 1985. Australian Centre for International Agricultural Research (AClAR) Proceedings No. 14, p. 364

Chapoto, A., Demeke, M., Onumah, G. E., & Ainembabazi, H. (2016). Getting more for farmers from post-harvest to market. Africa agriculture status report 2016.

Chegere, M.J. (2018). Post-harvest losses reduction by small-scale maize farmers: The role of handling practices. *Food Policy (2018),* https://doi.org/10.1016/j.foodpol.2018.05.001

Chen, X., Wu, L., Shan, L., & Zang, Q. (2018). Main factors affecting post-harvest grain loss during the sales process: A survey in nine provinces of China. *Sustainability, 10,* 661, p 1-13; doi:10.3390/su10030661

Chen, Y. (2016) Spatial autocorrelation approaches to testing residuals from least squares regression. *PLoS ONE, 11*(1): e0146865. doi:10.1371/journal.pone.0146865.

Committee for Economic and Commercial Cooperation, COMCEC (2016). Reducing postharvest losses in the OIC member countries. COMCEC Coordination Office, Ankara/Turkey.

Connerley, Ed. & Schroeder, L. (1996). Rural transport planning approach paper. Knowledge, Information and Technology Center (KNIT) Africa Region, the World Bank.

Costa, S. J. (2014). Reducing food losses in Sub-Saharan Africa-improving post-harvest management and storage technologies of smallholder farmers: An action research evaluation trial from Uganda and Burkina Faso. UN World Food Programme, Kampala, Uganda|Ouagadougou, Burkina Faso

Creswell, J. W. (2007). *Qualitative inquiry and research design: Choosing among five approaches* (2nd ed.). Thousand Oaks, CA: Sage.

Creswell, J. W. (2009). *Research design: Qualitative, quantitative, and mixed methods approaches* (3rd ed.). Thousand Oaks, CA: Sage.

Creswell, J. W. (2014). *Research design: Qualitative, quantitative, and mixed methods approaches* (4th ed.). Thousand Oaks, California: Sage Publications.

Crotty, M. (2003): *The foundations of social research: meaning and perspectives in the research process* (3rd edition). London: Sage Publications

CSA. (2018). Agricultural sample survey: Report on area and production of major crops for private peasant holdings, meher season, Vol. 1. Addis Ababa, Ethiopia.

Demissie, B. S. (2009). Factors affecting the adoption of soil and water conservation practices in North Eastern Ethiopia: A case of Meket Woreda, Amhara National Regional State (Master's thesis, Addis Ababa University), Addis Ababa, Ethiopia.

Dessalegn, T., Solomon, T., Gebrekiristos, T., Solomon, A., Seboka, S., Chane, Y, … Subramanyam, B. (n.d.). Assessment of wheat post-harvest losses in Ethiopia. Feed the Future Innovation Lab for the Reduction of Post-harvest loss.

Dominguez, S. S. (2003). Quinoa—postharvest and commercialization. *Food Reviews International, 19*:1-2, 191-201, DOI: 10.1081/FRI-120018885.

Donnges, C. (2001). Rural transport and local government units how to improve rural transport for the rural poor? Transport and Communications Bulletin for Asia and the Pacific, No.71, 2001, ILO, Geneva.

Elshafie, M. (2013). Research paradigms: The novice researcher's nightmare. *Arab World English Journal, 4*(2), 4-13.

Emana, B., Afari-Sefa, V., Nenguwo, N., Ayana, A., Kebede, D, & Mohammed, H. (2017). Characterization of pre- and postharvest losses of tomato supply chain in Ethiopia. *Agriculture & Food Security, 6*(3), 1-11, DOI 10.1186/s40066-016-0085-1.

Ethiopian Institute of Agricultural Research (2016). Post-harvest handling, processing and engineering research strategy (2016-2030), EIAR, Addis Ababa Ethiopia

Ewonetu, G. (2013). Identifing major constraints of ground water use for irrigated crop production: Fogera plain, North Western Ethiopia. Master of Professional Studies (MPS), Cornell University.

Federal Democratic Republic Ethiopia Ministry of Agriculture and Natural Resources (2018). Postharvest management strategy in grains in Ethiopia. Addis Ababa, Ethiopia.

Federal Democratic Republic of Ethiopia Ministry of Agriculture (2015). Agricultural growth program II (AGP-II): Program design document. Addis Ababa, Ethiopia.

Food and Agriculture Organization of the United Nations. (1994). Grain storage techniques Evolution and trends in developing countries. FAO Agricultural Services Bulletin No. 109, Rome, Italy.

Food and Agriculture Organization of the United Nations. (2008). Water and Cereals in Drylands. Rome, Italy.

Food and Agriculture Organization of the United Nations. (2011). Continental programme on post-harvest losses (PHL) reduction: Rapid country needs assessment, Malawi. Working paper No: 09/019 FAO-AfDB MLW, Rome, Italy.

Food and Agriculture Organization of the United Nations. (2012). Feeding the world. Rome, Italy, Food Outlook, www.fao.org/giews/english/fo/index.htm.

Food and Agriculture Organization of the United Nations. (2018). World food and agriculture – statistical pocketbook 2018. Rome, Italy. 254 pp. Licence: CC BY-NC-SA 3.0 IGO.

Food and Agriculture Organization of United Nation (2009). How to feed the world in 2050. Food and Agriculture Organization (FAO), Rome, Italy.

Gabriel, A. H., & Hundie, B. (2006). Farmers' post-harvest grain management choices under liquidity constraints and impending risks: implications for achieving food security objectives in Ethiopia. Poster paper prepared for presentation at the international association of agricultural economists conference, Gold Coast, Australia, August 12-18, 2006

Gani, A., Wani, S. M., Masoodi, F. A., & Hameed, G. (2012). Whole-grain cereal bioactive compounds and their health benefits: *A Review. J Food Process Technol 3*:146. doi:10.4172/2157-7110.1000146

Gatzweiler, F. W., & Braun, J. V. (2016). Innovation for marginalized smallholder farmers and development: An overview and implications for policy and research. In: Gatzweiler, F. W., & Braun, J. V. (eds.) Technological and Institutional Innovations for Marginalized Smallholders in Agricultural Development. DOI 10.1007/978-3-319-25718-1_1

Gatzweiler, F. W., & Braun, J. V. (2016).Technological and institutional innovations for marginalized smallholders in agricultural development

Gebru Hailu & Belew Derbew (2015). Extent, causes and reduction strategies of postharvest losses of fresh fruits and vegetables–*A Review. Journal of Biology, Agriculture and Healthcare*, 5(5).

Gebru, M., Remans, R., Brouwer, I., Baye, K., Melesse, M. B., Covic, N., & Habtamu,F. (2018). Food Systems for Healthier Diets in Ethiopia: Toward a Research Agenda. international Food Policy Research Institute (IFPRI) Discussion Paper 01720, Research Program on agriculture for nutrition and health, April 2018.

Gilligan, D. O. (2004). The economics of agricultural labor exchange with evidence from Indonesia (PhD dissertation, University of Maryland).

Gliem, J. A., & Gliem, R. R. (2003). Calculating, interpreting, and reporting Cronbach's Alpha reliability coefficient for Likert-type scales. Refereed paper: Midwest research to practice conference in adult, continuing, and community education

Gogo, E.O., Opiyo, A.M., Ulrichs, Ch., & Huyskens-Keil, S. (2017). Nutritional and economic postharvest loss analysis of African indigenous leafy vegetables along the supply chain in Kenya. *Postharvest Biology and Technology, 130*, 39–47, http://dx.doi.org/10.1016/j.postharvbio.2017.04.007.

Goldratt, E.M. & Cox, J. (1992). *The Goal - A process of ongoing improvement*. Second Rev. Ed., North River Press Publishing Corporation, Great Barrington, MA.

Goldratt, E.M. (1990). *What is this thing called the Theory of Constraints*? North River Press, Croton-on-Hudson, NY.

Goldratt, E.M. (1990). *What is this thing called the Theory of Constraints*? North River Press, Croton-on-Hudson, NY.

Goldratt, E.M. and Cox, J. 1992. *The Goal - A Process of Ongoing Improvement* (Second revised Edition), North River Press Publishing Corporation, Great Barrington, MA.

Goldsmith, P. D., Martins, A. G., & Moura, A. D. (2015). The economics of post-harvest loss: A case study of the new large soybean - maize producers in tropical Brazil. *Food Sec. 7*:875–888, DOI 10.1007/s12571-015-0483-4.

Gollin, D. (2014). Smallholder agriculture in Africa: An overview and implications for policy IIED Working Paper. IIED, London. http://pubs.iied.org/14640IIED

Grant, B. M., & Giddings, L. S. (2002) Making sense of methodologies: A paradigm framework for the novice researcher. *Contemporary Nurse*, *13*(1), 10-28.

Gray, P. S., Williamson, J. B., Karp, D. A., & Dalphin, J. R. (2007). The research imagination: An introduction to qualitative and quantitative methods. Cambridge: Cambridge University Press. https://doi.org/10.1017/CBO9780511819391

Greene, W. H. (2003). Simulated maximum likelihood estimation of the normal-gamma stochastic frontier model. *Journal of Productivity Analysis, 19*, pp. 179–190.

Greene, W. H. (2012). Econometric analysis, 7th ed., pearson education, Inc., publishing as Prentice Hall, One Lake Street, Upper Saddle River, NJ 07458.

Gujarati, D. N. (2004). Basic Econometrics, 4th ed., McGraw-Hill, New York.

Hazell, P., Poulton, C., Wiggins, S., & Dorward, A. (2006). The future of small farms: synthesis paper. Latin American Center for Rural Development to the preparation of the World Development Report 2008 "Agriculture for Development"

Hengsdijk, H., & Boer, W.J. (2017). Post-harvest management and post-harvest losses of cereals in Ethiopia. *Food Sec. (2017) 9*:945–958, DOI 10.1007/s12571-017-0714-y.

Heshmati, A. (2017). Economic transformation for poverty reduction in Africa: A multidimensional approach. Taylor & Francis.

Hodges, R. J., Buzby, J. C., & Bennett, B. (2011). Postharvest losses and waste in developed and less developed countries: opportunities to improve resource use. *Journal of Agricultural Science (2011), 149*, 37–45, doi:10.1017/S0021859610000936.

Hussen, S, Beshir, H., & W/Hawariyat, Y. (2013). Postharvest loss assessment of commercial horticultural crops in South Wollo, Ethiopia challenges and opportunities. *Food Science and Quality Management, Vol.17*, ISSN 2224-6088 (Paper) ISSN 2225-0557 (Online)

Integrated. (2016). In: Cambridge Advanced Learners Dictionary & Thesaurus, 4th ed. [online] Available at: http://dictionary.cambridge.org/dictionary/british/integrate?q=integrated [Accessed 20 June 2019].

J. Kimiywe (2015). Food and nutrition security: challenges of post-harvest handling in Kenya. *Proceedings of the Nutrition Society, 74*, 487–495, doi:10.1017/S0029665115002414

Jana, R., Bandyopadhyay, S., & Choudhuri, A. K. (2013). Reciprocity among farmers in farming system research: Application of social network analysis, *J Hum Ecol*, *41*(1): 45-51.

Kaminski, J., & Christiaensen, L. (2014).Post-harvest loss in Sub-Saharan Africa: What do farmers say? Policy Research Working Paper 6831. The World Bank, Washington DC.

Kannan, E. (2014). Assessment of pre and post harvest losses of important crops in india. Agricultural Development and Rural Transformation Centre Institute for Social and Economic Change Bangalore- 560 072

Kanchanasuwan, S. (2018). Consolidated Cold Chain Design for Fresh Fruit Supply Chains in Developing Countries: A Simulation Study (PhD dissertation, School of Business, IT and Logistics College of Business, RMIT University), Melbourne, Australia.

Kasso, M., & Bekele, A. (2016). Post-harvest loss and quality deterioration of horticultural crops in Dire Dawa Region, Ethiopia. *Journal of the Saudi Society of Agricultural Sciences*, http://dx.doi.org/10.1016/j.jssas.2016.01.005.

Khaledi, M., Weseen, S., Sawyer, E., Ferguson, S., & Gray, R. (2010). Factors influencing partial and complete adoption of organic farming practices in Saskatchewan, Canada. *Canadian Journal of Agricultural Economics 58*: 37–56, DOI: 10.1111/j.1744-7976.2009.01172.x.

Kikulwe, E. M., Okurut, S., Ajambo, S., Nowakunda, K., Stoian, D., & Naziri, D. (2018). Postharvest losses and their determinants: A challenge to creating a sustainable cooking banana value chain in Uganda. *Sustainability, 10*, 2381; doi:10.3390/su10072381

Kirsten, J. F., & Zyl, J. V. (1998) Defining small-scale farmers in the South African context, *Agrekon*, *37*:4, 551-562, DOI: 10.1080/03031853.1998.9523530.

Kong, S., Nanseki, T., & Chomei, Y. (2015). Farmers' perception of loss in post–harvest of rice yield in Cambodia. *J. Fac. Agr., Kyushu Univ., 60* (2), 569–576, http://hdl.handle.net/2324/1543429

Lebo, J & Schelling, D. (n.d.). Design and appraisal of rural transport infrastructure: Ensuring basic access for rural communities. World Bank technical paper no. 496.

Leclere, M. J. (1994).The decomposition of coefficients in censored regression models: understanding the effect of independent variables on tax payer behavior. *National Tax Journal*, *47*(4) 837-845.

Leta, E. F. (2008). The link between food security and land degradation: Analysis of determinants in drought prone areas of North East Ethiopia. A case of Sekota woreda (Master's thesis Addis Ababa University) Addis Ababa, Ethiopia.

Mada, D. A., Hussaini, D. I., Medugu, A. I., & Adams, I. G. (2014). Study on impact of post harvest losses and post harvest technology in Ganye Southern Adamawa State-Nigeria. *Global Journal of Science Frontier Research (D) Volume 14* Issue 2 version 1.

Maganga, A., Mehare, A., Ngoma, K., Magombo, E., & Gondwe, P. (2011). Determinants of smallholder farmers' demand for purchased inputs in Lilongwe District, Malawi: evidence from Mitundu extension planning area. Munich Personal RePEc Archive (MPRA) Paper No. 34590, https://mpra.ub.uni-muenchen.de/34590.

Manti, S., & Licari, A. (2018). How to obtain informed consent for research. *Breathe, 14* (2), 145–152. https://doi.org/10.1183/20734735.001918

Martey, E., Al-Hassan, R. M., & Kuwornu, J. K. (2012). Commercialization of smallholder agriculture in Ghana: A Tobit regression analysis. *African Journal of Agricultural Research*, *7*(14), 2131-2141, DOI: 10.5897/AJAR11.1743.

Martin, S. (2016). Storage matters: Managing grain, securing finance, and building markets. (PhD dissertation, University of Waterloo), Ontario, Canada.

Martins, A. G. (2013). Post-harvest loss in tropical soybean systems: Brazilian managers' perceptions and mitigation strategies: two manuscripts (Master's thesis, University of Illinois). Retrieved from https://www.ideals.illinois.edu/bitstream/handle/2142/45441/Anamaria_Gaudencio%20Martins.pdf.

McNamara, P. E., & Tata, J. S. (2015). Principles of designing and implementing agricultural extension programs for reducing post-harvest loss. *Agriculture, 5,* 1035-1046; doi:10.3390/agriculture5041035

Meena, M. S., Prasad, M., & Singh, R. (2009). Constraints perceived by rural agro-processors in adopting modern post-harvest technologies. *Indian Res. J. Ext. Edu. 9* (1).

Midega, C. A., Murage, A. W., Pittchar,J. O., & Khan, Z. R. (2016). Managing storage pests of maize: Farmers' knowledge, perceptions and practices in western Kenya. *Crop Protection*, *90*, 142-149, http://dx.doi.org/10.1016/j.cropro.2016.08.033

Minten, B., Engida, E., & Tamru, S. (2016). How big are post-harvest losses in Ethiopia? Evidence from *teff* (ESSP Working Paper 93). International Food Policy Research Institute,Washington, D.C.

Morgan, D. L. (2007). Paradigms Lost and Pragmatism Regained Methodological Implications of Combining Qualitative and Quantitative Methods. *Journal of Mixed Methods Research*, *1*(1).

Moser, Ch., Christopher, B., & Minten, B. B. (2005). Missed opportunities and missing markets: Spatio-temporal arbitrage of rice in Madagascar.

Nambiro, E. (2008).Trends in land use and agricultural intensification in Kakamega, Western Kenya (PhD dissertation, University of Bonn), Germany.

Nijhawan, L. P., Janodia, M. D., Muddukrishna, B. S., Bhat, K. M., Bairy, K. L., Udupa, N., … Musmade, P. B (2013). Informed consent: issues and challenges. *Journal of Advanced Pharmaceutical Technology & Research, 4*(3), DOI: 10.4103/2231-4040.116779.

Njoki, W. A. (2018). Socio-cultural and economic factors influencing household post-harvest cereal loss in Wikililye location, Kitui county, Kenya (Master's thesis, South Eastern Kenya University).

Okoruwa V.O., Ojo, O.A., Akintola, C.M., Ologhobo, A.D., & Ewete, F.K. (n. d.). Post harvest grain management storage techniques and pesticides use by farmers in South-West Nigeria. *Journal of Economics and Rural Development vol. 18* No. 1.

Panpakdee, C., & Limnirankul, B. (2018). Indicators for assessing social-ecological resilience: A case study of organic rice production in Northern Thailand. *Kasetsart Journal of Social Sciences, 39 (2018),* 414-421, http://dx.doi.org/10.1016/j.kjss.2017.07.003.

Parmar, A. (2018).Post-harvest handling practices and associated food losses in sweet potato and cassava value chains of southern Ethiopia (PhD dissertation, the University of Kassel), Germany.

Parmar, A., Hensel, O., & Sturm, B. (2016). Post-harvest handling practices and associated food losses and limitations in the sweetpotato value chain of southern Ethiopia. NJAS - Wageningen Journal of Life Sciences xxx (2016) xxx–xxx, article in press

Pasetto, S. (2018). Guidelines on the measurement of harvest and post-harvest losses recommendations on the design of a harvest and post-harvest loss statistics system for food grains (cereals and pulses). Global Strategy to improve Agricultural and Rural Statistics (GSARS), Rome, Italy

Popova, Y. (2017). Relations between wellbeing and transport infrastructure of the country. Procedia Engineering 178, 579 – 588, doi: 10.1016/j.proeng.2017.01.112.

Prabhakar, A. Ch., & Alemu, Y. (2013). Agricultural development-led industrialization strategy in Ethiopia: An overview. *African Journal of Political Science and International Relations*, *7*(5), 237-246, DOI: 10.5897/AJPSIR10.042.

Ridolfi, C., Hoffmann, V., & Baral, S. (2018). Post-harvest losses: Global scale, solutions, and relevance to Ghana. International Food Policy Research Institute (IFPRI) review, march 2018: pp 1-15.

Saba, S. S., & Ibrahim, H. I. (2018). Postharvest Loss in Rice: Causes, Stages, Estimates and Policy Implications. *Agricultural Research & Technology: Open Access Journal 15*(4): DOI: 10.19080/ARTOAJ.2018.15.555964

Satish, P. (2007). Rural infrastructure and growth: *An Overview Ind. Jn. of Agri. Econ, Vol. 62*, No.1.

Schneider, K., & Anderson, L. (2010). Yield gap and productivity potential in Ethiopian agriculture: staple grains & pulses. Evans School Policy Analysis and Research (EPAR) Brief No. 98, October 12, 2010

Scotland, J. (2012).Exploring the Philosophical Underpinnings of Research: Relating Ontology and Epistemology to the Methodology and Methods of the Scientific, Interpretive, and Critical Research Paradigms. *English Language Teaching*, *5*(9).

Shah, D. (2014). Empirical assessment of pre- and post-harvest losses of soyabean crop in Maharashtra. Artha Vijnana , LVI(3), 307-317.

Shah, S. R., & Al-Bargi, A. (2013). Research paradigms: researchers' worldviews, theoretical frameworks and study designs. *Arab World English Journal*, *4*(4) 252 - 264.

Shiraishi, S. (2006). From beer to money: Labor exchange and commercialization in Eastern Uganda. *African Studies Quarterly*, *Volume 9*, Issues 1 & 2, pp 39-53.

Sieber, N. (1999). Transporting the yield: Appropriate transport for agricultural production and marketing in Sub-Saharan Africa. *Transport Reviews, 19*(3), 205-220, DOI: 10.1080/014416499295493

Suehara, T. (2006). Labor exchange systems in Japan and DR Congo: Similarities and differences. *African Studies Quarterly, Volume 9*, Issues 1 & 2, pp 55-65.

Suleiman, R. A. (2015). Current maize production, postharvest losses and the risk of mycotoxins contamination in Tanzania. Agricultural and Biosystems Engineering Conference Proceeding Paper No. 152189434, pp1-128 (doi:10.13031/aim.20152189434).

Taherzadeh, A., & Hojjat, S. S. (2013). Study of post-harvest losses of wheat in North. *International Research Journal of Applied and Basic Sciences,* 4 (6), 1502-1505.

Taiwo, A., & Bart-Plange, A. (2016). Factors responsible for post-harvest losses and their effects on rice producing farmers: A case study of Afife and Aveyime rice projects in the Volta region of Ghana. Retrieved from https://www.irjet.net/archives/V3/i4/IRJET- V3I4201.pdf

Taylor, L. J. & Esan, T. O. (2012). Goldratt's theory applied to the problems associated with the mode of transportation, storage and sale of fresh fruits & vegetables in Nigeria. *Journal of African Research in Business & Technology*, Vol. 2012 (2012), DOI: 10.5171/2012.862202.

Tefera, T., Kanampiu, F., Groote, H., Hellin, J. Mugo, S., Kimenju, S., … Banziger, M. (2011). The metal silo: An effective grain storage technology for reducing post-harvest insect and pathogen losses in maize while improving smallholder farmers' food security in developing countries. *Crop Protection, 30,* 240-245, doi:10.1016/j.cropro.2010.11.015.

Tegegne Gebre Egziabher (2007). Rural-Urban Linkage and the Role of Small Urban Centers in Enhancing Economic Development in Ethiopia. In: Gete, Z., P. Trutmann, and Aster, D. (eds.), 2007. Fostering New Development Pathways: Harnessing Rural-urban Linkages (RUL) to Reduce Poverty and Improve Environment in the Highlands of Ethiopia. Proceedings of a planning workshop on Thematic Research Area of the Global Mountain Program (GMP) held in Addis Ababa, Ethiopia, August 29-30, 2006. Global Mountain Programme. pp 235.

Temesgen, M. (2016). Post harvest losses in Ethiopian food production chain. Addis Ababa University, 23 August, 2016

Tesfaye Sebeko (2015). Assessment of postharvest loss for perishable produces from wholesalers to consumers: A case study of Et-fruit distribution company in Addis Ababa, Ethiopia (Master's thesis, Swedish University of Agricultural Sciences), Sweden, Uppsala.

The Rockefeller Foundation. (2015). Perspectives to reducing post-harvest losses of agricultural products in Africa. Background paper, Abdou Diouf International Conference center, 21-23 october 2015, Dahar, Senegal.

The Royal Society. (2009). Reaping the benefits: Science and the sustainable intensification of global agriculture. University of Cambridge, UK, England.

Tobin, J. (1958). Estimation of relationships for limited dependent variables. *Econometrica, 26*(1), 24-36.

Tokuori, T. (2006). The economy of affection and local enterprises in Africa: Empirical evidence from a network study in Burkina Faso and Senegal. *African Studies Quarterly, Volume 9,* Issues 1 & 2, pp 79-101.

Tolosa, D. (2005). Rural livelihoods, poverty and food insecurity in Ethiopia: A case study at Erenssa and Garbi communities in Oromiya Zone, Amhara National Regional State (PhD dissertation, Norwegian University of Science and Technology), NTNU Trondheim.

Tutuba, N. B. & Vanhaverbeke, W. (2018). Beekeeping in Tanzania: why is beekeeping not commercially viable in Mvomero? *Afrika focus, 31*(1), 213-239.

U.S. Department of State (2013). Postharvest loss challenges discussion paper, November 13, 2013 Office of Agriculture, Biotechnology, and Textile Trade Affairs, Bureau of Economics and Business Affairs, U.S. Department of State.

Vasco, C. (2014). Reciprocal and wage labour in rural Ecuador: A quantitative analysis. *Journal of Agriculture and Rural Development in the Tropics and Subtropics, 115*(1), 23–30.

Walker, P.T. (1983). Crop losses: the need to quantify the effects of pests, diseases and weeds on agricultural production. *Agric. Ecosystems Environ.*, *9*: 119-158.

Warmbrod, J. R. (2014). Reporting and interpreting scores derived from Likert-type scales. *Journal of Agricultural Education, 55*(5), 30-47. doi: 10.5032/jae.2014.05030

World Bank (1997), Rural development: Vision to action: A sector strategy, The World Bank, Washington, D.C., U.S.A.

World Bank. (2011). Missing Food: The case of postharvest grain losses in Sub-Saharan Africa. Report Number 60371-AFR, the World Bank, Washington, D.C.

Yeboah, S. (2015). Influence of condition of road transport infrastructure on rural agricultural development in the Jaman South district (Master's thesis, Kwame Nkrumah University of Science and Technology).

CHAPTER 5: THE EFFECTS OF RURAL ROAD TRANSPORT ON SMALLHOLDER FARMERS' AGRICULTURAL PRODUCTIVITY IN HORRO GUDURU WOLLEGA ZONE, WESTERN ETHIOPIA

Abstract

This study is carried out to examine access of rural road infrastructure and its effects on smallholder farmers' agricultural productivity in Horro Guduru Wollega Zone, Western Ethiopia. A three stage random sampling technique was employed to select 500 farming households in the study area and data were collected on their socio-economic and farm specific characteristics. The collected data were analyzed using descriptive statistics and stepwise multiple regression analysis. The result of multiple regression model used revealed that distance to major market is important in predicting agricultural productivity of smallholder farmers at 5% levels of probability in Abe Dongoro, Amuru and Hababo Guduru districts. Ownership of intermediate means of transport was also found to influence agricultural productivity in Horro, Amuru and Hababo Guduru districts ($p = 0.05$). Further analysis of the regression model showed a significant negative correlation between distance to nearest all weather roads and distance to zonal head quarter on one hand and agricultural productivity on the other hand in Abe Dongoro, Hababo Guduru and Amuru districts. Rural kebeles of Abe Dongoro and Amuru districts which has vast agricultural potential were found to be the most inaccessible in Horro Guduru Wollega Zone. It is therefore suggested that interventions in the transport sector should include provision of rural roads as well as measures that will help improve vehicle supply in rural areas. An attempt has to be done also to increase the use of intermediate means of transport to ease agricultural inputs and outputs mobility and farm access.

Keywords: *Agricultural productivity; Horro Guduru; Rural road; Smallholder*

Published in:

Tamene, S., Megento, T. L. (2017): The effect of rural road transport infrastructure on smallholder farmers' agricultural productivity in Horro Guduru Wollega Zone, Western Ethiopia. AUC Geographica, 52, No. 1, pp. 79–89

https://doi.org/10.14712/23361980.2017.7

5.1 Introduction

The overall development of agriculture depends on various supportive rural infrastructural facilities (Usman et al., 2013). Efficient and effective rural transportation serves as one of the channels for the collection and exchange of goods and services, movement of people, dissemination of information and the promotion of rural economy (Adedeji et al., 2014). It is also clear that development of rural infrastructure generally contributes significantly to the level and quality of rural development. Countries that have developed their rural infrastructure have recorded higher and better quality of rural development than those that have failed to do so (Economic Commission for Africa, 2013).

The existence of accessible, acceptable, efficient transportation system is a pre-condition for linking remote farm areas located far from consumer centers with the agricultural production process (Taiwo, 2013). The transport system is fundamental to economic and social development in rural areas, and significant investment is required to ensure it is of a suitable level. Transport is considered as a key factor involved in agricultural development all over the world. It is the only means by which food produced at farm site is moved to different homes as well as markets. Market for agricultural produce is created by transport; furthermore, transport increases interaction among geographical and economic regions and opens up new areas to economic focus (Tunde, 2012). Road transport is the most predominant mode of transportation in all over the world and this is a confirmation of the crucial role transport plays in the socio-economic development of a nation (Ajiboye, 2009).

In Ethiopia, studies have shown that, at national level, the agricultural sector employs, at least, 80% percent of the working population (Worku, 2011). More than 48% of the Nation's Gross Domestic Product (GDP) comes from agriculture. The smallholder sub-sector plays an important role in generating national output and livelihood systems in the predominantly agro-based economy of Ethiopia. The agricultural sector of Ethiopia accounts for more than a third of gross domestic product and generates more than 90 percent of export earnings (Worku, 2011).

In Ethiopia, the issue of rural transportation development has continued to be of national importance. For instance, most of the rural roads are in poor condition, and this has imposed significant cost on the national economy especially to the agricultural activities due to increased vehicle operating costs and travel times. The Federal Government of Ethiopia has embarked on various programs like Growth and Transformation Plan (GTP) at one time or the other to ensure the provision of adequate transport facilities to meet the needs of the rural population but these programs have not been able to achieve required successes. It is against this background that this study examines the impact of rural road transport infrastructure on agricultural productivity in Horro Guduru Wollega Zone, western Ethiopia. This study underlines the essentiality of the role and contribution of the rural road transport systems in supporting efficient rural agricultural activities, especially the productivity of small-scale producers.

In light of the above, it becomes expedient to examine rural transportation problems, so that the extent of the problems can be known, and possible solution proffered to achieving sustainable rural development. In this study, an attempt has been made to analyze the effects of rural road infrastructure on smallholder farmer's agricultural productivity.

5.2 Problem Statement and Research Objectives

Many rural Africans still suffer from poor access to markets, health, schooling, and high transport costs (Heyen-Perschon, 2001). Inadequate rural roads make it hard for farmers to produce more and to transport any surpluses after harvest. Traffic on most rural roads still consists mainly of pedestrians often carrying head loads (DFID, 2008; Lindsay, 2015). Poor and inadequate rural roads have been the main concern by both small producers and consumers. Rural Africa has only 34% of road access covered as compared to 90% in the rest of the world (AFDB, 2010).

Rural transport infrastructure is still poorly developed in Ethiopia, and therefore it is an impediment for the growth of the rural as well as national economy. For instance, only 27% (Lulit, 2012) of the rural population has access to all weather roads in 2011, compared to 60% in India and 61% in Pakistan (Giz, 2014). The road density of Ethiopia was 0.049 km/

sq.km during the same period which falls far behind the average road density of lower middle income countries which is about 0.3 km/sq.km (IRF, 2006; Lulit, 2012). Therefore, most places in the country especially in the rural areas have still low road accesses and poor connectivity to major road networks.

Ethiopia's rural road network is one of the least developed in sub-Saharan Africa. The poor tends to live in isolated villages that can become virtually inaccessible during the rainy seasons. When there is a post-harvest marketable surplus, it is not always easy to reach the markets. Limited accessibility has also cut off small-scale farmers from sources of inputs, equipment and new technologies. Crop productivity is therefore low because farmers lack these important inputs. In particular, inadequate access to fertilizer is a real problem in many parts of Ethiopia where farmers have to cope with diminishing soil fertility **(**Fakayode et al., 2008). Consequently, efficient rural road transport infrastructure is central to raising agricultural productivity and increasing growth in Ethiopia. However, evidence show that a weak rural road transport infrastructural base has been one of the major factors militating against the attainment of the Ethiopia's growth and development objectives.

It is extremely difficult for most farmers who live and farm in the Horro Guduru Wollega Zone to gain access to all weather roads vehicles on which to transport their farm produce to home and market centers on time. In effect, the socio-economic wellbeing of the smallholder farmers is seriously affected due to high cost of agricultural in- puts and depressed prices of farm produce. Poor road conditions, high transport costs and distant markets have been identified as factors that hamper improved market access for smallholder farmers in Horro Guduru Wollega Zone.

Despite being the second populous country in Africa and one of the poorest, the question of how to reverse low agricultural productivity in Ethiopia is one that the research community has scarcely touched upon. To the researcher's knowledge, no attempt has been made to estimate the effects of poor rural road infrastructure on the structure of smallholder farm production in Ethiopia. This study aims to fill that gap using cross-sectional data from the survey of 500 farming households in four districts of Horro Guduru Wollega Zone, Western Ethiopia.

The principal objective of the study is to investigate the effects of rural road transport infrastructure on agricultural productivity of smallholder farmers. Particularly, this research was undertaken to achieve the following three specific objectives: (1) identify the socio-economic characteristics of smallholder farmers in the study area, (2) identify the available and mostly used means of transportation in the study area, and (3) examine farmers' agricultural productivity level in relation to the existing road transportation infrastructure.

5.3 Research Questions

- What are the socio-economic characteristics of the smallholder farmers in the study area?
- What explains the present quality of rural road transport infrastructure in the study area?
- Is rural road transport infrastructure a significant determinant of agricultural productivity?

5.4 Research Methodology

5.4.1 Study Area

This study was conducted in Horro Guduru Wollega zone, Western Ethiopia. The capital town of the zone, Shambo, is located 314 km away from Addis Ababa to the Western part of Ethiopia. The zone comprises nine rural districts. According to the report of CSA (2011), Horro Guduru Wollega zone covers a total land area of 8,097km^2; a total population of 641,575 of which 50.09% are male and 49.91% are female. This study was conducted in four districts of Horro Guduru Wollega zone namely, Ababo Guduru, Horro, Abe Dongoro and Amuru (Figure 5.1).

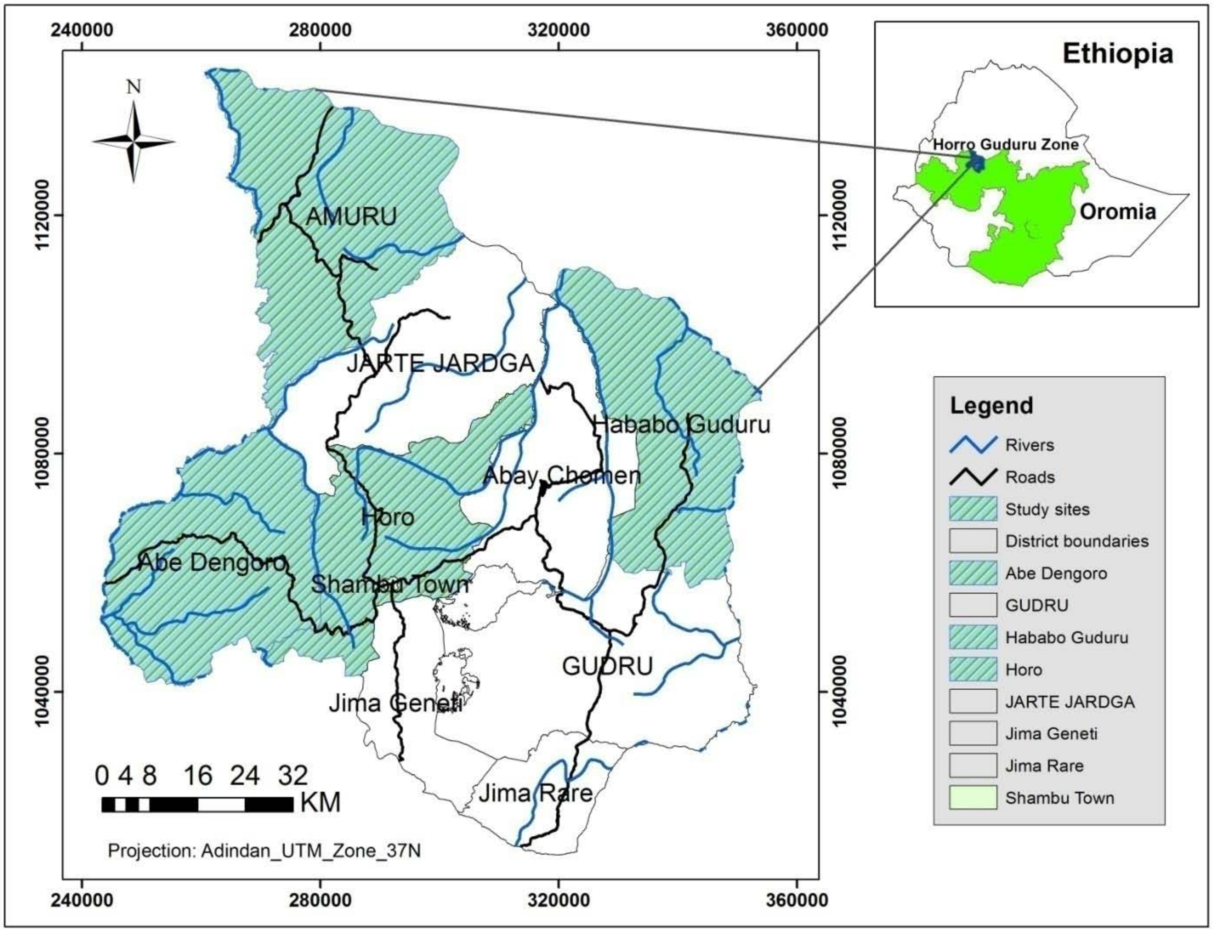


Figure 5.1. *Map of study area, Horro Guduru Wollega Zone by districts*.

Source: Adapted from Finance and Economic Development Bureau of Oromia, 2016

5.4.2 The Research Design

Survey designs are the most important research designs in quantitative research (Creswell, 2012). In explaining the effect of rural road transportation infrastructure on the agricultural productivity of smallholder farmers, survey research design was adopted and relevant data were collected through structured household questionnaire. The questionnaires are designed to collect data regarding farm-household characteristics (i.e. age, gender, education, family composition and farm size), the existing rural road transport facilities in the area, and the available and mostly used means of transportation, quality of rural roads and status of smallholder farmers' agricultural productivity. Thus, for this specific research a cross-sectional survey method was employed as it is comparatively less costly, less time consuming, easier to employ, and most appropriate for data collection from smallholder farmers (Brown & Suter, 2012; Saunders et al., 2007).

5.4.3 Sampling Technique and Sample Size Determination

Horro Guduru Wollega Zone was identified as one of the potential cereal crop producing corridors of Ethiopia. On the contrary, the existing rural road transport infrastructure in the zone is not satisfactory to support the existing agricultural potential of the area. Keeping this in view, HGWZ was purposively selected by the researcher. A Multistage simple random sampling procedure was used to derive a sample size of 500 respondents in 16 rural kebeles of the four districts of the study area. The first stage involves a random selection of four districts from the nine districts of HGWZ. Alternatively, the names of all districts of HGWZ were written on pieces of paper and the desired sample (four districts) were selected by picking the required number of papers. In such simple random sampling method, the selection of one district is independent of the selection of another district. As a result, four districts (Hababo Guduru, Horro, Amuru and Abe Dondoro) were selected. The second stage involves the random selection of four rural kebeles (RKs) from each of the four districts making a total of 16 RKs. The same simple random sampling procedure was used in the selection of RKs in each district.

The third and final stage was the random selection of farm households from each RK. The list of farm households in each RK was compiled with the assistance of the extension agents and RK manager. This list of farm households will form the sampling frame for this particular research. According to Gray et al. (2007) suggestion, the researcher used 95 % confidence level (plus or minus 5 percentage points as a reasonable margin of error) to determine the sample size for this specific study. Accordingly, there will be only a 5 per cent chance that the actual coverage in this population is outside the margin of error determined by the survey. In other words, we can be confident that in 95 out of 100 surveys the true rate in the population would lie within this margin. These calculations must be repeated for each of the sample RKs in the respective sample districts. It is usual that RKs may vary considerably in the number of smallholder farmers they contain and hence to avoid bias, probability proportional to size (PPS) was employed (Table 5.1). RKs with larger size of smallholder farmers would have a proportionately greater chance of being included in the sample than those with small size of smallholder farmers. Thus, 500 smallholder farmers from the four districts were sampled for the study (Table 5.1).

Table 5.1. Sample design outlay for selecting study respondents.

Sample Districts	RK	Total farm household size	Sample size at 95% confidence level
Hababo Guduru	Moti Kawo	713	37
	Lalistu Lova	717	39
	Koticha Melole	260	15
	Sirba Lova	416	22
Horro	Odaa Buluk	549	25
	Haro Aga	1117	57
	Tokuma Alshava	789	39
	Abe Dulacha	692	30
Amuru	Jawi Migir	516	29
	Gobu Sirba	476	25
	Haro Gudina	418	23
	Warabera	236	19
Abe Dongoro	Lomicha	978	47
	Oda Boti	433	24
	Botora Bora	469	28
	Mender 25	873	41
	Total	**9652**	**500**

Source: Own sample design by using data obtained from kebele, 2016.

5.4.4 Methods of Data Collection

Both primary and secondary information were obtained for the study. The primary data were gathered through a structured household questionnaire administered by trained enumerators to the selected household heads of smallholder farmers. The study questionnaire was first pre-tested for reliability and validity. Essentially, the data were cross-sectional in nature. These data were collected between February 2016 and June 2016. The primary data include: the socio-economic characteristics of smallholder farmers such as marital status, gender, household size, farming experience, farmland size, level of education, mode of transportation often used for transporting agricultural produce from farm to home and from home to market. Rural road transport infrastructure condition such as distance to major market, distance to the nearest all weather road, ownership of intermediate means of transport in household, road distance to zonal headquarter, travel time on foot to nearest major city are among the primary data included in the household survey.

A pre-tested structured questionnaire for sample household farmers was used for primary data collection. A total of 500 copies of structured questionnaire were directly administered to the selected 500 smallholder farmers across the 16 selected samples RKs. Sample household farmers generally agreed to answer the questions willingly, and non response was almost zero. The data collection exercise took five months and involved the researcher and trained data collectors in each selected sample RKs.

The primary data obtained from the study respondents was augmented with secondary data sources. The secondary data were collected from books, journals, bulletins, magazines, internet and other literature materials. Production and productivity of major agricultural crops and related information of the study area was collected from CSA abstracts and statistical handbooks as well as from regional, zonal and district level agriculture and rural development offices.

5.4.5 Data Processing and Analysis

Statistical analysis was performed using Statistical Package for Social Sciences (SPSS) software version 20. Data gathered from respondents was subjected to different statistical techniques. These were including the descriptive statistics (mean, percentage, frequency, coefficient of variation). Inferential statistics such as simple correlation, stepwise multiple regression methods was employed to examine and establish statistical relationship between agricultural productivity as dependent variable and rural road transport infrastructure as various independent variables. A multiple regression analysis provides a means for objectively assessing the degree and nature of the relationship between dependent and independent variables. The multiple regression analysis for examining the relationships between rural road transport variables and smallholder farmers' agricultural productivity level was carried out in a stepwise method because it takes into account the issue of collinearity, the identification of outliers and the significance of linear regression coefficients. The stepwise method is sequential in approach, starting the analysis by selecting the best predictor of the dependent variable. Additional independent variables are selected in terms of the incremental explanatory power they can add to the regression model. Independent variables are added as long as their partial correlation coefficients are statistically significant.

In order to check whether there is a problem of multicollinearity, the rule of thumb, according to Gujarati (2004), is a value >= 0.8 in correlation coefficients between variables. As a result, Variance Inflation Factor (VIF) was computed for the variables used in regressions and no problem of multicollinearity was detected. Similarly, to check for model fit, the Hosmer and Lemeshow Test was used, which correctly predicted more than 80% of the variables.

5.5 Analytical Model

The dependent variable, smallholder farmers' agricultural productivity level (yield), was measured in quintals per hectare (q/ha) and in birr/quintal. The following analysis seeks to establish whether there is any systematic relationship between rural road transport condition and smallholder farmers' agricultural productivity level. For this purpose a multivariate regression analysis was employed. This is because the model and variables used in this analysis satisfy the following three principles of this method: (1) there is only one dependent variable, (2) this variable is a parametric number, and (3) there are several parametric independent variables. Social science researchers commonly describe the different ways they measure things numerically in terms of scales of measurement, which come in three flavors: nominal, ordinal, interval or ratio scales (Brown, 2001). Each is useful in its own way for quantifying different aspects of variables. Before analyzing a data set, it is important to determine each variable's scale of measurement because certain types of statistical procedures require certain scales of measurement. In this research, the variables used to explain the socio-economic characteristics of smallholder farmers are measured at nominal and ordinal level of measurement. Whereas, many of the dependent and independent variables used in the regression analysis in this research are measured at an interval or ratio level of measurement. A multiple regression analysis provides a means for objectively assessing the degree and nature of the relationship between dependent and independent variables. The regression model for this specific case is of the form:

$Y = a + b_1x_1 + b_2x_2 + b_3x_3\ldots\ldots\ldots\ldots b_{27}x_{27} + U_i$

In which:

Y = the agricultural productivity level (the dependent variable), measured by the monetary value of the total annual yield from farm in birr comprising all crops grown on the farms and their market prices

a = intercept

$b_1, b_2, b_3, b_4, b_5, b_6, b_7, b_8$ ----b_{27}= change (coefficient) in agricultural productivity levels associated with a unit change in the farmers socio-economic variables and rural road transport variable (the independent variable) considered.

$Y = a + b_1x_1 + b2x2 + b3x3\ldots\ldots\ldots\ldots b27x27 + U_i$, where:

Y = Total annual crop yield from farm (Monetary value in birr)

X_1 = Farming Experience (in years)

X_2 = Age of respondent (in years)

X_3 = Marital status (married, single and widow)

X_4 = distance to the nearest all weather road (in km)

X_5 = Education level of household head (no formal education, primary, secondary and tertiary education)

X_6 = Ownership of intermediate means of transport in household (IMT) (number of IMTs in the household)

X_7 = Vocational skill of household head (No = 1, Yes =2)

X_8= Distance to Major Market (DSMM) (In Kilometres)

X_9 = Sex of household head (SEX) 1, if male; 0, if female

X_{10} = Road distance to zonal headquarter (in Kilometres)

X_{11}= Travel time on foot to nearest major city (min)

X_{12} = frequency of visits to the nearest town (daily, weekly, fortnightly, monthly and occasionally)

X_{13} = Category of Road access (asphalt concrete road, gravel road and earth road)

X_{14} =Road surface condition (Good, Fair and Bad)

X_{15} = Road access condition (no vehicular access, dry season only access and all weather access)

X_{16} = Road reliability in raining season (reliable and not reliable)

X_{17} = major means of transportation (Head loading/human portage, animal drawn carts, pack animals and truck/car)

X_{18} = Farm Inputs (None, one input, two inputs and three inputs)

X_{19} = Household size (Number of household members)

X_{20} = Farm size (in hectares)

X_{21} = Transport cost to the farm (in birr)

X_{22} = waiting time at the road side before accessing commercial vehicles (min)

X_{23} = Distance to agricultural extension offices (km)

X_{24} = Distance to agricultural farmer training centers (km)

X_{25} = Distance to agricultural cooperatives (km)

X_{26} = Distance to microfinance institutions (km)

X_{27} = Distance to the farm (in km)

Ui = Error term assumed to have a zero mean and constant variance.

5.6 Results and Discussion

5.6.1 Socioeconomic Characteristics of Respondents

Table 5.2. Socioeconomic characteristics of respondent smallholder farmers, N=500

	characteristics	Frequency	Percent
Sex of household head	Male	450	90
	Female	50	10
Marital status	Married	400	80
	Single	40	8
	Widow	60	12
Education level of household head	No formal education	120	24
	Primary education	260	52
	Secondary education	70	14
	Tertiary	50	10
Household size	1-3	125	25
	4-6	170	34
	7-9	130	26
	10-12	75	15
	Mean= 6		
Farming experience	1-10	40	8
	11-20	225	45
	21-30	110	22
	31-40	75	15
	41-50	50	10
	Mean= 15		
Farm size	≤ 1	50	10
	1.1-2.0	145	29
	2.1-3.0	170	34
	3.1-4.0	100	20
	>4	35	7
	Mean= 2.4		

Source: Computed from the field survey, 2016.

Table 5.2 presents the summary statistics for socioeconomic characteristics of the respondents. With respect to the first research question, it was found that the majority of the respondents are male (90.0%) and married (80%). About 24% of the respondents do not have formal education and this affects their innovation and diffusion of new ideas which might further reduce their agricultural productivity. An average household size of farming household in the study area is made of about 6 persons. The finding in this investigation was somewhat higher compared to a 4.8 persons per household at national level (CSA, 2007). A possible explanation for this might be that they may be ready source of family labor on the farm. Furthermore, the rural economy is normally associated with small-scale family farms. Such units of production are characterized by labor intensive operations and limited resources.

Moreover, the study reveals that majority (45%) of the sampled farmers have between 11-20 years of farming experience. This indicates that most of the farmers sampled have enough farming experience. From table 5.2, it can be seen that the mean score for farm land holding sizes per household was found to be 2.4 hectares which is above the national average of 1.14 hectares (CSA, 2015). Just 10 % of the respondents have farms less than 1 hectare where as the majority (34 %) of the respondents cultivated between 2.1 and 3.0 hectares. This indicates that majority of the farming population in the study area are small scale farmers and were producing at subsistence level probably as result of the condition of poor rural road infrastructure that may not support large-scale and commercial production. Only 7% or 35 of the 500 respondents have farms above 4 hectares in size. This indicates that majority of the farming population in the area are small scale farmers.

5.6.2 Mode of Transportation Used by Smallholder Farmers

Table 5.3. Mode of transportation of agricultural produce from farm to home and from home to market

District	Mode of transport to move produce from farm to home				Total	Mode of transport to move produce from home to market				Total
	Headloading/human porterage	Pack animal	Animal cart	Motorized vehicle		Headloading/ human porterage	Pack animal	Animal cart	Motorized vehicle	
Hababo Guduru	54(48%)	33(29%)	19(17%)	7(6.2%)	113(100%)	44(40%)	31(27%)	7(6%)	31(27%)	113(100%)
Horro	53 (35%)	57(38%)	30(20%)	11(7%)	151(100%)	30(20%)	59(39%)	8(5%)	54(36%)	151(100%)
Amuru	38(40%)	31(32%)	19(20%)	8(8%)	96(100%)	24(25%)	36(37%)	3(3%)	33(35%)	96(100%)
Abe Dongoro	59(42%)	56(40%)	17(12%)	8(6%)	140(100%)	34(24%)	59(42%)	5(4%)	42(30%)	140(100%)
All	204(44%)	177(30%)	85(21%)	34(5%)	500 (100%)	115(23%)	215(43%)	35(7%)	135(27%)	500(100%)

Source: Computed from the field survey, 2016.

Table 5.3 shows that 44% of those who were interviewed indicated that they used human porterage as a means of transport to move their agricultural produce from farm to home. Likewise, of the 500 smallholder farmers who completed the questionnaire, just 177 (30%) of them indicated that they employed the use of pack animal to transport their agricultural produce from farm to home whereas 21% use animal cart (mule, donkey or horse) for the same purpose. Surprisingly, only a minority of respondents (5%) reported that they are using motorized transport to move their agricultural produce from farm to home. Taken together, the most obvious finding to emerge from this analysis is that smallholder farmers largely depend on traditional non- motorized mode of transport to move their agricultural produce. This result is in agreement with the findings of different researchers (Usman et al., 2013; Starkey, 2005; Barwell, 2006) who observed that, most rural dwellers in Africa depend more on IMT than motorized transport. Surveys such as that conducted by Usman et al. (2013) have shown that owing to the very poor condition of road transport in Kwara State of Nigeria only 1.1% of the respondents own personal four wheeled vehicles and hence many people are forced to depend on motorcycle and bicycle as means of transportation. A similar work by (Porter, 2013) revealed the fact that since poor people rarely own motorized means of transport, so walking, cycling and animal traction predominates.

The higher percentage use of head porterage was observed in Abe Dongoro and Hababo Guduru which is 42% and 48% respectively as compared to the other two districts. There are several possible explanations for this result. First, these two districts are said to be far away from zone capital shambo and less attention was given to them with regard to road transport infrastructure development. Second, the physical topography of Abe Dongoro district is not welcoming the use of motorized transport. The most likely reason for the large percent (36%) of smallholder farmers in Horro district to use motorized transport to move agricultural produce from home to market is due to its physical proximity to zonal capital. One possible reason behind the use of pack animals by the majority of respondents (43%) as compared to motorized transport (7%) is because of the bad condition of the rural roads from their home to markets. Another possible explanation for these results may be the lack of adequate capital to pay for motorized transport. These results seem to be consistent with other research findings which revealed that bad condition of the road affects cost of transportation of agricultural produce (Moyo, Machir, 2015; Hine, 2001). It can therefore be assumed that the effect of higher percentage use of head porterage in the study area has limited the potential level of farmers' production for the reason that they can only carry certain quantity at a time.

Table 5.4. Multivariate correlation analysis on rural road transport infrastructure condition and agricultural productivity using stepwise multiple regression method

Districts	Stepwise regression method		
	Variables	Standardized Coefficients	R^2
Abe Dongoro	Distance to major market	- 0.579	0.58
	Distance to the nearest all weather road	-0.670	
	The frequency of visits to the nearest town	+ 0.598	
	Transport cost for farm produce	- 0.599	
Horro	Distance to major market	- 0.328*	0.39
	Distance to the nearest all weather road	- 0.279*	
	Ownership of intermediate means of transport in a household	+ 0.57	
	Category of road access	+ 0.43	
	Road access condition	+0.49	
	Transport cost for farm produce	-0.45	
Amuru	Distance to major market	- 0.484	0.669
	Ownership of intermediate means of transport in a household	+0.54	
	Road distance to zonal headquarter	-0.44	
	Distance to the farm	-0. 49	
	Transport cost for farm produce	-0.45	
Hababo Guduru	Distance to major market	- 0.597	0.563
	Distance to the nearest all weather road	- 0.486	
	Ownership of intermediate means of transport in household	+0.52	
	Road distance to zonal headquarter	- 0.62	
	frequency of visits to the nearest town	+0.48	

a Dependent variable: Agricultural productivity

* Regression coefficient is not statistically significant at 0.05 levels

Source: Computed from the field survey, 2016.

5.6.3 Distance to Major Market and Agricultural Productivity

As indicated in table 5.4 above, the correlations between distance to major market and agricultural productivity in this investigation accounted for Abe Dongoro (- 0.579), Amuru

(- 0.484) and Hababo Guduru (- 0.597) districts. The regression results show that distance to major market negatively related (and statistically significant at the 5% level) to agricultural productivity. The implications for this finding is that farm households found at far distant from the market are less likely to produce crops for marketable surplus since the market price decays with physical distance, ultimately defining a threshold beyond which crop production is not economically viable.

The result thus obtained is compatible with the findings of Stifel et al. (2003) that got statistically significant and negative correlation between agricultural productivity and distance to market center. This finding is also in agreement with Hine and Ellis' (2001) findings which showed that intensity of food production decreases as distance to market increases. In contrast to this finding, however, Goletti et al. (2001) found that distance to the nearest market does not statistically affect farmer's productivity.

5.6.4 Distance to the nearest all Weather Road and Agricultural Productivity

The other rural road transport related variable used in the regression analysis to estimate the effect of rural road on agricultural productivity was the distance to the nearest all weather road. The results of the correlational analysis in this research showed a significant and negative correlation (- 0.67) between distance to the nearest all weather road and agricultural productivity for Abe Dongoro district. This is the indication that the presences of all-times accessible roads as the principal means of access to the farm household causes transport services to exist, which in turn is expected to increase their agricultural productivity.

A strong relationship between distance to the nearest all weather road and agricultural productivity has been reported in the literature. For instance, prior study by (Obayelu et al., 2014) has noted the importance of paved or good gravelled roads for the evacuation of agricultural produce. The observed correlation between the two variables might be explained by the fact that the growth of farm productivity is linked closely to the type and quality of rural road infrastructure in place. This means that countries that will provide adequate, affordable and accessible road infrastructure in rural areas will succeed in increasing their agricultural productivity.

5.6.5 Frequency of Visits to the nearest Town and Agricultural Productivity

It is apparent from table 5.4 above that the frequency of visits to the nearest town correlates positively with agricultural productivity (0.598) quite revealing that the higher the frequency of visit by smallholder farmers the higher their farm productivity. Recent investigations reported by Osuolale and Ogunniyi (2015) also support the hypothesis that the frequency of visits to the nearest markets determine access to agricultural input and output markets. In a similar case in South Africa, Chaminuka et al. (2008) found that farmers who frequently visit the towns usually access different service like extension services, cooperatives, banks and post offices at a time. It can thus be suggested that investing in the growth and development of rural town centers will have positive benefits for smallholder farmers by making such services more easily accessible.

5.6.6 Transport Cost for Farm Produce and Agricultural Productivity

It is argued that competitive rural transport is required to ensure that the advantages from reductions in transport costs are passed on to smallholder farmers. Unfortunately in Horro Guduru Wollega Zone this is far from the case. A significant negative correlation was found between transport cost for farm produce and agricultural productivity (- 0.45) denoting that the higher the transport cost that farmers pay for their agricultural produce to move from farm to home or home to market the lower their farm productivity. This result provides further support for the hypothesis that reduced transport costs lower the costs and profitability of supplying modern inputs such as fertilizers, seeds, extension services and other technologies which finally increases crop productivity. This finding seems to be consistent with other researches (Jacoby, 2007; Sabandar, 2004) which found that differences in crop productivity among farm households are partly attributable to transport costs.

5.6.7 Category of Road Access and Agricultural Productivity

Category of road access correlates positively with agricultural productivity (0.43), which means as the quality of road access increases (i.e from earth road to gravel) the productivity of smallholder farmers will increase. It is encouraging to compare this finding with that found by Ashagidigbi et al. (2011) who found a significant positive correlation between category of road access and economic productivity of farmers' output. Similarly, by using time series data for 256 districts in India Narayanamoorthy, (2006) found a strong and positive relationship between road infrastructure development and agricultural productivity. These lines of reasoning have been supported by many African and Asian studies (Kassali et al., 2012; 2014; Tunde, 2012; Felloni et al., 2000; Qin, Zhang 2012).

5.6.8 Ownership of Intermediate means of Transport and Agricultural Productivity

Closer inspection of table 5.4 above shows that ownership of intermediate means of transport was highly correlated with agricultural productivity in Horro (+ 0.57), Amuru (+0.54), Hababo Guduru (+0.52) districts implying the higher the proportion of ownership of intermediate means of transport the higher the productivity of farm households. This result may be explained by the fact that the various intermediate means of transports complement motorized transport systems, fulfilling needs for collecting and distributing agricultural produce over relatively short distances. Another possible explanation for this result is that intermediate means of transport are appropriate to transport small and medium loads as compared to motorized means of transport. These results are in line with the work of Sabandar (2004), who argued that local market and intermediate means of transport are critical in relation to rural welfare. This finding corroborates the ideas of Stifel et al. (2013), who found a 50 percent reduction in transport costs when using IMT as opposed to motorized means of transport. Similar conclusions were raised by World Bank (1988), who argued that transporting crops to village markets and collection points often involves intermediate means of transport, to connect to the larger, motorized transport services needed to move produce to distant markets.

5.6.9 Road Distance to Zonal Headquarter and Agricultural Productivity

As indicated in table 5.4, the correlations between road distance to zonal headquarter and agricultural productivity were higher for Amuru (-0.44) and Hababo Guduru (- 0.62) districts compared to those of other two districts. This higher correlation for Amuru and Hababo Guduru districts might be attributed to their relative remoteness from zonal center. This finding indicates that since zonal center is considered to be the hub for input and produce markets, as proximity to zonal center decreases farm productivity of farming household is found to decrease. In the literature, a well-established inverse relationship between these two variables was found by many studies. An example of this is the study carried out by Philemon (2014) that strongly emphasized remoteness and consequent poor access to social-services and opportunities as a key factor in low farm productivity. In another major study, Stifel and Minten (2008) found that rice prices are 13 percent more variable in the most remote areas compared to the least remote.

There are some empirical evidences that support these general arguments in Ethiopia as well. For example, Arethun and Bhatta (2012) conducted on contribution of rural roads to access to- and participation in markets in Ethiopia and they come up with the conclusion that road accessibility as one of the major factors influencing the productivity of rural household. Likewise, Kifle (2010), in his dissertation work entitled ‘ Road Infrastructure and Rural Poverty in Ethiopia’ found the fact that remoteness from the market forced smallholder farmers either to accept low prices for agricultural produce they market or consume it at farm level although they prefer to sell.

5.6.10 Distance to the Farm and Agricultural Productivity

Finally, the other rural road transport related variable assumed to influence smallholder farmers’ agricultural productivity was the distance to farm plot. Thus, in Amuru district there was a significant negative correlation (-0.49) between distance to the farm and agricultural productivity. Preliminary results from stepwise regressions indicate that distance to farm contribute to explain farm performance by correlating negatively, and statistically significant to agricultural productivity. Therefore, farmers in Amuru district covered long distances before getting to their farm plots and this is expected to influence the productivity and production performance of farmers. This result may be explained by the fact that when the farm land of smallholders is far apart from their home the greater was the cost of: transportation, farm management and supervision. This in turn hindered the optimal application of modern agricultural inputs and led to low productivity. It is encouraging to compare this finding with that found by Ojo and Afolabi (2003). In their study on ‘Effects of farm distance on productivity of farms in Nigeria’, Ojo and Afolabi found that farm distance to key infrastructure such as road correlate negatively with agricultural productivity. Similarly, further studies by (Ekbom, 1998; Ojo, 2008) also observed statistically significant effects of farm distance on agricultural performance of smallholder farmers.

5.7 Conclusion

The main goal of the current study was to explain the effect of rural road transport on smallholder farmers' agricultural productivity in Horro Guduru Wollega Zone, Western Ethiopia. One of the more significant findings to emerge from this study is that distance to major market, category of road access, road access condition, ownership of intermediate means of transport, transport cost for farm produce, distance to the nearest all weather road and the frequency of visits to the nearest town, road distance to zonal headquarter were found to be important in predicting agricultural productivity in the study area. Spatial vulnerability in road quality and availability was observed among the four selected districts of Horro Guduru Wollega Zone. The quality of rural road infrastructure in Horro Guduru Wollega Zone indicates that the zone is still backward in terms of rural road infrastructure development despite its huge agricultural potential. A large proportion of the total length of all the roads in the study area is not paved. Due to the high agricultural potential of the area, these roads nevertheless, carry considerable volume of traffic in rural areas. The ability to carry traffic can be enhanced if these rural roads are properly maintained. There is urgent need to rehabilitate the roads in order to improve rural road accessibility which further increases smallholder farmers' agricultural productivity in rural areas.

Acknowledgements

This research was financially supported by the Ministry of Education of the Ethiopian Democratic Republic, Addis Ababa University and Wollega University. Authors would like to thank the editor in chief Eva Štefanová as well as the two anonymous reviewers for their constructive comments and recommendations.

References

Adedeji, O. A., Olafiaji, E. M., Omole, F.K., Olanibi, J.A., & Lukman, Y. (2014): An Assessment of the Impact of Road Transport on Rural Development: A case Study of Obokun Local Government Area of Osun State, Nigeria.

AFDB (2010): Infrastructure-African Development Bank. Retrieved on 22th August, 2011, from http://www.afdb.org/en/topics-sectors/sectors/infrastructure/

Ajiboye, A. O., & Afolayan, O. (2009): The Impact of Transportation on Agricultural Production in a Developing Country: A case of Kolanut Production in Nigeria. International Journal of Agricultural Economics and Rural

Arethun, T., Bhatta, B.P. (2012): Contribution of Rural Roads to Access to- and Participation in Markets: Theory and Results from Northern Ethiopia. Journal of Transportation Technologies, 2012, 2, 165-174. http://dx.doi.org/10.4236/jtts.2012.22018.

Ashagidigbi, W. M., Abiodun, O. F., & Samson, O. A. (2011): The Effects of Rural Infrastructure Development on Crop Farmer's Productivity In Osun State. World Rural Observations 2011, 3(1). http://www.sciencepub.net/rural

Barwell, I. (1996): Transport and the Village: Findings from African Village Level Travel and Transport Surveys and Related Studies. World Bank Discussion Paper, no. 344. The World Bank. Washington, DC.

Brown, J. D. (2001): Using surveys in language programs. Cambridge: Cambridge University Press.

Brown, T., & Suter, T. (2012). Marketing research (8th ed.). Mason, OH: South-Western Publishing.

Chaminuka, P., Senyolo, G.M., Makhura, M.N., Belete, A. (2008): A factor analysis of access to and use of service infrastructure amongst emerging farmers in South Africa. Agrekon, Vol 47, No 3.

Creswell, J.W. (2012): Educational Research: Planning, Conducting, and Evaluating Quantitative and Qualitative Research. 4thEdition. SAGE publications: London.

CSA (2007): The 2007 Population and Housing Census of Ethiopia: Statistical Report for Oromiya.

CSA (2011): Federal Democratic Republic of Ethiopia Central statistical Agency Statistical Abstract. Addis Ababa, Ethiopia.

CSA (2015): Key Findings of the 2014/2015 (2007 E.C.) Agricultural Sample Surveys. The Federal Democratic Republic of Ethiopia Central Statistical Agency. Addis Ababa, Ethiopia.

DFID (2008): Better roads for Africa, Research News Research for Development. Retrieved on 19th August 2011, from http://www.dfid.gov.uk/r4d/news.asp?ArticleID=50292

ECONOMIC COMMISSION FOR AFRICA (2013): Infrastructural Development and Rural Transformation

Ekbom, A. (1998): Some Determinants to Agricultural Productivity- an application to the Kenyan highlands. Presented at the World Conference of Environmental Economics, Venice, Italy, 25-27 June, 1998.

Felloni, F., Wahl, T., Wandschneider, P. (2000): Evidence of the effect of infrastructure on agricultural production and productivity: Implications for China. Department of Agricultural Economics, Washington State University, Pullman, WA.

Gray, P. S, Williamson, J. B., Karp, D. A., & Dalphin, J. R. (2007): The Research Imagination: An Introduction to Qualitative and Quantitative Methods. Cambridge: Cambridge University Press.

GIZ (2014): Improving Rural Transport Infrastructure: Experience from Bangladesh. An overview on the Rural Infrastructure Improvement Project (RIIP-1). WAGNER, A., SCHMID, D (eds.). Federal Ministry for Economic Cooperation and Development (BMZ). https://www.researchgate.net

Goletti, F., Gruhn, P., Bhatta, A. (2001). Farmer productivity in Nepal. Discussion paper No.17. Agricultural Sector Performance Review TA3536- NEP, Kathmandu, Nepal.

Gujarati, D. N. (2004): Basic Econometrics, Fourth Edition. The McGraw−Hill Companies.

Heyen-perschon, J. (2001): Non-Motorized Transport and its socio-economic impact on poor households in Africa: Cost-benefit analysis of bicycle ownership in rural Uganda, Jinja, Uganda.

Hine, J. L., Ellis, S. D. (2001): Agricultural Marketing and Access to Transport Services. Rural Transport Knowledge Base; Rural Travel and Transport Program 2001.

International Road Federation (2006) 'World Road Statistics', Statistical Report.

Jacoby, H., Minten, B. (2007). On Measuring the Benefits of Lower Transport Costs. World Bank, Washington, DC, Mimeo.

KassalI, R., Ayanwale, A. B., Idowu, E. O., & Williams, S. B. (2012): Effect of Rural Transportation System on Agricultural Productivity in Oyo State, Nigeria. Journal of Agriculture and Rural Development in the Tropics and Subtropics Vol. 113 No. 1 pp 13– 19.

Kifle, A.W. (2010): Road Infrastructure and Rural Poverty in Ethiopia. Ph.d dissertation. Department of Development and Economic Studies. University of Bradford.

Lindsay, A. K. (2015): Rural Roads and Agricultural Development in Swaziland. Journal of Social Science Studies ISSN 2329-9150 2015, Vol. 2, No. 1

Lulit, A. (2012): Impact of Road on Rural Poverty Evidence Form Fifteen Rural Villages in Ethiopia. MA thesis. Erasmus University Rotterdam, Institute of Social Studies (ISS), The Hague, the Netherlands.

Moyo, W., & Machiri, A. (2015): An Assessment of the Contribution of Road Transport Systems to Smallholder Agricultural Production in Bubi District. International Journal for Research in Physics, Chemistry and Applied Science, 1(1), 1-14.

Narayanamoorthy, A., Hanjra, M. A. (2006): Rural Infrastructure and Agricultural Output Linkages: A Study of 256 Indian Districts. Indian Journal of Agricultural Economics, 61(3), 444-459.

Obayelu, A. E., Olarewaju, T. O., Nurudeen L., & Oyelami, N. L. (2014): Effect of Rural Infrastructure on Profitability and Productivity of Cassava-Based Farms in Odogbolu Local Government Area, Ogun State, Nigeria. Journal of Agricultural Sciences Vol. 59, No. 2 pp 187-200. DOI: 10.2298/JAS1402187O.

Ojo, S. O. (2008): Effects of Land Acquisition for Large Scale Farming on the Performance of Small Scale Farming in Nigeria. Journal of Human Ecology, 24(1): pp 35-40

Ojo, S.O., AFOLABI J. A. (2003): Effects of Farm Distance on Productivity of Farms in Nigeria. Journal of Applied Science, 6(1): 3331 – 3341.

Osuolale, T. O., Ogunniyi, G. (2015): Promoting Food Production Through Input Services and Rural Infrastructures. Academic Research Journal of Agricultural Sciences and Research. Vol.3(8), pp 224-230. DOI:10.14662/ARJASR2015.043

Philemon, K. (2014): Roads and Rural Development: Evidence from a Longitudinal Household Survey in Kenya. PhD dissertation. Faculty of Economics at the National Graduate Institute for Policy Studies (GRIPS), Kyoto University. Kyoto, Japan.

Porter, G. (2013): Transport Services and their Impact on Poverty and Growth in Rural Sub-Saharan Africa, AFCAP/ Durham University.

Qin, Y., Zhang, X. (2012). The Road to Specialization in Agricultural Production: Evidence from Rural China. International Food Policy Research Institute (IFPRI) Discussion Paper 01221. October 2012. Development Strategy and Governance Division.

Sabandar, W. P. (2004): Transport development and the rural economy: Insights from Indonesia. PhD dissertation. University of Canterbury.

Saunders, M., Lewis, P., & Thornhill, A. (2007). Research methods for business students (4th ed.). Harlow, England: Financial Times/Prentice Hall.

Starkey, P. (2005): Methodology for the Rapid Assessment of Rural Transport Services. Seminar on Sustainable Access and Local Resource Solution, 28th- 30th November, 2005, Bangkok. http://www.docstoc.com/doc/43488005/26-paul-starkey

Stifel, D., Minten, B., Dorosh, P. (2003): Transactions Costs and Agricultural Productivity: Implications of Isolation for Rural Poverty in Madagascar.Cornell University. Discussion Paper No 56. http://www.cgiar.org/ifpri/divs/mssd/dp.htm

Stifel, D., Minten, B. (2008): Isolation and agricultural productivity. Agricultural Economics, 39 (1), 1–15. DOI: 10.1111/j.1574-0862.2008.00310.x

Stifel, D., Minten, B., Koro, B. (2013): Economic Benefits and Returns to Rural Feeder Roads: Evidence from a Quasi-Experimental Setting in Ethiopia. International Food

Policy Research Institute (IFPRI)/the Ethiopian Development Research Institute (EDRI), Addis Ababa, Ethiopia. https://economics.lafayette.edu

Taiwo, A., Kumi, F. (2013): An Appraisal of Road Condition Effect on Rural Transportation in Sekyere Central District of the Ashanti Region of Ghana .Journal of Transportation Technologies, 2013, 3, 266-271

Tunde, A.M., Adeniyi, E.E. (2012): Impact of Road Transport on Agricultural Development: a Nigerian Example. Ethiopian Journal of Environmental Studies and Management (EJESM) 5(3), 232-238. https://doi.org/10.4314/ejesm.v5i3.3

Usman, B. A., Adefila, J. O., Musa, I. J. (2013): Impact of rural road transport on agricultural production in Kwara State, Nigeria. Nigerian Journal of Agriculture, Food and Environment. 9(2): pp 20-25

Worku, Ibrahim. (2011): Road Sector Development and Economic Growth in Ethiopia. EDRI Working Paper 4. Addis Ababa, Ethiopia: Ethiopian Development Research Institute.

World Bank (1988): Road Deterioration in Developing Countries: Causes and Remedies, Washington DC, World Bank.

CHAPTER 6: GENDER DIFFERENCES IN ACCESS TO RURAL TRANSPORT AND ITS IMPLICATION ON AGRICULTURAL PRODUCTION: THE CASE OF HORRO GUDURU WOLLEGA ZONE, WESTERN ETHIOPIA

Abstract

In a society where women's inequality remains deeply rooted gender norms and unequal gender power relations dictate the role of men and women. In Ethiopia, women's access to rural transport is limited. This qualitative research is aimed to explore the gender differences in access to rural transport and its implication for agricultural performance. Focus group discussions, in-depth interviews and observations were used to collect data. By using purposive and snowball sampling, a total of 32 in-depth interview, 12 key informant interview and 96 focus group discussion participants were selected. The qualitative data were collected using semi-structured and open-ended interview protocols and analyzed using qualitative thematic content analysis. According to the results of women's focus groups, men control household's transport means (donkey, horse, and mule). Women typically only control such resources if they are female headed household. These activities are done through head-loading or back-loading. To improve rural women's access to transport infrastructures and hence their agricultural productivity, greater consideration needs to be given to interventions in intermediate means of transport, and other time- and load-reducing measures such energy saving cooking equipments and rural child care centers.

***Keywords**: Agricultural production; Gender differences; Horro Guduru Wollega; Rural transport*

Published in:

Tamene, S., Megento, T. L. (2017): Gender Differences in Access to Rural Transport Infrastructure and Agricultural Production: The Case of Horro Guduru Wollega Zone, Western Ethiopia. Global Journal of HUMAN-SOCIAL SCIENCE: B Geography, Geo-Sciences, Environmental Science & Disaster Management Type: Double Blind Peer Reviewed International Research Journal, Publisher: Global Journals Inc. (USA), Volume 17 Issue 4 Version 1.0 Year 2017

https://globaljournals.org/GJHSS_Volume17/3-Gender-Differences-in-Access.pdf

6.1 Introduction

Around the world, in much of development work, transport above everything is the ultimate enabler since it unlocks growth potentials, creates jobs, and brings wealth to local communities. World Bank (2008) showed that 1 billion poor people in developing countries today lack access to basic all-weather roads. Transport in the rural areas relates principally to basic needs and is carried out mostly on foot or with the aid of intermediate means of transport (World Bank, 2010; Tamene & Megento, 2017). Rural transport-related issues such as access to markets, health care, fuel wood, water, grinding mill and other basic facilities play an important, but underappreciated role in perpetuating women's disadvantaged position in society. Women smallholder farmers living in remote areas have to spend longer hours collecting water or processing food than women living in areas better endowed with infrastructure and this appears to be a significant constraint on their meaningful participation in productive economic sectors like agriculture (FAO, 2010; Gebre-Selassie & Bekele, 2010; porter, 2008).

According to United Kingdom Department for International Development (2010), total agricultural outputs in Africa could increase by up to 20% if women's access to agricultural inputs was equal to men's. Gender gaps in access to rural transport infrastructure seem substantial in sub-Saharan Africa where agriculture is a more important source of livelihoods than in other regions. Reducing this gender gap is therefore, a priority for improving women's access to basic resources in agriculture-based countries (FAO, 2010). Such gender-differentiated access to rural transport infrastructure determines the ability of men and women smallholder agricultural producers to receive fair prices for their produce.

Women and men occupy different positions and face different working conditions in rural labor markets across the developing world and hence they experience different levels of access to rural transport infrastructure (FAO, 2010; FAO, 2016). Rural men and women have no equal access to rural transport infrastructure and services necessary to achieve their individual potential and fulfill their obligations to the household. Owing to gender biased socio-cultural norms and unequal gender power relations, women in most developing countries have less access to rural transport infrastructure as compared to their male counterparts and hence their ability to own and acquire appropriate time saving transport facilities is restricted (porter, 2008; FAO, 2016). This further differentially determines how they may contribute to and benefit from rural livelihood.

Gender intensified inequalities in access to rural transport infrastructure are complex and require an understanding of how household dynamics and gender power relations interact. The reasons for gender differences in access to rural transport infrastructure are many, and are often intertwined.

Although different countries have very different levels and trajectories of gender inequalities, in most societies men and women have distinct economic and social roles and responsibilities, and consequently transport use and provision are highly gendered (Bamberger & Davis, 2001; Booth et al., 2000).

Even though, women are not the only vulnerable groups to be susceptible to lack of rural transport infrastructure, due to their specific reproductive roles and responsibilities, they have several unique rural transport needs that were not shared by the majority of their male counterparts (Porter, 2008). The successful transport service and infrastructure developments in rural areas of developing countries are unattainable without due consideration of gender idiosyncratic transport demand and supply patterns (Zogo & Epo, 2016).

Due to their higher decision making power over household resources, men can afford to pay for higher transport costs that rural transporters are able to charge. But, due to their lower incomes and weak bargaining power, women cannot afford to pay such higher prices for vastly poor transport facilities, which add to the costs of inaccessibility from which they already suffer. Therefore, women are recognized to lack access to rural transport and suffer more acute accessibility problems than their men counterparts. Indeed, the success of harmonious and all-inclusive rural development depends on access to well planned, efficient, affordable and equitable rural transportation systems (Gutierrez & Kuiper, 2010; Holste, 2009).

Even though, not sufficiently recognized and valued, promoting gender equality in access to rural transport infrastructure is an essential component of sustainable economic growth and poverty reduction. Improving women's access to rural transport infrastructure can enhance women's agricultural productivity, economic decision-making power and their entrepreneurial opportunities. Addressing gender equality in access to rural transport infrastructure is therefore central to achieving rural agricultural development goals (Fernando & Porter, 2002).

6.2 Statement of the Problem

Women are taking up a larger share of agricultural production in many low income countries. At the same time, they continue to be the main care providers for their family members (Grassi et al., 2015). In his speech on the annual meeting of the Clinton Global Initiative during September 2009, the former President Bill Clinton addressed that "Women perform 66% of the world's work, and produce 50% of the food, yet earn only 10% of the income and own 1% of the property" (as cited in OECD, 2011, p. 6). If women had the same access to productive resources as men, they could increase yields on their farms by 20-30%. This could raise total agricultural output in developing countries by 2.5-4%, which could in turn reduce the number of hungry people in the world by 12-17% (OECD, 2011).

Although progress has been made, there are clearly many gender-specific rural transport constraints still at work among smallholder farmers of developing countries. Even in the absence of adequate rural transport provision, women shoulder the main responsibility for household chores, care provision and other unpaid work to support their families and communities (FAO, 2010). Despite women's role and responsibility for a disproportionate share of the household's transport burden, they have more limited access to transport facilities. Unequal gender power relations and the resulting women's weak bargaining power relative to their men counterparts within households severely limit women's ability to make claims over their contributions (FAO, 2010). Marginalization of women in the use of transport infrastructure poses some challenges on maintaining adequate levels of agricultural productivity and is against the principles of gender inclusive rural development (Creighton & Yieke, 2006; FAO, 2011).

A disproportionate share of the unpaid work burden falls on rural women's shoulders, thus restricting the time they have available for productive work like agriculture. The burden of water and fuel collection is likely to reduce the amount of time women can spend in paid work (Grassi et al., 2015; Chen, 2008). Many women smallholder farmers in low-income countries face disproportionate obstacles in accessing and using rural transport as opposed to their men counterparts. These results in women's relative lack of mobility, self-esteem and confidence in relation to men in decision making over household income (Quisumbing & Pandolfelli, 2009; African Development Fund, 2001)

In Ethiopia, where gender biased cultural norms appear to be significant, women have vastly inferior access to rural transport facilities and are less likely to control over how transport resources are mobilized within households. Limited rural transport infrastructure is a challenge mainly in rural areas of Ethiopia with a high dispersion of people and remote villages. Countries with large rural areas such as Ethiopia also display high shares of women having difficult access to motorized, non-motorized as well as local mode of transportation (Dercon et al., 2009; Muleta & Deressa, 2014). Such problems of gender-differentiated access to transportation are partly exacerbated by gender-blind rural transport policies and programs. Women's limited access to rural transport facilities also constrains their access to other important productive resources and opportunities such as extension, microcredit schemes, women-friendly formal financial systems, training, input and output markets, and other complementary supporting services (Ogato et al., 2009). Unequal access to such important productive assets is an important source of gender disadvantage likely to undermine the achievement of women's agricultural productivity (Eneyew & Mengistu, 2013; Bryceson & Howe, 1993; Gebre-Selassie & Bekele, 2010).

Gendered transport is a subject that received scant attention from policy makers and development specialists. Despite its necessity in development endeavors, gender equality in access to rural transport infrastructure is not sufficiently recognized and valued. Until now, however, little attempt has been made to assess the extent to which, and how, gender-differentiated impact of rural transport infrastructure constrains rural women's agricultural productivity.

In Ethiopia, by overlooking the vast majority of women who reside in male-headed households, many gender-focused transport and agricultural development researches targeted exclusively women headed households (Muleta & Deressa, 2014; Eneyew & Mengistu, 2013; Ahmed, 2013; Bryceson & Howe, 1993; Dea, 2016). Hence, little attempt has been made to assess the domestic transport burden of women who reside in male-headed households.

In Ethiopia, past transportation studies were more inclined towards urban areas compared with existing work done on the transport situation of women in rural areas (eg., Dagnachew, 2011; Eshete, 2015; Schmidt & Mekamu, 2009; Nyarirangwe, 2008). Limited rural transport studies have been undertaken in Ethiopia focusing more on the effects of rural access roads on poverty and livelihood strategies (Ahmed, 2013; Dercon et al., 2009; Porter, 2012). Consequently, less attention has been devoted to study transport patterns and needs of rural women smallholder farmers. Therefore, rural women's and men's substantially different patterns of mobility constitute a promising area for potential research.

In light of the above research gaps, it becomes expedient to examine the problem of gender differential access to rural transportation infrastructure, so that the extent of the problems can be known, and possible policy interventions delivered to achieving gender inclusive rural development.

6.3 Theoretical Underpinnings of the Study

This section discusses the theoretical lens used to explore gender differences in access to rural transport infrastructure and services. Feminist theories of gender power relations are relevant to explore the nature of gender inequality in the society (Buiten, 2007; Lewis, Undated; Mannathoko, 1992). The cultural, social and political determinants of gender differences in access to rural transport infrastructure and services can be easily viewed through a feminist theoretical lens in a number of ways. For instance, Feminist theories inform us that any serious effort to reduce gender disparities in access to and use of rural transport will involve altering the distribution of power within the rural household to the benefit of disadvantaged groups that are in most cases women.

A feminist approach to gender inequities leads us to examine not only the links between gender, rural transport, and agricultural productivity, but also the distribution of power between men and women smallholder farmers in the rural setting. There are a number of reasons why feminist theory may be particularly relevant to explore gendered differences in access to rural transport and its effect on agricultural production. Feminism is concerned with equity, oppression, and justice, which are central themes in access to rural transport infrastructure and services (Lebo, 1999; Buiten, 2007). Feminist theory also recognize that gendered barriers to access to and use of rural transport resources like decision making power and control over such economic resources at farm household level require political solutions (Fernando & Porter, 2002).

According to the feminist philosophical discourse, women were not taken into account in rural transport planning and hence they were marginalized from the use of and control over rural transport infrastructure (Mahapa, 2003). Mahapa further argued that a true study on gendered rural mobility and accessibility as well as equally gendered design in rural transport infrastructure planning must come from considering a broad concept of domestic travel patterns to include women's needs and demands. Various feminist theories try to tackle gender inequality from different perspectives. They are very much concerned with and seek to bring change in suppressed status of women. Therefore, feminist theory aims to identify the sources of women's oppression, the varied nature and impact of gendered power relations and possible ways in which to address this power imbalances threaded through with gender.

To sum up, this study has got its foundation within feminist theories of gender and development to elaborate and explain men and women smallholder farmers' experience on gender differences in access to rural transport infrastructure and services and its implication for agricultural performance. Gender and development is one of the three dominant feminist theories designed to assist in the analysis of gender related topics particularly in the areas of women empowerment.

6.4 Objective

The principal objective of the study is to investigate gender differences in access to rural transport infrastructure and its effect on woman's participation in agricultural production.

To achieve the main objective, the following specific objectives are identified:

1) To identify the extent of gender differences in access to and control over rural transport resources and its associated effect on their participation in agricultural production

2) To examine gender disparities in rural transport mode choice and describe the role of IMT in reducing rural women's transport burden

3) To investigate gender differences in relation to rural travel pattern and behavior

4) To explore the major distinction between rural transport burden falling on women and men

5) To examine the trip chaining characteristics of men and women smallholder farmers

6.5 Research Questions

- Is there gender discrimination in the ownership of and access to rural transport facilities?
- To what extent do gender differences determine rural transport modal choice?
- Are there economic, social and cultural factors in place which determine rural women's /men's travel pattern and transport burden?
- Why women smallholder farmers often trip-chain than their men counterparts?

6.6 Research Methodology

This methodology section gives a brief account of the study area, research design, data collection strategies and data analysis. It also provides a detailed account of ethical issues related to data collection and challenges faced the research process. Since there was no one right technique to collect qualitative data, a combination of data collection methods including focus group discussions (FGDs), in-depth interviews (IDIs), key informant interviews (KIIs), and participant observation were used to offer a holistic interpretation of the phenomenon being studied. Interviews and focus group discussions were tape-recorded, transcribed verbatim and analyzed using inductive thematic analysis approach.

6.6.1 Study Area

This study was conducted in Horro Guduru Wollega zone, Western Ethiopia. The capital town of the zone, Shambo, is located 314 km away from Addis Ababa to the Western part of Ethiopia. The zone comprises nine rural districts. According to the report of CSA (2011), Horro Guduru Wollega zone covers a total land area of 8,097km^2; a total population of 641,575 of which 50.09% are male and 49.91% are female. This study was conducted in four districts of Horo Guduru Wollega zone namely, Ababo Guduru, Horro, Abe Dongoro and Amuru (Figure 6.1).

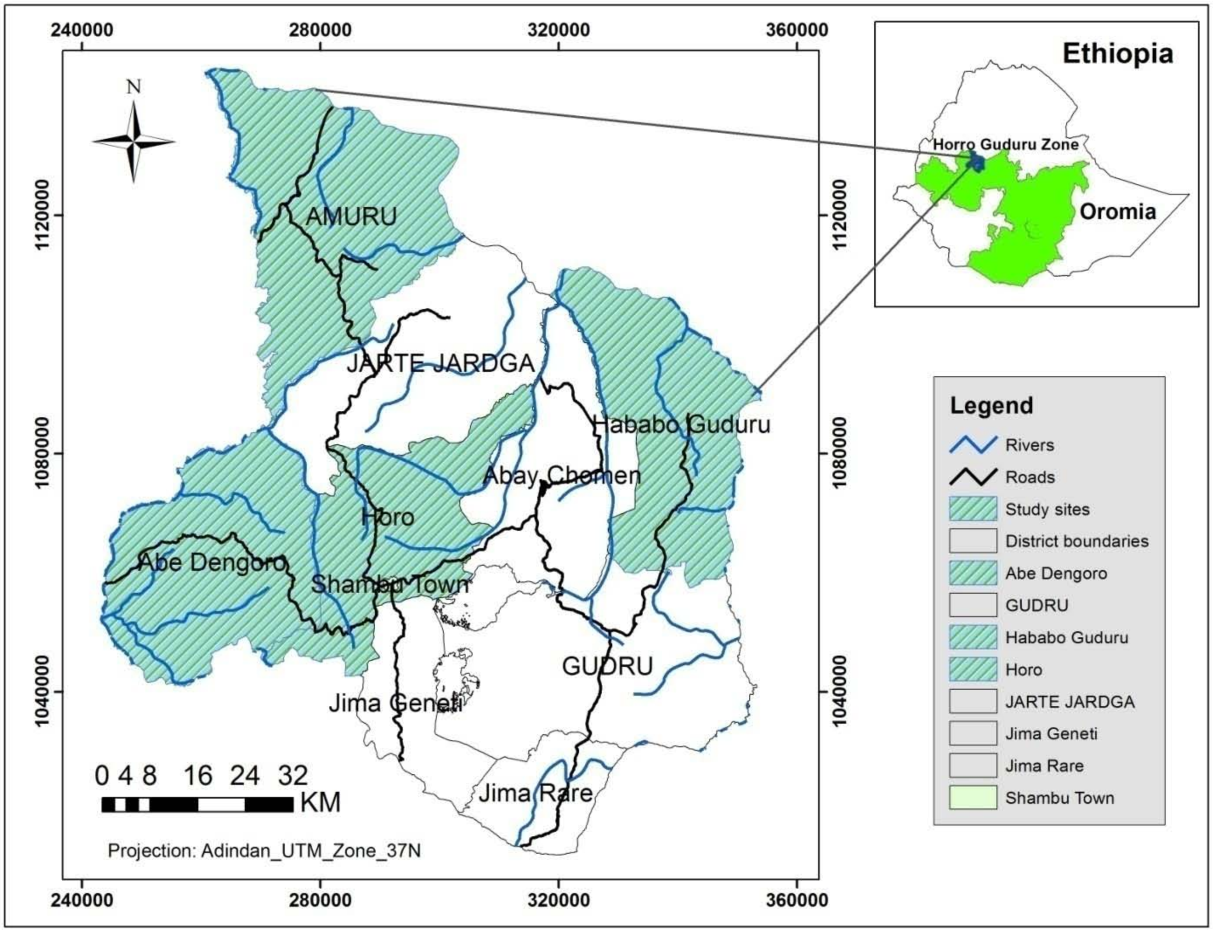


Figure 6.1. Map of study area, Horro Guduru Wollega Zone by districts.
Source: Adapted from Finance and Economic Development Bureau of Oromia, 2016

6.6.2 Research Design

Concerning the research design, this research employed exploratory qualitative research design. Since the aim was to explore the real-life experiences of gender differences in access to rural transport infrastructure and agricultural production, qualitative approach was chosen for this specific research (Creswell, 2012). Qualitative research methods are also effective in identifying intangible factors, such as social norms, socio-economic status, gender roles and gendered differences and characteristics in a society (Denzin & Lincoln, 2005). Qualitative research methods are often employed to obtain more detailed descriptions and explanations of experiences, behaviors, and beliefs. Furthermore, it can answer the whys and hows of human behavior, opinion, and experience—information that is difficult to obtain through more quantitatively-oriented methods of data collection. The philosophical views of the study were focusing more on the constructivist view that deals with gender differences in access to household resources. The methodology used was Interpretive Description. Both primary and secondary data sources were used for this study. The primary sources were obtained via key informant interview (semi-structured), in-depth interview (unstructured), observation tools and focus group discussions.

The research used interpretivism epistemological viewpoint, since the aim of this research is more interested in interpreting deeper meaning in discourse that is represented in a collection of personal narratives or observed behaviors and activities. Since this research is concerned with revealing multiple realities as opposed to searching for one objective reality, interpretivism epistemological viewpoint was taken for granted as appropriate philosophical framework.

6.6.3 Study Population and Sampling

Purposive and snowball sampling were used to recruit participants for FGDs, IDIs and KIIs. First, 12 focus group discussions (4 with women smallholder farmers, 4 with men smallholder farmers and 4 with mixed sex smallholder farmers) were held in 16 rural kebeles across four districts of Horro Guduru Wollega Zone (Ababo Guduru, Abe Dongoro, Amuru, and Horro). In each focus group discussion an average of 8 individuals were participated. Therefore, a total of 48 women and 48 men smallholder farmers were participated in focus group discussions. Second, from each rural kebeles of the study districts one men and one women smallholder farmer (i.e. 16 men and 16 women) were purposively selected to participate in in-depth interviews. Therefore, a total of 32 IDIs were conducted in 16 different rural kebeles across the four study districts. Finally, expert purposive sampling was used to select the 2 male and one female local government officials from each of the four study districts making up a total of 12 key informants for the study (Table 6.1). The key informants consisted of one expert each from district agricultural office, district rural transport office and district gender office.

Table 6.1. Distribution of in-depth interviews, key informant interviews and focus group discussions

Districts	IDIs (32)		KIIs(12)		FGDs(96)		
	women	men	women	men	women	men	mixed sex
Ababo Guduru	4	4	1	2	8	8	4 each sex = 8
Abe Dongoro	4	4	1	2	8	8	4 each sex = 8
Amuru	4	4	1	2	8	8	4 each sex = 8
Horro	4	4	1	2	8	8	4 each sex = 8
Grand Total	16	16	4	8	32	32	16 each sex = 32

Sources: Own design, 2016

6.6.4 Data collection methods and tools

Focus Group Discussions

A focus group discussion (FGD) is a form of interview that involves addressing questions to a group of individuals who have been selected for this specific purpose. This approach offers the opportunity of allowing people to probe each other's reasons for holding a certain view. In this study, 12 FGDs were conducted to obtain the experiences of men, women and mixed sex smallholder farmers towards the topic under study. In total, there were 32 women, 32 men and 32 mixed sex participants.

To solicit more information than what could be obtained from individual farmers, FGDs were held with women, men and mixed sex farmers' groups in different rural kebeles of the study districts. Focus group discussion was designed to solicit information from participants not only on their own perception but on the community perceptions, thoughts, feelings, experiences, reactions and attitudes towards gender differences in access to rural transport infrastructure and its implication for agricultural production (Kvale, 1996)

While recruiting the focus group discussion participants, special emphasis was placed on the composition of the group participants in line with Robinson (1999). Both single-sex and mixed groups were included in the study, as well as the age and religion of focus group members were also considered. Equal numbers of women and men smallholder farmers were included in the FGDs in order to give different chances of representation of views. During each focus group discussion maximum care was also taken to minimize dominant voices that can skew results and affect participation of others. A moderator or group facilitator is usually engaged to guide participants and help them participate in the discussion. Female facilitators were used in women focus group discussions to avoid the potential barriers and encourage them to speak up and express their ideas freely. Experienced local facilitators/moderators were used to encourage participation, build trust and relationships and support an open discussion among focus group discussants.

By taking a great care of restraining themselves from sharing their views about the topic of discussion, facilitators or moderators played a great role in time management, in interviewing and guiding the group's discussions. They also established a comfortable atmosphere within the group encouraging all participants to be part the discussion.

The main topics of the discussion were gender roles and relations, men's and women's to access and control over rural transport infrastructure, day-to-day mobility patterns of men and women, travel purposes of men and women smallholder farmers and existing practices and challenges in rural transport infrastructure. Using the observation method alongside FGDs helped the researcher to capture individual emotions as well as non-verbal information (facial expressions, changes in volume of speech and body language) from FGD participants. The FGDs were conducted using interview guides as data collection tools aiming at answering the already set objectives. These interview FGD guides were developed before the study and improved upon after the pilot study. The guides were designed in such a way that many possible answers could be derived from the discussion, while avoiding short questions and leading questions.

In-depth Interviews (IDIs)

In-depth interviews are useful in collecting more in-depth information or exploring new issues in-depth on sensitive topics that are less likely to be discussed in groups (Boyce and Neale, 2006). In-depth interviews were used to enable the researcher to explore in detail each smallholder farmer's perspective on gender differences in access to rural transport infrastructure. Hence, in four districts of Horro Guduru Wollega zone a total of 32 in-depth one-on-one interviews (8 in-depth interviews in each district) were conducted. These face to-face in-depth interviews were carried out with one male and one female smallholder farmers in each rural kebeles of the four study districts making up a total of 8 and 32 in-depth interviews in each district and across four districts of the study area respectively (Table 6.1). IDI participants ranged in age from 30 years to 65 years, with an average of 45 years of age. Just like in FGDs, an equal number of men and women smallholder farmers were participated in in-depth interviews.

The participants in the in-depth interviews were purposively selected from the focus group discussants based on their knowledge of the issues of investigation. Each IDI took approximately 30 to 40 minutes and carried out by the researcher together with one trained facilitator between January and February 2016. Most in-depth interviews were held in neutral venues which provided reasonable privacy for the participants.

The central questions of the in-depth interviews focus on women's rural travel needs and choices, intra-household decision-making on the use and control over household resources including rural transport facilities and the availability of IMT. Women's disproportionate rural transport load and their agricultural productivity, respondent's personal attitude towards the division of productive and reproductive work among male and female family members as well as social and cultural norms hindering rural women's access to rural transport infrastructures were also among the main topics addressed during in-depth interviews.

To obtain detailed information from in-depth interview participants, an unstructured interview guide was used. This interview guide was pre-tested with two smallholder farmers (one male and one female) and amended based on this pilot test. All of the in-depth interviews were conducted in Afan Oromo, translated in to English and then transcribed. Of the total 32 IDIs 23 of them were tape recorded, for the nine unrecorded interviews, the researcher took notes and wrote up the detailed accounts after each interview session is completed.

Key Informant Interview (KII)

Key informant interviews provide more vertical depth to the information already gathered through participant observations and focus group discussions. It also helps to obtain expert opinions and perceptions on appropriateness, effectiveness, and sustainability of programs and strategies directly related to the topic under study. Key informant interviews were mainly aimed at gaining appropriate contextual information and to clarify some issues that appeared vague or uncertain from the information gained through the focus group discussions (Bernard, 2006).

Key informant interviews were used to collect information from people with specific knowledge and experience of rural transport infrastructure and agricultural production. The aim was to obtain information that would not easily be obtained from focus group discussions and IDIs. Hence, for this specific study three key informant interviews were conducted in each district making up a total of 12 KIIs (Table 6.1). The interviewees were a District Agriculture Officer, a District road transport Officer and a District Gender Officer.

Since there is only one woman gender officer at district level, one one-on-one semi-structured interview with district level women gender officer who work on gender equality and empowerment were conducted in all study districts. KIIs were conducted towards the end of the field work (during April 2016) after FGDs and IDI were completed. For the purpose of these interviews, interview guide was made available aiming at answering the already set research objectives.

Key informant interviews were conducted with local government officials who were professional expertise and knowledgeable in matters related to gender differences in access to rural transport infrastructure and agricultural production. Key informants were purposively selected from different sector offices (agriculture and rural development, rural transport and gender office) on the basis of relevance, functions and involvement in transport, agriculture and gender issues. Key informants were interviewed at their places of work.

6.6.5 Method of Data Analysis

Qualitative inductive thematic data analysis was used to manage and analyze data collected from FGDs, IDI and KIIs. After collecting the primary qualitative data from the study participants, all information is coded according to specific individual code number. Focus group discussions, in-depth and key informant interviews were tape-recorded, transcribed verbatim and analyzed using inductive thematic analysis method. A Field note was organized into easy to retrieve sections to help the researcher to familiarize himself with the data. The researcher read through the interview responses to look for and uncover themes, trends and patterns, which were used to code the findings. Coding then began for each category of research participants of women and men smallholder farmers, from which themes emerging from the data were generated for analysis. Field notes and Interview transcripts were analyzed using an inductive thematic approach geared towards identifying patterns in the data by means of thematic codes (Bowen, 2005). Thus, the themes of analysis were emerged from data coding after the data was collected, rather than before the fieldwork. Data coding and analysis was done manually using Microsoft Excel for recording. The themes that emerged from the codes form the basis of findings.

6.7 Ethical Issues

Maximum care was taken to ensure the privacy, respect, and dignity of all research participants at all levels. Personal Identities of participants in the FGDs and in-depth interviews remain anonymous. FGD moderators received one-day training in research ethics, including confidentiality. Confidentiality was also emphasized at the beginning of each FGD, in-depth interview and key informant interview and a statement agreeing to maintain confidentiality was included as part of the participant consent forms.

6.8 Results and Discussion

6.8.1 Gender Differences in Access to Rural Transport Infrastructure

In rural areas access needs and patterns of travel and transport vary from men to women depending on types of local culture and tradition. Differences between female and male key informant interviewees were noted on their opinions regarding gender differences in access to rural transport infrastructure. Overall, all but one of the female key informant interviewees thought that gender equality in access to rural transport infrastructure is an important development goal as well as something that should be integrated into government policy and program at all levels. The male key informant interviewees, however, had a wider variety of opinions regarding the importance of gender equality in access to rural transport infrastructure, from very supportive to very negative.

In general, two main points of references arise when gender differences in access to rural transport infrastructure are discussed with key informant interviewees. The first and most common view is that gender differences are important in the context of the rural transport sector. This perspective is held by a majority of the women and four of the men. It is based on the reasoning that there are differences between women and men smallholder farmers and their travel needs or modal choices, such differences demand careful rural transport policy and program at all levels. Such experts and practitioners believe that it is more important that all users be ensured equal accessibility regardless of sex and that this aspect is already covered in ensuring that the transport system be accessible to all. The other four of men key informant interviewees doubt the relevance of gender equality in access to rural transport infrastructure.

There is a marked gender gap in access to and control over productive resources. This finding is in line with the study conducted in Uganda by World Bank (2014) that states women comprise a significant share of the work force in agriculture but have unequal access to and control over productive resources including access to rural transport resources. The same study revealed that, due to gender differential access to rural transport infrastructure, women's productivity in agriculture still lags significantly behind men's.

The second perspective held by women and men key informant interviewees is that gender differences in access to rural transport infrastructure is less important in the context of the rural transport infrastructure and agricultural sector. This view is held by half of the men and one of the women. It is based on the premise that even though there are differences in access to rural transport infrastructure between women and men and their travel patterns and demands, such variations lack relevance and therefore have no effect on agricultural productivity of smallholder farmers. These groups of KII participants believe that rural transport policy and planning are gender neutral.

6.8.2 Gender and Rural Transport Mode Choice

Traditional or local means of transport, including pack animals (donkeys, horse, mule) and animal drawn carts, may have an important role to play in filling the transport gap where conventional motorized transport services are poor. However, women focus group participants in Amuru showed that the ownership and use of traditional or local means of transport is widely male-dominated as a result of economic and/or socio-cultural factors. In other districts of the study site women focus group discussants mentioned several constraints that women face in accessing and using local transport means including women's more limited income to purchase local transport means, their restricted access to such means without the permission of their male counter parts, women's perceived lack of physical strength to handle draught animals or push animal drawn carts, cultural prohibitions on women in riding draught animals like horse and mule (Porter, 2007).

According to personal observations across all study districts, Walking and back loading, shoulder loading and head loading are the major means of travel and transport. Animal drawn carts are available only in very few rural kebeles due to the absence of accessible roads. The available animal drawn carts are mostly used for non-domestic travel and transport activities as opposed to domestic and social activities carried out by women. In its appraisal report about Wacha-Maji road upgrading project, African Development Fund (2002), clearly showed the heavy work load and consequent time constraints of rural women in Ethiopia.

6.8.3 Gender Similarities and Differences in Relation to Travel Pattern and Behavior

One of the core gender issues of access to transport services that emerged in the mixed sex focus group session in Ababo Guduru district was gender differential impacts of rural transport infrastructure. These focus group discussants seem to agree that the multiple reproductive roles of women tended to dictate their mobility in terms of how far and how long they can travel from the residence.

Mulu Soressa aged 40, in a woman focus group discussion participation held in Haro Aga rural kebele of Horro district, described the rural transport burden of women:

> *Women in rural areas make trips for different purposes, some of which include going to local market, fetching water, collecting firewood and food processing (grinding mills). These household responsibilities are not usually done by our husbands due to traditional gender-based division of labor.*

As it is possible to understand from the views of women and men KII participants, while men consistently travel further than women and are more likely to travel by traditional or motorized transport means, the mobility patterns of women in rural areas tend to relate to their domestic, economic and social tasks. Women make trips to take care of their children, fetching water, firewood and food processing, handle household responsibilities and to maintain community and social networks. These major differences in the mobility needs of rural men and women are grounded in the traditional gender-based division of labor. Yet, gender-related norms, practices and perceptions continue to ensure that men's and women's opportunities remain unequal. For rural women the most prominent mode of travel remains walking and head-loading or back-loading. Because rural women are vulnerable members of the society due to their multiple productive, reproductive and community roles, considering how rural transport policies and projects address their needs is important for socially and economically sustainable rural transport policy.

Many researches on gender travel characteristics revealed that a dichotomy exists between men and women mobility patterns in both developed and developing countries particularly with respect to modal choice, distance travel and frequency of trips to different locations (Peter, 2000; Oyesiku, 2002; Adetunji , 2013)

Improved rural access roads required women to exercise more caution in looking after children, fearing that without their constant supervision children would run onto the road. Similarly, one of women in-depth interview participant in the same district commented on significant differences in access, mobility and accessibility between men and women in utilizing both local level transport and motorized transport methods. Studies elsewhere have identified some major gender differences in access to transport where women experience constraints on their mobility due to their reproductive work, cultural restrictions, and different travel needs from their men counterparts (Porter, 1995, 2002; Mandel, 2004).

Therefore, this study explored the gender differences in access to rural transportation and mobility, responsiveness of rural transport systems to needs and choices of women and their participation in decision making over the use and control of household transport facilities. The results of this qualitative research study show significant disparity in trip rate, duration and purpose of travel, travel behavior, travel mode between women and men in all districts of the study area. Therefore, increasing women's access to rural transport assets and narrowing the gender gap would directly improve women's agricultural productivity by reducing their vulnerability and enhancing their self-esteem, bargaining power and sense of control. This is not only important for women's benefit alone but for the well-being of the household in general.

6.8.4 Women's Domestic Responsibilities and Rural Transport

This qualitative research study investigated in detail travel patterns in four districts of Horro Guduru Wollega Zone for access to domestic facilities, with a special focus on the transport of water, firewood and of crops to grinding mills. According to FGD results almost all households travel to a grinding mill once in a week. The time and energy involved is directly proportional to the distance to the mill. Establishment of crop grinding mills at village level or closer to the home reduces the transport burden of women related to this activity at the same time would release time and energy for productive and socially beneficial activities. Many women focus group participants emphasized the need to form rural female cooperatives that provide grain milling services for their communities and thus reduced women's heavy burden.

Women focus group participants at Haro Gudina rural kebele of Amuru district described the main reasons for why they need rural female cooperatives as follows:

> *Since women in rural areas have multiple productive, reproductive and Community roles, the availability of rural female cooperatives may provide different services like grain milling services and rural credit services that might solve rural cash*

constraints for women that further help them to afford transport costs to move from their home to different centers (market, grinding mill, health centers).

With the exception of 3 women participants in IDI, all others make trips to the grinding mill on foot through either head-loading or back-loading and almost all households are more than one and half hour away from the grinding mill. For those who used local transport means like donkey to carry grain crops to the grinding mill and back home, even though the load was carried on a donkey-the owner still walked. It was the woman who went to grind the grain in almost all cases. In occasions when a woman gives birth for a child or get sick, a man will be forced to go to the grinding mill. But, he tends to use a locally available means of transport or other intermediate means of transport.

A closer look at the view forwarded by both men and women focus group discussion participants reveals that gathering firewood for cooking represents a significant portion of rural women's time and energy. Shackleton et al. (2011) and Sunderland (2012) also confirmed that firewood collection is a solely female responsibility. Time spent collecting firewood for fuel as well as the cooking and related cleaning activities are a drain on the time of the women primarily responsible for these tasks. Especially as local firewood supplies continue to diminish due to deforestation, rural women have to cover substantial distances on foot to collect firewood from distant sites. In another study by Green stream (2010), it was reported that women have to cover considerable distances on foot to collect firewood for household use and for sale, as it is one of the few avenues open to them to meet their requirements for a basic income. Lack of rural transport facilities are additional barriers to women in accessing firewood in the form of limited supply. In terms of addressing households' need for firewood, planting fast-growing trees close to the village was given greater attention by key informant participants across all study districts. Various fuel saving technologies (fuel-efficient or improved stoves) therefore important in order to reduce the amount of firewood women have to use for cooking and freed-up time for income-generating activities.

6.8.5 Trip Chaining Characteristics of Men and Women Smallholder Farmers

"I have three reasons for going to market. One, I must buy for household consumption, two, I have to go to grinding mills, three, I have to ask relatives and four, sometimes taking sick family member to health center." [41 years aged women IDI participant, Horro district]. This comment was made as a response to a travel pattern during in-depth interview. Many other women farmers in other districts of the study area made similar comments.

For example, Abalti and Gizeshe were key informants at Abe Dongoro and Amuru Districts respectively. These women informants summarized the trip chaining characteristics of women in rural areas as follows:

> *The mean number of trip chains commuted by rural women per day is greater than that of their men counterparts. Women are most likely to form complex trip chains (combine several purposes into one trip) and their multiple responsibilities require them to combine work trips for different purposes. Most of this trip chains were for reproductive activities and were made through walking as opposed to car based trip chains. Therefore, women's reproductive roles can often undermine their productive roles, as they are obliged to support men's primary income generating activities.*

Their words draw attention to the fact that women are most likely to form complex trip chains (combine several purposes into one trip) and their multiple responsibilities require them to combine work trips for different purposes. This finding is in line with the findings of (Rosenbloom, 1988; Rosenbloom, 1989; Strathman & Dueker, 1994; McGuckin, & Murakami, 1999; Al-Kazily et al., 1994), which argued that compared to men, women are more likely to trip chain on the way to and from work. Therefore, rural transportation issues for women differ from those for men in that women frequently face circumstances that many men do not. In particular, among women FGD participants (Horro, Amuru, and Abedongoro) the determining factors for transport modal choices are: the necessity of making multiple activities (trip-chaining)- marketing, grinding mills, taking child to clinic for medical follow up. Therefore, this analysis reveals that trip-chaining behavior is related to gender roles and responsibilities.

6.9 Conclusion and Recommendation

Gender is an important but largely neglected aspect of rural transport infrastructure planning and provision. Men and women hold different socio-economic roles and responsibilities that are associated with different patterns of transport access, needs, and use. For many women in rural areas, walking remains the predominant mode of travel, because other transport modes are often not available, are culturally not encouraged, are too expensive, or are located too far away from home for women to access. In Ethiopia, despite women's essential contribution to household food production and provision, their access to rural transport infrastructure is limited. The existing rural transport systems of Ethiopia are not adequately geared towards the needs of women. This research aims to find ways forward in order to alleviate rural women's disproportionate transport burden in rural districts of western Ethiopia.

The problem of gender differential access to rural transport infrastructure is apparent in Horro Guduru Wollega Zone, where women's control and decision making power over household incomes are low and transport services are few. Conventional rural transport planning has overlooked village level transport solutions for short-distance transport, especially the needs of women smallholder farmers. Based on inductive thematic analysis approach in rural districts of western Ethiopia, this study explores gender differences in access to rural transport infrastructure and its implication for agricultural production.

To improve rural women's mobility and hence their agricultural productivity, greater consideration needs to be given to investment in local footpaths, footbridges, village level roads, intermediate means of transport, and other time- and load-reducing measures. Rural transport infrastructure planning efforts should consider the needs of women smallholder farmers. Intermediate means of transport plays a great role in facilitating local level transport activities. Because women were responsible for most transport around the village, they benefited from the spread of animal drawn carts, hand carts, wheelbarrows which could be used to carry people, water, firewood and crops. Therefore, to improve rural women's access to rural transport infrastructures and hence their agricultural productivity, greater consideration needs to be given to investment in intermediate means of transport, and other time-saving and load-reducing measures such energy saving cooking equipments and rural child care centers.

References

Adetunji, M. (2013). Gender Travel Behaviour and Women Mobility Constraints in Ilesa, Nigeria. doi: http://dx.doi.org/10.7708/ijtte.2013.3(2).09

African Development Fund (2001). Federal Democratic Republic of Ethiopia: Butajira-Hossaina-Sodo Road Upgrading Project. Appraisal Report. *Federal Democratic Republic of Ethiopia*. Addis Ababa, Ethiopia

African Development Fund (2002). Wacha-Maji Road Upgrading Project. Appraisal Report. Addis Ababa, Ethiopia

Ahmed, M. E. (2013). Poverty and Livelihood Strategies of Female-headed Households in Rural Ethiopia: the Case of Libo Kemkem Woreda, South Gondar. Ph.D Dissertation. Bahir Dar University

Al-Kazily, Joan, Carol Barnes and Norman Coontz (1994). "Household Structure and Travel Behavior." NPTS Demographic Special Reports. Washington, D.C.: Federal Highway Administration.

Bamberger, M., & Davis, A. S. (2001).Women and Rural Transport in Development. Rural Transport Knowledge Base and Rural Travel and Transport Program. Retrieved from http://www.worldbank.org/gender/transport

Bernard, H. R. (2006). Research Methods in Anthropology: qualitative and quantitative approaches (4th ed.). Lanham, MD : AltaMira Press

Booth, D., Hanmer, L., & Lovell, E. (2000). Poverty and Transport. A report prepared for the World Bank in collaboration with DFID. *Overseas Development Institute*. Portland House, London. Retrieved from https://www.odi.org/sites/odi.org.uk/files/odi-assets/publications-opinion-files/3554.pdf

Bowen, G.A. (2005). Local-Level Stakeholder Collaboration: A Substantive Theory of Community-Driven Development. *Journal of the Community Development Society, 36*(2): 73–88.

Boyce, C. & Neale, P. (2006). Conducting In-depth interviews: A Guide for Designing and Conducting In-depth Interviews for Evaluation Input. Retrieved from http://www.pathfind.org/site/DocServer/m_e_tool_series_indepth_interviews.pdf?docID=6301

Bryceson, D., & Howe, J. (1993). Rural Household Transport in Africa: Reducing the Burden on Women? *World Development*, 21(11), 1715-1728. Retrieved from DOI: 10.1016/0305-750X(93)90079-O

Buiten, D. (2007). Gender, Transport and the Feminist Agenda: Feminist Insights towards Engendering Transport Research. Transport and Communications Bulletin for Asia and the Pacific No. 76 p. 21-33.

Chen, M. (2008). Women and Employment in Africa: a Framework for Action. Background Document Commissioned by the Danish Foreign Ministry for the Second Conference of the Africa Commission in November 2008. Harvard University WIEGO Network.

Creighton, C., & Yieke, F. (2006). Gender Inequalities in Kenya. Paper presented at the Conference on Understanding Gender Inequalities in Kenya, held at Egerton University, Kenya, from 5th to 8th April 2004.

Creswell, J.W. (2012). Educational Research: Planning, Conducting, and Evaluating Quantitative and Qualitative Research (4th ed.). SAGE publications: London.

CSA (2011). Federal Democratic Republic of Ethiopia Central statistical Agency Statistical Abstract. Addis Ababa, Ethiopia.

Dagnachew A. B. (2011). Road and Urban Storm Water Drainage Network Integration in Addis Ababa: Addis Ketema Sub-city. *Journal of Engineering and Technology Research 3*(7), 217-225.

Dea, M. (2016). The Prospects, Challenges and Causes of Gender Disparity and its Implication for Ethiopia's Development: Qualitative Inquiry. *Journal of Education and Practice*, *7* (4): 24-37.

Denzin, N., & Lincoln, Y. (Eds.). (2005). Handbook of Qualitative Research (3rd ed.). Thousand Oaks, CA: Sage

Dercon, S., Gilligan, D.O., Hoddinott, J., & Woldehanna, T. (2009). The Impact of Agricultural Extension and Roads on Poverty and Consumption Growth in Fifteen EthiopianVillages.
American Journal of Agricultural Economics 91 (4): 1007-1021. Retrieved from DOI:https://doi.org/10.1111/j.1467-8276.2009.01325.x

Eneyew, A., & Mengistu, S. (2013). Double Marginalized Livelihoods: Invisible Gender Inequality in Pastoral Societies. *Societies 2013* (3): 104–116. Retrieved from doi:10.3390/soc3010104.

Eshete, M. (2015). Public Transportation System: The Case of Addis Ababa. MA thesis, Addis Ababa University

FAO (2010). Gender Dimensions of Agricultural and Rural Employment: Differentiated Pathways Out of Poverty Status, Trends and Gaps. Rome. Retrieved from www.fao.org/docrep/013/i1638e/i1638e.pdf

FAO (2011). The State of Food and Agriculture, 2010-2011: Women in Agriculture, Closing the Gender Gap for Development. FAO, Rome.

FAO (2011). The State of Food and Agriculture, 2010-2011: Women in Agriculture, Closing the Gender Gap for Development. Food and Agriculture Organization (FAO), Rome. Retrieved from http://www.fao.org/docrep/013/i2050e/i2050e00.htm

FAO (2016). Gender Mainstreaming into Agricultural Markets and Rural Economies, Gendered Labor Access and Opportunities in the Rural Landscape and in Agricultural Markets. FAO Study, Paper No.3, October 12, 2016.

Fernando, P. & Porter, G. (2002). Bridging the gap between gender and transport. In Priyanthi Fernando and Gina Porter, (eds.), *Balancing the Load: Women, Gender and Transport* (London, ZED Books), pp.1-14.

Gebre-Selassie, A., & Bekele, T. (2010). A Review of Ethiopian Agriculture: Roles, Policy and Small-scale Farming Systems. Koperazzjoni Internazzjonali (KOPIN) and Emmanuel Development Association (EDA) Addis Ababa, Ethiopia. Retrieved from www.icu.it/agriculture

Grassi, F., Landberg, J., & Huyer, S. (2015). Running Out of Time: The Reduction of Women's Work Burden in Agricultural Production. Food and Agriculture Organization of the United Nations, Rome.

Green stream (2010). Gender and the Clean Development Mechanism (CDM): Opportunities for CDM to Promote Local Positive Gender Impacts. Available at http://formin.finland.fi/public/default.aspx?contentid=220759&nodeid=40817&contentlan=2&culture=en-US

Gutierrez, M. T., & Kuiper, M. (2010). Women in Infrastructure: Boosting Gender Equality and Rural Development. Gender and Rural Employment Policy Brief No. 5. International Labor Organization (ILO) and International Fund for Agricultural Development (IFAD)

Holste, S. (2009). Gender and the Rural Access Program in Afghanistan. World Bank. Transport Week. Working Session for Transport Task Teams on Gender Mainstreaming. Washington D.C.

Kvale, S. (1996). Interviews. An Introduction to Qualitative Research Interviewing. London

Mandel, J.L. (2004). Mobility Matters: Women's livelihood strategies in Poeto Novo, Benin. *Gender, Place and Culture, 11*(2): 258-284.

Lebo, J. (1999). The importance of gender in socially sustainable transport programs: a donor perspective, proceedings from the 1999 World Bank Gender & Transport Conference, Washington DC, 22 April 1999.

Lewis, D. (Undated). Feminist theory and women's movements in Africa, published online through the African Gender Institute, Cape Town, accessed on 20 December 2015 from www.gwsafrica.org.

Mahapa, S. (2003). Spatial and social exclusion: travel and transport needs of rural women in Limpopo, South Africa, PhD dissertation, University of Pretoria, accessed on 10 April 2015 from http://upetd.up.ac.za/thesis/available/etd-06042004-104050/unrestricted/01thesis.pdf.

Mannathoko, C (1992). Feminist theories and the study of gender issues in Southern Africa. In R. Meena, (ed.), Gender in Southern Africa: Conceptual and Theoretical Issues (Harare, SAPES Books), pp. 71-91.

McGuckin N, & Murakami, E. (1999). Examining Trip-Chaining Behavior: a Comparison of travel by men and women. Transp Res Rec 1693, 79-85.

Muleta, A. N., & Deressa, D. F. (2014). Determinants of Vulnerability to Poverty in Female Headed Households in Rural Ethiopia. *Global Journal of Human-Social Science (E), 14* (5) Version 1: 9-15. Retrieved from https://globaljournals.org/GJHSS_Volume14/2-Determinants-of-Vulnerability.pdf

Nyarirangwe, M. (2008). Harnessing the Utility of Urban Infrastructure Asset Management in Ethiopian Cities: Challenges and opportunities. Proceedings of the 27th Southern African Transport Conference, 7-11 July 2008, Pretoria, South Africa.

OECD (2011). Women's Economic Empowerment. Policy messages from the DAC Network on Gender Equality (GENDERNET), Issues paper, April, 2011. OECD, Paris. Retrieved from http://www.oecd.org/dac/gender

Ogato, G. S., Boon, E. K., & Subramani, J. (2009). Improving Access to Productive Resources and Agricultural Services through Gender Empowerment: A Case Study of Three Rural Communities in Ambo District, Ethiopia. *J Hum Ecol*, *27*(2): 85-100.

Oyesiku, O. (2002). From Womb to Tomb. 24th Inaugural Lecture, Olabisi Onabanjo University.

Peter, D. (2000). Gender and Transport in Developing Countries: A Background Paper in Preparation for CSD-9. London/Berlin: UNED forum/German Federal Environment Ministry.Available from Internet: http://www.earthsummit2002.org/workshop/bpaper.htm

Porter, G. (1995). The Impact of Road Construction on Women's Trade in Rural Nigeria. *Journal of Transport Geography 3* (1): 3-14.

Porter, G. (2002). Living in a Walking World: Rural Mobility and Social Equity Issues in Sub-Saharan Africa. *World Development*, *30* (2): 285-300.

Porter, G. (2007). Transport, (im)mobility and spatial poverty traps: issues for rural women and girl children in sub-Saharan Africa

Porter, G. (2008). Transport Planning in Sub-Saharan Africa II: Putting Gender into Mobility and Transport Planning in Africa. *Progress in Development Studies*, 8 (3), 281-289. Retrieved from http://dx.doi.org/10.1177/146499340800800306

Porter, G. (2012) Transport Services and their Impact on Poverty and Growth in Rural Sub-Saharan Africa: Literature Review. Technical Report to the Africa Community Access Programme, Department for International Development, London. Retrieved from http://r4d.dfid.gov.uk/Output/192608/

Quisumbing, A. & Pandolfelli, L. (2009). Promising Approaches to Address the Needs of Poor Female Farmers- Resources, Constraints and Interventions, IFPRI (International Food Policy research Institute) discussion paper 00882, IFPRI, Washington D.C.

Robinson, N. (1999). The Use of Focus Group Methodology—with selected examples from sexual health research. *Journal of Advanced Nursing*, *29*(4), 905–913. Retrieved from http://onlinelibrary.wiley.com/doi/10.1046/j.1365-2648.1999.00966.x/pdf

Rosenbloom, S. (1988). The Impact of Growing Children on their Parents' Travel Behavior: A Comparative Analysis. Transportation Research Record 1135 .Transportation Research Board, National Research Council, Washington, D.C., pp. 17-25.

Rosenbloom, S. (1989). Trip-Chain Behaviour: A Comparative and Cross-Cultural Analysis of the Travel Patterns of Working Mothers. In Gender, Transport and Employment, edited by Margaret Grieco, Laurie Pickup, and Richard Whipp. Vermont: Gower Publishing Company.

Schmidt, E., & Mekamu K. (2009). Urbanization and Spatial Connectivity in Ethiopia: Urban Growth Analysis Using GIS. Development Strategy and Governance Division, International Food Policy Research Institute–Ethiopia Strategy Support Program 2, Ethiopia. Retrieved from http://www.ifpri.org

Seguino, S. (2012). From micro-level gender relations to the macro economy and back again: Theory and policy. In Deborah Figart and Tonia Warnecke (eds), Handbook of Research on Gender and Economic Life, Edward Elgar.

Shackleton, S., Paumgarten, F., Kassa, H., Husselman, M., & Zida, M. (2011). Opportunities for Enhancing Poor Women's Economic Empowerment in the Value Chains of Three African Non-timber Forest Products. *International Forestry Review*, *13*(2), 136–151.

Strathman, J. G., & Dueker, K. J. (1994). Understanding Trip Chaining: 1990 NPTS Subject Area Report. Center for Urban Studies. Portland State University

Sunderland, T. (2012). Challenging Perceptions about Men, Women, and Forest Product Use: A Global Comparative Study. http://dx.doi.org/10.1016/j.worlddev.2014.03.003

Tamene, S. & Megento, T. L. (2017). The Effect of Rural Road Transport Infrastructure on Smallholder Farmers'Agricultural Productivity in Horro Guduru Wollega Zone, Western Ethiopia. *AUC Geographica*, *52*(1), 79-89. Advance online publication. https://doi.org/10.14712/23361980.2017.7

United Kingdom Department for International Development (2010). Agenda 2010 - The Turning Point on Poverty: Background Paper on Gender.

World Bank (2008). Safe, Clean, and Affordable Transport for Development. The World Bank Group's Transport Business Strategy 2008-2012. The World Bank, Washington, D.C. Retrieved from http://www.worldbank.org/transport/

World Bank (2010). Mainstreaming Gender in Road Transport: Operational Guidance for World Bank Staff. THE World Bank Group. Transport papers, TP-28. Washington, D.C. Retrieved from http://www.worldbank.org/transport/

World Bank (2014). Gender, Economic Productivity and Development in Uganda: Recent Evidence and Policy Conclusions

Zogo, V. O., & Epo, B.N. (2016). Assessing Gender Inclusion in Cameroon's Rural Transport. *Journal of African Transformation*, *1* (2) 129-144.

CHAPTER 7: THEORETICAL AND METHODOLOGICAL REFLECTIONS, SYNTHESIS AND SUMMARY

7.1 Theoretical and Methodological Reflections

This section discusses the theoretical and methodological contributions that the researcher anticipate making to existing knowledge in the field of transport and agricultural geography. Thus, the theories used, models employed, philosophical positions taken give clue to the legitimate contribution that this dissertation made to the disciplinary conversation. I will try to explain how this research makes an original contribution to the body of knowledge in transport and agricultural geography sub-disciplines, justifying its importance and appropriateness in terms of its link to previous research.

The main contribution of this paper with regard to filling the knowledge gap, the researcher attempted to bring to light the constraints and opportunities of rural access in Ethiopia with special emphasis to smallholder farmers in Horro Guduru Wollega Zone. In this regard, the research seems to attain its goal of contributing towards bridging the gap in understanding the constraints and opportunities of rural access to transport infrastructure and transport services and its implication on smallholder farmers' agricultural productivity. These are thought to have some contribution to issues of other isolated or remote rural communities and the ongoing rural transport development program, policies and strategies in Ethiopia, though, the observations and insights seem to be specific to the study area.

The other important contributions of this research is that it brought the different sets of theories, models and concepts that help to develop deeper insights of the empirical observations in the areas of rural transport, input and output market participation, post-harvest loss, farmers' farm productivity and gender differential access to local transport assets. The theory of induced technical and institutional change (Hayami & Ruttan, 1993), transaction cost theory (Coase, 1937 in Madhok, 2002), theory of constraints (Goldratt, 1990), and feminist theory (Wollstonecraft, 1972 in Nehere, 2016) are the leading theories which contributed significantly to the development of this dissertation and have all been employed to help conceive the study from the wider set of theoretical viewpoints. Both divergence and convergence were seen between empirical findings or empirical evidences of this study and prior theories used to understand, predict and explain the topic under investigation. This means the research adds to existing understanding either by supporting or refuting in cases where divergent thoughts have emerged.

The theoretical orientation of the theory of induced technical and institutional change is based on changes in the relative resource endowments, which argues that technological innovations are needed to facilitate the replacement of relatively less scarce and cheap factors for more scarce and expensive ones (Hayami & Ruttan, 1985; 1993; Ruttan, 2008). The empirical findings of this research have supported this line of thinking. This is because, smallholder farmer's purchased input use (relatively less scarce and cheap factors of production) was found to decrease as landholding size (more scarce and expensive factors of production) increases.

Transaction cost theory was based on the central argument that costs are always incurred because of the friction involved in the market exchange process (Buitelaar, 2004; Martins et al., 2010). Accordingly, in line with Coase's transaction cost theory, the empirical findings of this research have shown that agricultural output market access is not uniform because of high transactions costs that smallholder farmers face in their marketing decision process. For example, distance from market center, transport cost and the cost of total time spent in marketing crop output were found to be significant determinants of smallholder farmers' output market participation. Therefore, this finding confirms the assertion from transaction cost theory that selling behavior of smallholder farmers is determined by the amount of time that it takes to move the produce to market. This is also further explained by the concept of friction involved in the market exchange, the central issue for transaction cost theory analysis (Whitford, 2016; Williamson, 1985). This highlights the need to develop a better understanding of rural transport infrastructure that encourages sustained smallholder farmers' agricultural commercialization.

The theory of constraints is a production management theory that has been formulated by an Israeli physicist Dr. Eliyahu Moshe Goldratt at the beginning of 1980s to explain the constraint (the bottleneck) along the production chain (Goldratt & Cox, 1992; Goldratt, 1990). The analyses in the empirical findings of this dissertation (chapter 4) reveals that in their crop production process (production chains i.e. from harvesting to marketing) smallholder farmers face different constraints that hinder them from reaching the maximum production potential. Thus, the theory of constraints (TOC) can be applied to explain the cause-and-effect thinking processes between the determinants of crop post-harvest loss at different chains of the post-harvest system and farmers' productivity. Therefore, from what do empirical findings in this study tell in the light of the existing theory shows that this study is relevant, significant and has some new contribution to make in the effort to minimize the perceived gap between formal theory and actual practice.

In order to conceptualize the socio-cultural, economic, and political determinants of gender differences in access to rural transport infrastructure and the resulting gender based agricultural performance, this dissertation draws on Wollstonecraft's Feminist theory (Wollstonecraft, 1972 in Nehere, 2016). Wollstonecraft, mother of First wave feminism argued that "women would be equal to men in every respect if they are provided same education and opportunities as men" (Nehere, 2016:6). This theory holds the central argument that gendered barriers to access to and use of economic resources at household level require gender based interventions (Hunt & Samman, 2016; United Nations, 2009). Feminist theory is concerned with equity, oppression, and justice, which are central themes in access to rural transport infrastructure and agricultural production in the empirical findings of this research (chapter 6). As observed from field observations, FGD and KII results of this study, gender power relations are relevant to explore the nature of gender inequality in the society.

As a result we can argue that our empirical finding is in accordance with the feminist philosophical discourse that women are not taken into account in rural development planning and hence they are marginalized from the use of and control over important resources as opposed to their men counterpart (Buiten, 2007; Hunt & Samman, 2016). Therefore, this confirmed the applicability of important concepts in Feminist theory like gendered power relations, gender inequities, Women empowerment, and marginalization for this study, further showing how theory is integrated into practice or evidence. Generally the empirical evidence generated in this study adds insights to the understanding on women's unequal access to economic resources. This suggests that to transform the lives of rural women smallholder farmers, the conventional power relations woven around gender have to be deconstructed.

Sometimes extending or expanding a theory familiar to certain discipline area to a new field of study or domain can be considered as a genuine contribution (Crane, Husted, & Henriques, 2016; Cornelissen & Durand, 2014; Corley & Gioia, 2011). In this dissertation an attempt has been made to expand the domain of transaction cost theory and constraint theory to the discipline of transport geography and rural agriculture. For instance a constraint theory is dominant in firms or industries. Similarly, transaction cost theory is dominant in economics with relation to costs incurred in making an economic exchange. In this dissertation the applicability of these two theories were tested in a new discipline (transport and agricultural geography) and found to be good in explaining the nexus between rural transport infrastructure and rural agriculture. Therefore, the researcher argues that to a certain extent this dissertation has made a legitimate contribution to expand the domain of a theory.

Concerning data collection and analysis methods, various rigorous techniques have been used. This technique can be adapted to research issues related to rural farmers' access to input and output markets and socio-economic and physical constraints to smallholder production in Ethiopia. Among the employed data gathering methods, frequent field observations were made to sample rural kebeles that helped the researcher to obtain and expand on a first-hand overview of rural road conditions, rural transport links to district towns as well as the researcher got chances to observe when farmers transport agricultural inputs and outputs to and from their fields prior to actual data collection.

More quantitative attributes like rural transport infrastructure-related variables (distance to all weather road, distance to nearest market, distance to farm plot, transport cost), household-level asset variables (off-farm income, landholding, livestock holding, cooperative membership), and demographic variables (family size, age, sex) were obtained through questionnaire survey. Qualitative data acquisition techniques, key informant interview (KII), In-depth Interviews (IDIs), observation, and focus group discussion (FGD), allowed the researcher to have deeper understanding of the perception of smallholder farmers towards the role of rural transport infrastructure in output market participation, gender differences in access to rural transport infrastructure, gendered rural transport mode choice, gender similarities and differences in relation to rural travel pattern and behavior, women's domestic responsibilities and rural transport, and trip chaining characteristics of men and women smallholder farmers were obtained through guides and checklists of the respective qualitative data gathering technique.

With regard to data analysis, various inferential and econometric techniques and models were used in this dissertation so as to deeply understand the nexus between rural transport infrastructure and smallholder agricultural production from different directions. For example, crop output market participation index (COPMPI), post-harvest loss index (PHLI), hierarchical regression model, double-hurdle model (probit and truncated regression) and tobit models were among the major indices, techniques and models used in this dissertation. These techniques can also be valuable for similar studies in different discipline areas in Ethiopia. Thus, this dissertation adds to the existing conceptual views of the investigated subject matter in bringing to light the existing academic discourses in view of the aforesaid models.

Similarly, an attempt has also been made to conduct interdisciplinary research that connects the two sub-discipline areas (transport geography and agricultural geography) where certain aspects of each sub-discipline are blended together to provide a more robust explanation on how the two sub-discipline areas interact. The three research publications on reputable journals in this dissertation can also be considered as a good contribution to the body of knowledge and may be used to demonstrate the author's capacity for independent scholarship. Last but not least, the fact that the data for hierarchical, tobit and truncated regression analysis have been tested for normality, multicollinearity, linearity, homoscedasticity and independence of errors prior to running the final regression analysis could be a great methodological contribution to similar studies. Certainly, with the exception of resource economics, development economics and agricultural economics fields, it is rare to find the application of these preliminary statistical diagnostics tests in social science fields.

7.2 Synthesis

7.2.1 Introduction

It is generally recognized that rural transport networks in Ethiopia are underdeveloped and of poor quality. It is estimated that only 17% of Ethiopia's rural population lives within two kilometers of an all-weather road, and in the World Bank's Infrastructure Index, Ethiopia is ranked 52 out of 53 countries of Africa (African Development Bank, 2011). However, despite such persisting problem of poor condition of rural transport networks and its adverse effect on smallholder farmers' agricultural productivity in the country, due attention is not given (Admassie, Berhanu, & Admasie, 2016; Rammelt, 2018). Rural transport infrastructure is one of the essential building blocks of rural development. The major impetus for this study, therefore, stemmed from the understanding that rural transport is one of the essential building blocks of rural agricultural transformation, and that the issue should receive policy attention.

It will be recalled that the major objective of this research was to explore state of existing rural transport in Horro Guduru Wollega Zone, with a particular focus on its availability, accessibility, affordability and quality as well as its effect on smallholder farmers' agricultural productivity and marketing. In this chapter, the results of the previous chapters are brought together in the form of synthesis in order to address the research questions of this dissertation. Similarly, the major institutional and policy implications of the findings for sustained rural transport vis-a-vis smallholder agriculture development will be dealt in this chapter.

7.2.2 The Role Played by Rural Transport in Access to Input and Output Markets

Long distances to major market and to all-weather road as well as the high cost of rural transport service due to poor rural road systems is one of the greatest constraints to get access to important input and output markets in the study area. Smallholder farmers have less incentive to intensify their production because chemical fertilizer and improved seeds are too expensive to transport to the farm (chapter 2), and because any surplus they might produce takes too much to transport it to the output market (chapter 3). The major problem facing smallholder farmers in Horro Guduru Wolleg Zone with respect to getting access to input and output markets is because the supply of transport infrastructure and services are in short supply and of poor quality.

It is revealed that uneven distribution of rural transport infrastructure and services as well as their quality were an important reason behind the disparities in total values of purchased input use (chapter 2) and intensity of crop output market participation (chapter 3) among smallholder farmers of the study area. The result showed that rural transport-related variables contributed 13.3% to the prediction of farmers' purchased input use over and above the remaining predictors. Similarly, proportional transaction costs (distance to the nearest market, transport cost) and time spent selling crop influenced the intensity of output market participation by smallholder farmers. As a result, low smallholder farmers' agricultural productivity results from several interrelated and mutually reinforcing factors: inefficient rural transport that further resulted in inefficient agricultural input and output markets, increased crop post-harvest loss, low prices for agricultural outputs, severe resource constraints, dysfunctional farmer associations, and weak extension services (chapter 2-5).

The resource, energy, and time savings brought by improvement of rural transport can yield agricultural productivity increments through making smallholder farmers access distant output markets and draw important agricultural inputs from a larger area with cheap cost, and hence stimulate local surplus production (Bogale, 2016; Melesse, 2017; Gebre-Egizabher, 2001; Salami et al., 2010; Bekele et al., 2010; Jayne et al., 2003).

7.2.3 Rural Transport and Storage Facility Induced Crop Post-harvest Losses

Crop post-harvest loss by smallholder farmers is one of the most complex problems in Horro Guduru Wollega Zone, with as much as 37% of cereal crop production lost at farm-level across different post-harvest chain (chapter 4). About 52% and 45% of the farmers surveyed reported that pest attack and inefficient traditional storage facilities are the major cereal crop post-harvest loss causing factors respectively. They further expressed that bad weather condition, wild animals, and poor marketing coordination are among crop post-harvest loss causing factors and home storage, harvesting, and transportation are the hotspot links for post-harvest losses of cereal crops in the chain.

It was argued by many researchers that most interventions focus on smallholder farmers' crop production that leads to improved productivity. However, this increased productivity is eroded by high crop post-harvest losses (Affognon et al., 2014; Amentae, 2016; Shah, 2014). Therefore, it was revealed that increasing smallholder farmers' agricultural productivity while losing much after harvest continues to undermine their profitability. Lack of adequate rural transport infrastructure and associated high transport costs, poor quality of roads, limited market access for agricultural outputs, poor communication facilities, poor agricultural extension services, and lack of improved storage facilities lead to slow continued problems of post-harvest losses resulting in low agricultural productivity (chapter 3-5).

The findings also revealed that men smallholder farmers incur less crop post-harvest losses than their women counterpart (chapter 4 and 6). The observed gender differential post-harvest loss results may be ascribed to the fact that men smallholder farmers generally have more access than women to rural transportation and services and post-harvest productive assets and finances which help reduce post-harvest losses (Kikulwe et al., 2018; The Rockefeller Foundation, 2015; Chen et al., 2018). Increased support to input and output market information via radio, television, mobile, and rural extension services so that smallholder farmers have better input and output price information. This, in turn help them access encouraging output prices at the farm gate as well as get productivity enhancing inputs at affordable and reasonable prices. Therefore, improvements of the intra-village foot path and earth road network, and the provision of all-weather road that connects villages (rural areas) to output urban markets, appropriate and affordable rural transport cost are therefore important conditions for smallholder farmers' reduced post-harvest loss and enhanced agricultural productivity.

7.2.4 Rural Transport and its Effects on Farmers' Crop Productivity

Some of the reasons for low agricultural productivity of smallholder farmers point to inadequate and inefficient rural transport infrastructure and services, particularly rural feeder roads that connect to all-weather road, long distances to input and output markets and associated high transport costs, lack of ownership to intermediate means of transport (IMT) and fragile and inappropriate foot paths that connect farm fields to homestead (chapter 5).

One of the more important findings to emerge from chapter 5 is that transport cost for farm input and output, distance to the nearest input and output market, quality of rural road access, ownership of IMT, distance travelled to the nearest all weather as well as distance to zonal headquarter and smallholder farmers' frequency of visits to the nearest town were found to be significant in predicting smallholder farmers' agricultural productivity in Horro Guduru Wollega Zone. In addition, geographical or district level vulnerability in transport infrastructure quality and availability was observed among the four selected districts of the study area.

It was argued that better rural transport infrastructure and services can reduce transport costs, time spent to marketing, and spoilage of agricultural outputs, and further allow for greater producer access to input and output markets, extension services and other productivity-enhancing opportunities (chapter 2-5). IMT as a means of transport in rural areas is often ignored in rural transport planning even though it plays a critical role in the mobility of rural communities. In their research findings Sabandar (2004) and Stifel et al. (2013) underlined that ownerships of intermediate means of transport are critical in relation to rural welfare in general and in boosting agricultural productivity in particular. Stifel et al. (2013) further reported a 50% reduction in transport costs when using IMT as opposed to motorized means of transport.

This clearly indicates that since the majority of smallholder farmers do not have the means to own a motorized transport, animal drawn carts and pack animals are critical to ease rural transport loads even though it is yet to receive the full attention it deserves. The findings therefore indicate that investment in rural roads, particularly ones that connect rural areas with input and output markets, investment in IMT and other resources, represents an important means to increased smallholder farmers' agricultural productivity.

7.2.5 Gender Differences in Access to Rural Transport Infrastructure and Services

Even though they are sometimes assisted by their children, particularly girls, in collecting firewood, fetching water, and travel to the grinding mill and market, women spend much more time on transport activities. Interesting observations on gender and rural transport in this research showed that women are disproportionately affected by poor rural transport infrastructure as well as by unpredictable and unreliable rural transport services, due to their gendered household responsibilities and status.

As transport is not gender-neutral, the availability, quality, adequacy and affordability of rural transport infrastructure and services are extremely important in helping rural women to ease their mobility and increase their productivity (Starkey, 2008; Fernando, 1997). To address gender inequity in access to rural transport infrastructure and rural transport services, women's ownership of intermediate means of transport is of great importance. Such an ownership and control over intermediate means of transport can also empower rural women through increased mobility and increased access to input and output markets (chapter 2-3 and 6).

Similarly, to achieve the sustainable development goal five (SDG 5) that claims to empower women in rural areas, gender-responsive integrated rural accessibility planning and incorporating the crosscutting issues of gender equality in rural travel and transport policies are a sine qua non for significantly improving women's agricultural productivity (chapter 5 and 6). Since women in rural areas assume a disproportionate travel and transport burden, their labor constraints can be reduced with labor saving transport like intermediate means of transport (IMT). Much productive time and effort saved through such local transport solutions can be translated to women's productive activities like agriculture.

Earlier studies by Matin et al. (2001) and Banjo (2012) showed that women were contributing at least 65% of the total transport effort in Africa. Banjo further argued that in Burkina Faso the loads carried by adult females ranged from 10.3 to 15.5 ton-kilometers compared with from 3.6 to 4.4 ton-kilometers by adult males. Household surveys in five study areas in Uganda, Zambia, and Burkina Faso also revealed that 87% of trips in rural

Africa take place on foot and that women spend more than 65% of the household effort and time spent on transport activities (Barwell, 1996). Reducing unnecessary effort and time spent on transport would thus increase time available for other productive economic activities. Since rural women transport their loads (collecting firewood, fetching water, going to grain mill and market) on tracks, foot paths, Community roads, and footbridges, these local transport infrastructure systems should be encouraged and require due attention from all levels of government.

7.2.6 Policy Implications for Sustainable Rural Transport and Agricultural Development

The following public policy recommendations have been suggested for critical consideration in light of the main discussions and conclusions to encourage proper incentives for sustainable and efficient rural transport as well as sustainable smallholder farmer agricultural development. This requires removing the existing disincentives to rural transport infrastructure and service improvement and creating or strengthening incentives for improved rural transport and mobility through mobilization of local revenues for rural access improvement that in turn improve smallholder farmers' agricultural performance.

Strong and effective policies, strategies, practices, and institutional arrangements towards safe, reliable, and cost-effective rural transport are central to increasing smallholder farmers'agricultural productivity in Horro Guduru Wollega Zone. Therefore, the following policy implications and recommendations are assumed to be used as a blueprint for policy makers and practitioners for future policy formulation and implementation regarding rural transport interventions that might contribute to improved agricultural productivity.

i) Rural community specific transport policies, programs, and strategies are required in all elements of rural transport: transport infrastructure, transport services, and location and quality of transport facilities.

ii) Rural transport and agricultural policy and their investment programs need to be better associated with existing sustainable development goal strategies (SDG).

iii) The strategic partnerships between rural transport and rural agricultural sectors needed to be developed and strengthened since agriculture and transport sector activities are mutually reinforcing and require close coordination of the two sectors for the maximum growth effect in development.

vi) Suitable policy environment that strives towards improving transport infrastructure and services that help in linking smallholder farmers to output and input markets need to be created.

vii) Prioritizing an enabling policy, regulatory and institutional environment that promote smallholder farmers access to credit facilities, farmers' agricultural cooperatives, extension services among others need to be in place.

viii) Develop supporting policies to promote an enabling environment for harnessing rural communication media (radio, television, and mobile phone) that help break the input and output market information bottlenecks and may lead to increased agricultural productivity need to be prioritized and appropriately sequenced.

xi) Investment in human capital development of smallholder farmers through short term informal training and adult education can help mitigate disparities in agricultural productivity among farmers.

xii) Developing rural transport policies that allow and promote the use of IMTs might improve the accessibility of rural households to basic economic services (input and output markets) through increased mobility, can also help to reduce post-harvest losses and narrow the gender differences in access to rural transport.

xiii) Gender-neutral rural transport and travel policies and strategies may help to ensure equal access to basic social and economic services for both men and women in rural areas.

7.3 Summary

Rural transport is one of the essential building blocks of rural agricultural transformation. However, it is immature and of poor quality in Horro Guduru Wollega Zone making all-weather access to basic social and economic services a difficult. The main objective of this research was to investigate rural transport constraints of smallholder farmers' agricultural productivity. A mixture of quantitative and qualitative approaches was employed to investigate the effect of rural transport infrastructure and services on smallholder farmers' agricultural productivity. The total sample of this study comprised of 500 smallholder farmers in Horro Guduru Wollega Zone.

Chapter 2: Effects of Rural Road transport on the intensification of purchased input use for major food crop production

This chapter analysis the effects of rural transport on smallholder farmers' intensification of purchased input use for major food crop production. It was revealed that size of land holding, off farm income, Membership in a cooperative, geographical location, distances to major market, to all-weather road, road quality and transport cost were significant predictors of smallholder farmers' intensification of purchased input use. The hierarchical multiple regression results indicated that these factors explain 82% of the total variation in purchased input use. Concerning the unique contribution of rural transport-related variables, they explain 13 % of the total variation in purchased input use over and above the other variables included in the model. Therefore, the quality of rural transport infrastructure and services determines the extent of input intensification among smallholder farmers. It was concluded that improving the condition of rural road infrastructure and access to quality rural transportation services are vital in encouraging smallholder farmers' purchased input use that in turn boost their agricultural productivity.

Chapter 3: Transportation and marketing constraints of smallholder farmers' output market participation

This chapter investigates factors influencing crop output market participation decisions and the intensity of participation among smallholder farmers in Horro Guduru Wollega Zone, Western Ethiopia. Data were obtained by employing a combination of methods that include household survey, Focus group discussion and key informant interview. Different of statistical techniques (probit regression, truncated regression, and One-way ANOVA) were employed to analyze the data with the intention of digging over the subject matter from different perspectives. It was shown that fixed transaction costs related to information search, bargaining about the prices and the best periods for selling crop produce and household characteristics such as livestock ownership, road quality, credit access, cooperative membership, extension visit, and ownership of radio, mobile phone and television had a statistically significant influence on binary decision of output market participation.

The truncated regression result further revealed that transport cost, distance to the nearest market, time spent selling crop, ownership of animal cart, off-farm income, amount of crop production, and household size influenced the intensity or degree of output market participation. The study further discovered that farmers' geographical location, agro-ecological condition and distance to the nearest all weather road were tied to their intensity of crop output market participation. Consequently, improving rural transport infrastructure and services, improving market-oriented extension services, improving access to rural communications media that help increase market information, strengthening local farmer associations, enhancing smallholder asset accumulation were some of options to encourage farmers to increase their output market participation that in turn could boost their agricultural production and productivity.

Chapter 3: Rural transport and storage induced post-harvest losses of major food crops among smallholder farmers

The intent of this chapter has been twofold: investigating the percentage post-harvest losses and main factors affecting such losses at different stages in the post-harvest chain, and examining smallholder farmers' attitude about severity of postharvest losses causing factors. This was achieved through primary data obtained by household by using structured questionnaires in four districts of Horro Guduru Wollega Zone. In this chapter Likert assessment scale and Tobit regression were used to analyze the data. The results revealed that the maximum post-harvest loss was found to be 20.4% for maize followed by *teff* (13.8%) and wheat (11%). The Likert assessment scale clearly identified farmer-level cereal crop post-harvest loss causing factors in order of their severity.

Using the Tobit model, family size, sex, educational status, access to credit, labor reciprocity, crop price condition, storage facilities, and tropical livestock unit were found negatively and significantly affecting farm-level crop post-harvest losses. Whereas, distance to the nearest market center, transport cost, distance to all-weather road, distance to farm plot, and crop production level were found positively and significantly affecting farm-level crop post-harvest losses.

The Tobit regression results indicated significant and positive effect of distance to all-weather road, distance to the nearest market center, transport cost, distance to farm plot, and amount of crop production on extent of smallholder farmers' cereal crop post-harvest losses. Similarly, the result found significant and negative effect of labor reciprocity, crop price condition, and ownership of livestock, traditional storage facilities, sex, household size, educational status, and access to credit on extent of smallholder farmers' cereal crop post-harvest losses. In this context, promoting indigenous farm labor exchange arrangements, strengthening of farmers' cooperative organizations, development of local market centers and improved storage facilities, and investment in transport infrastructure and improved rural transport services helps in achieving reduced farm-level post-harvest losses.

Chapter 4: The effect of rural road transport on smallholder farmers' agricultural productivity

This chapter analyses the social and economic access to rural road infrastructure and its effects on smallholder farmers' agricultural productivity in Horro Guduru Wollega Zone, Western Ethiopia. Stepwise multiple regression model was used to predict the association between smallholder farmers'agricultural productivity on one hand and the different rural transport infrastructure and services related variables on the other hand. It was found that ownership of intermediate means of transport, distance to major market, distance to nearest all weather roads, distance to zonal head quarter were important predictors of smallholder farmers' agricultural productivity in the study area.

The results also showed that 44, 30, and 21% of those who were interviewed indicated that they used human porterage, pack animal, and animal cart respectively as a means of transport to move their agricultural produce from farm to home. Similarly, 43, 27, and 23% of those who were interviewed reported that they used pack animal, human porterage, motorized car respectively as a means of transport to move their agricultural produce from home to market center. The successful and sustainable improvement of production and productivity of smallholder farmers is dependent on the efficacy of the rural transport system. Moreover, the commercial transformation of smallholder farmers' production system from age old subsistence orientation to commercial orientation is also tied to good rural transport infrastructure and services. Hence, to increase smallholder farmers' agricultural production and productivity, interventions in the rural transport sector that might include improvements in foot paths, animal drawn carts, foot bridges, tracks, feeder roads is important.

Chapter 5: Gender differences in access to rural road transport and its implication on agricultural production

In this chapter, rural men and women travel and transport patterns and their difference in access to different transport modes was explored. Focus group discussions with different groups, in-depth interviews and observations were used to collect the necessary qualitative data. The overall objective of this chapter was to investigate gender differential access to rural transport infrastructure and services and its effect on rural woman's participation in agricultural production.

A feminist theoretical lens was used explore gender differences in access to rural transport infrastructure and services. . It was revealed that due to their double responsibilities as domestic care givers and agricultural workers, rural women are more likely than men to suffer from poor access to rural transport infrastructure and services. Thus, this has a greater relative impact on their agricultural productivity.

It was shown that collecting firewood, fetching water, visiting the grain grinding mill, walking to the market to buy necessary ingredients for home consumption represent the greatest transport burden on rural women. These rural transport and travel activities are done through head-loading or back-loading since women do not have the power to mobilize and control over the locally available intermediate mode of transport (donkey, horse, and mule, animal cart). However, these transport problems of women which relate to their domestic responsibilities are of little importance to men. Therefore, to solve rural women's transport problems, greater consideration needs to be given to interventions in intermediate means of transport, and other time- and load-reducing measures such energy saving cooking equipments, rural child care centers, bringing service centers near rural villages.

References

Admassie, A., Berhanu, K., & Admasie , A. (2016). Employment Creation in Agriculture and Agro-industries in the Context of Political Economy and Settlements Analysis. Partnership for African Social and Governance Research, Working Paper No. 016, Nairobi, Kenya.

Affognon, H., Mutungi, C., Sanginga, P., & Borgemeister, C. (2014). Unpacking postharvest losses in Sub-Saharan Africa: A meta-analysis. *World Development*, *66*, 49–68. doi.org/10.1016/j.worlddev.2014.08.002

African Development Bank (2011). Federal Democratic Republic of Ethiopia Country Strategy Paper 2011-2015.

Amentae, T. K. (2016). Evaluation of supply chains and post-harvest losses of selected food commodities in Ethiopia. Licentiate Thesis Report 088, Swedish University of Agricultural Sciences, Uppsala, Sweden.

Banjo, G., Gordon, H., & Riverson, J. (2012). Rural Transport Improving its contribution to Growth and Poverty Reduction in Sub-Saharan Africa. Sub-Saharan Africa Transport Policy Program (SSATP), Working Paper No. 93.

Barwell, I. (1996). Transport and the Village: Synthesis of Findings and Conclusions from Village-Level Travel and Transport Surveys and Related Case Studies. Discussion Paper 344. Washington, D.C.: World Bank.

Bogale, Belew Dagnew (2016). Socioeconomic Impacts of Road Development in Ethiopia: Case Studies of Gendewuha - Gelago, Mile - Weldiya and Ginchi - Kachisi Roads, PhD dissertation, University of South Africa.

Buitelaar, E. (2004). A transaction-cost analysis of the land development process. *Urban Studies, 41*(13), 2539–2553. doi: 10.1080/0042098042000294556

Buiten, D. (2007). Gender, Transport and the Feminist Agenda: Feminist Insights towards Engendering Transport Research. Transport and Communications Bulletin for Asia and the Pacific No. 76.

Chen, X., Wu, L., Shan, L., & Zang, Q. (2018). Main factors affecting post-harvest grain loss during the sales process: A survey in nine provinces of China. *Sustainability, 10,* 661, 1-13. doi:10.3390/su10030661

Corley, K. G. & Gioia, D. A. (2011). Building Theory about Theory Building: What Constitutes a Theoretical Contribution? Academy *of Management Review, 36* (1), 12–32.

Cornelissen, J. P. & Durand, R. (2014). Moving Forward: Developing Theoretical Contributions in Management Studies. *Journal of Management Studies, 51*(6), 995-1022. doi: 10.1111/joms.12078

Crane, A., Husted, B. W., & Henriques, I. (2016). What Constitutes a Theoretical Contribution in the Business and Society Field? *Business & Society, 55*(6) 783–791. doi: 10.1177/0007650316651343

Fernando, P. (1997). Balancing the Load: Gender Issues in Rural Transport. London: International Forum for Rural Transport and Development.

G/Egizabher, Tegegne. (2001). Rural-Urban Linkages under Different Farming Systems: The Cases of Coffee and Non-Coffee Growing Regions in Ethiopia. Social Science Research Report Series, no.21, Addis Ababa: OSSREA.

Goldratt, E.M. & Cox, J. (1992). *The Goal - A Process of Ongoing Improvement* (Second revised Edition), North River Press Publishing Corporation, Great Barrington, MA.

Goldratt, E.M. (1990). *What is this thing called the Theory of Constraints*? North River Press, Croton-on-Hudson, NY.

Goldratt, E.M. (1990). *What is this thing called the Theory of Constraints*? North River Press, Croton-on-Hudson, NY.

Hayami, Y. & Ruttan, V. W. (1985). Agricultural development, the Johns Hopkins University Press, Baltimore.

Hayami, Y. & Ruttan, V. W. (1993). Induced techincal and institutional change evaluation and reassessment: Two chapters. Bulletin Number 93-1, University of Minnesota Economic Development Center, Minnesota, USA.

Hunt, A. & Samman, E. (2016). Women’s economic empowerment: Navigating enablers and constraints. Development Progress Research Report, Asian Development Bank.

Jayne, T. S. A., Govereh, J., Wanzala, M. & Demeke, M. (2003). Fertilizer market development : a comparative analysis of Ethiopia , Kenya , and Zambia. *Food Policy*, *28*, 293–316.

Kikulwe, E. M., Okurut, S., Ajambo, S., Nowakunda, K., Stoian, D., & Naziri, D. (2018). Postharvest losses and their determinants: A challenge to creating a sustainable cooking banana value chain in Uganda. *Sustainability*, *10*, 2381. doi:10.3390/su10072381

Madhok, A. (2002). Reassessing the fundamentals and beyond: Ronald Coase, the transaction cost and resource-based theories of the firm and the institutional structure of production. *Strategic Management Journal, 23*, 535–550. doi: 10.1002/smj.247

Martins, R. A., Serra, F. R., Leite, A. da S, Ferreira, M. P., & Li, D. (2010). Transactions cost theory influence in strategy research: A review through a bibliometric study in leading journals. XXXIV Encontro da ANPAD.

Matin, N., Mukib, M., Begum, H. & Khanam, D. (2001). “Spatial Mobility and Women's Empowerment: Implications for Developing Rural Transport in Bangladesh.” In P. Fernando and G. Porter, eds., Balancing the Load. London: Zed Books.

Melesse, T. M. (2017). Agricultural Intensification and Market Participation under Learning Externality: Impact Evaluation on Small-scale Agriculture, Maastricht University and UNU-MERIT.

Nehere, K. P. (2016). The Feminist Views: A Review. *Feminist Research*, *1*(1), 3-20 .doi.org/10.21523/gcj2.16010101

Rammelt, C. (2018). Infrastructures as Catalysts: Precipitating Uneven Patterns of Development from Large-Scale Infrastructure Investments. *Sustainability, 10*, 1286. doi:10.3390/su10041286.

Ruttan, V. W. (2008). Induced technical change induced institutional change and mechanism design.Paper presented at the 10th International Workshop on Institutional Economics, Institutions, Technology and their Roles in Economic Growth, University of Hart.

Sabandar, W. P. (2004). Transport development and the rural economy: Insights from Indonesia. PhD dissertation. University of Canterbury.

Salami, A., Kamara, A. B., & Brixiova, Z. (2010). Smallholder Agriculture in East Africa: Trends, Constraints and Opportunities. Working Papers Series No. 105 African Development Bank, Tunis, Tunisia.

Shah, D. (2014). Empirical assessment of pre- and post-harvest losses of soyabean crop in Maharashtra. *Artha Vijnana , LVI*(3), 307-317.

Starkey, P. (2008). Rural transport services in Africa: Lessons from rapid appraisal surveys in Burkina Faso, Cameroon, Tanzania and Zambia. SSATP Working Paper No. 87B. Sub-Saharan Africa Transport Policy Program (SSATP), The World Bank, Washington DC, USA. 114p.

Stifel, D., Minten, B., Koro, B. (2013): Economic Benefits and Returns to Rural Feeder Roads: Evidence from a Quasi-Experimental Setting in Ethiopia. International Food Policy Research Institute (IFPRI)/the Ethiopian Development Research Institute (EDRI), Addis Ababa, Ethiopia. https://economics.lafayette.edu

The Rockefeller Foundation. (2015). Perspectives to reducing post-harvest losses of agricultural products in Africa. Background paper, Abdou Diouf International Conference center, 21-23 october 2015, Dahar, Senegal.

United Nations (2009). Women's Control Over Economic Resources and Access to Financial Resources, including Microfinance. The Department of Economic and Social Affairs of the United Nations, Division for the Advancement of Women, New York

Whitford, A. B. (2016). Oliver E. Williamson, Markets and Hierarchies: Analysis and Antitrust Implications. In M. Lodge, E. C. Page, & S. J. Balla (Eds.), *the Oxford Handbook of* Classics in Public Policy and Administration, pp. 1-15. doi:10.1093/oxfordhb/9780199646135.013.12

Williamson, O. (1985). The economic institutions of capitalism: Firms, markets, relational contracting, New York: Free Press.

Appendices

Appendix 1. Questionnaire

Smallholder farmers survey Questionnaire

1. Sample information

1.1 .Name of enumerator______________________________

1.2. Date of enumeration______________________________

1.3. Name of district__________________________________

1.4. Name of rural kebele______________________________

1.5. Agro-ecological zone______________________________

2. Farm household's background information

2.1. Household head name _____________________age ________ sex_____ religion _________

2.2. Family status

2.2.1. Marriage a) single b) couple c) divorced d) widowed

2.2.2. If married, number of children you have: Male__________female ______total ______

2.2.3. total family size including husband, wife, children and relatives living with you_______

3. Educational status

A) Illiterate e) Grade 7-8

B) Read only f) Grade 9-10

C) Rea and Write g) Grade 11-12

D) Grade 1-6 h) 12^+

4. Livelihood condition

a) Main occupation ____

b) Other than farming, if you perform any other activity for your living, please mention these activities __________________________

5. Farm characteristics

5.1. What is the total area of your farm land holding in hectare?

a) Private _____________ d) lease in__________

b) Rented _____________ e) lease out_________

c) Sharing ____________

5.2. Area of farm land ______ grazing ______ residential and garden ________ fallowing _____

5.2.1. At how many different places were your farms located in 2007/08 EC production year? _________ places

5.2.2. Land area cultivated in hectare for the following crops:

a) maize__________________b) wheat_____________c) *Teff*_________

5.3. Total number of labour engaged in agriculture______________________

5.4. Agricultural wage rates of farm workers in birr_________________________

5.5. Working hours on the farm (per week)________________________________

5.6. participate/member in a farming association or agricultural cooperatives?

a) yes b) no if no why____

5.7. Livestock owned: tell the status/number of your livestock by type

Livestock type	number	Remark
Ox		
cow		
Donkey		
Mule		

horse		
Sheep		
Goat		
hen		

5.8. Communication means ownership

communication type	Yes/no	Remark
Radio		
Television		
Mobile phone		

5.9. Total post-harvest loss for the following crops in 2007/2008 EC production period

Crop type	guess /estimated lost at	Major causes
wheat	1.Harvesting___________kg per ha 2.platform drying______ kg per ha 3. Transport__________ kg per ha 4. Threshing___________ kg per ha 5. Winnowing___________ kg per ha 6. Transport to home____ kg per ha 7. Home storage _________ kg per ha 8. Transport to market____ kg per ha 9. marketing_____________kg per ha	
Teff	1.Harvesting___________kg per ha 2.platform drying______ kg per ha 3. Transport__________ kg per ha 4. Threshing___________ kg per ha 5. Winnowing___________ kg per ha 6. Transport to home____ kg per ha 7. Home storage _________ kg per ha 8. Transport to market____ kg per ha 9. marketing_____________kg per ha	
Maize	1.Harvesting___________kg per ha 2.platform drying______ kg per ha 3. Transport__________ kg per ha 4. Threshing___________ kg per ha 5. Winnowing___________ kg per ha 6. Transport to home____ kg per ha 7. Home storage _________ kg per ha 8. Transport to market____ kg per ha 9. marketing_____________kg per ha	

5.10. Which category of storage facility do you use?
a) traditional b) modern
5.11. How do you rate the price of cereal crops in your area
a) attractive b) not attractive

5.12. Rate the following cropl Post-harvest loss causing factors in your area

Potential Post-harvest loss causing factor	Not at all influential	Slightly influential	Somewhat influential	Very influential	Extremely influential
Delayed harvesting and threshing					
Bad weather					
Traditional harvesting and threshing methods					
Wild animals					
Pests					
Livestock animals					
Thefts by humans					
Insufficient transportation					
Traditional storage facilities					
Damage caused to grains during threshing					
Strong wind when blowing the chaft					
Labour shortage during peak season					
Defects in methods of packing, and handling Poor marketing coordination					
Contamination with foreign matter					

6. Accessibility to different social, institutional, economic and physical infrastructures

6.1. Distance to the nearest agricultural input market in km________________

6.2. Distance to the nearest agricultural output market in km_______________

6.3. Farm access road

a) tarred road b) un-tarred road c) footpath

6.4. Market access to agricultural input market

a) bad b) fair c) good d) very good e) excellent

6.4. Your capacity to transport own agricultural produce

a) Very little b) little c) high d) very high

6.5. The attitude of smallholder farmer to the quality and type of transport service offered

a) bad b) fair c) good d) very good e) excellent

6.6. The most important journey purposes of a household

a) work on farm b) market c) social d) accessing medical care

6.7. Are there better roads to travel to market and from market?

a) yes b) no if no why?______________

6.8. Are there sufficient vehicles to move to/from markets?

a) yes b) no if no why?____

6.9.Are there more frequent and reliable transport services in your area?

a) yes b) no if no why?_______________________________________

6.10. How do you rate the transport cost in your area?

a) very cheap b) cheap c) very expensive d) expensive

6.11. Amount of Transport cost _____________________________ Birr per 100 kg per km

6.12.How much time do you spent to sell crops?________________________hours

6.13. Transport costs for evacuation of yields of 100 kg of the following crops to storage/collection point

Transport cost birr/hectare								
crop	Yield (kg/ha)	Human portages	bicycle	motorcycle	car	Horse cart	Hand cart	donkey
Maize								
Wheat								
Teff								

6.14. Transport costs for evacuation of yields of 100 kg of the following crops to the nearest market

Transport cost birr/hectare								
crop	Yield (kg/ha)	Human portages	bicycle	motorcycle	car	Horse cart	Hand cart	donkey
Maize								
Wheat								
Teff								

4.15. Average distance and travel time to the following facilities/places

Facility/place	Distance (in km)	Travel time (in hours)	Transport Cost to get in to the facility/place (birr/km)	Weekly, monthly & yearly visit to)
Farm yard				
Fertilizer distribution center				
agrochemicals				
Improved seeds center				
Credit institution				
Agricultural Extension offices				
Agricultural research center				
Farmer training center (FTC)				
Health center				
Potable water source				
Primary school				
Input market center				
Output market center				
All weather roads				
Dry weather roads				

Non-motorized transport service				
Motorized transport service				
Grinding mills				
Bank				
Agricultural cooperatives				
District center				
Zonal center				
Regional center				

6.16. Cost of agricultural inputs used per hectare for the following crops in 2007/08 crop season

Crop type	cost of agricultural inputs used per hectare (in birr)		
	Chemical fertilizer	Agrochemical (pesticides, insecticides & weed killer)	Selected seed
Maize			
Wheat			
Teff			

6.17. Quantity of inputs used, outputs harvested and market prices for the following crops in 2007/08 crop season

Crop type	Quantity of inputs used per hectare				outputs harvested in kg	farm get prices in birr/kg	market prices in birr/kg
	chemical fertilizer in kg	agrochemical in litter	selected seed in kg	labor (in man days)			
Maize							
Wheat							
Teff							

6.18. Average travel distance in kilometers to take your agricultural produce by motorized vehicles to the following places on the following road categories

Road category	Nearest market center	District center	Zonal center	Commodity exchange center
Paved roads				
Unpaved roads				
Not accessible by vehicles				

6.19. Average travel distance in kilometers to take your agricultural produce by animal powered transport to the following places on the following road categories

Road category	Nearest market center	District center	Zonal center	Commodity exchange center
Paved roads				
Unpaved roads				
Not accessible by vehicles				

6.20. Average travel distance in kilometers to take your agricultural produce by human powered vehicles to the following places on the following road categories

Road category	Nearest market center	District center	Zonal center	Commodity exchange center
Paved roads				
Unpaved roads				
Not accessible by vehicles				

6.21. Average travel time in hours to take your agricultural produce to the nearest market by motorized vehicles on the following road categories

Road category	Nearest market center	District center	Zonal center	Commodity exchange center
Paved roads				
Unpaved roads				
Not accessible by vehicles				

6.22. Average travel time in hours to take your agricultural produce to the nearest market by animal powered transport on the following road categories

Road category	Nearest market center	District center	Zonal center	Commodity exchange center
Paved roads				
Unpaved roads				
Not accessible by vehicles				

6.23. Average travel time in hours to take your agricultural produce to the nearest market by human powered vehicles on the following road categories

Road category	Nearest market center	District center	Zonal center	Commodity exchange center
Paved roads				
Unpaved roads				
Not accessible by vehicles				

6.24. What is the maximum load, average speed and average cost when using animal powered transport to transport your agricultural produce to the market on the following road categories?

Road category	animal powered transport	maximum load in kg	average speed in hrs/km	average cost in birr/kg
On main roads	Horse cart			
	Pack donkey			
On secondary roads	Horse cart			
	Pack donkey			
On feeder roads	Horse cart			
	Pack donkey			

6.25. What is the maximum load, average speed and average cost when using motorized vehicles to transport your agricultural produce to the market on the following road categories?

Road category	motorized vehicles	maximum load in kg	average speed in hrs/km	average cost in birr/kg
On main roads	motorcycle			
	cars			
On secondary roads	motorcycle			
	cars			
On feeder roads	motorcycle			
	cars			

.

6.26. Number of market outlets for cereal crops______________________

7. Crop Production**.**

7.1 Number of years you have been staying in crop farming ________

7.2 Mention at least three of the crops in which you concentrate in your cultivation practice ____________, ____________&______________ (from big to low concentration)

7.3 What are the reasons (s) for your concentration more often on the above crops? Give reasons in descending order?

________ are more suited to the agro climatic zone

________ easily workable and less tiresome

________ give high yield per unit area of farm than others

________ charge better price income than others

_______ are principal food item of the family

7.4 Mention the type of crops you produce mainly for market or to sale for cash need ___________, __________&____________

7.5 Identify the type of agricultural inputs on which your production is based upon and what is the reason for?

☐ Traditional agricultural inputs only, why? ________________

☐ Modern agricultural inputs only, why? ___________________

☐ Both traditional and modern agricultural inputs, why? ______

8. Status of utilization of traditional agricultural inputs.

Indicate the type of traditional agricultural inputs you often utilize in your crop production practices. Circle your response(s) for which you utilize

8.1 Labor force

a) Personal labor only d) Family labor g) Oxen for cultivation.

b) Dugda e) Daboo

c) Hired Labor f) Pack animals

If other _________________, ______________&_____________________

9. Status of utilization of modern agricultural inputs.

9.1 Barkume improved wheat variety

a) I apply regularly until now d) I did not utiliz at all

b) I apply sometimes e) Restarted

c) Discontinued

If you had not utilized or discontinued, what were the main reasons?

a) is expensive c) lack of interest or willingness

b) is not available d) not convinced on the benefit

Other reasons ____

If your reason is lack of interest, why? ____

9.2 Maize (BH-660) variety

a) I apply regularly until now d) I did not utiliz at all

b) I apply sometimes e) restarted

c) Discontinued

If you had not utilized or discontinued, what were the main reasons?

a) is expensive c) lack of interest or willingness

b) is not available d) not convinced on the benefit

Other reasons ____

If your reason is lack of interest, why? ____

9.4. Chemical fertilizer

a) I apply regularly until now d) I did not utilized at all

b) I apply some times e) Restarted

c) Discontinued

9.4.1 If you utilized, what kind of chemical fertilizer? ___________________________

9.4.2 If you had not utilized or discontinued chemical fertilizer, what were the main reasons?

a) is expensive c) lack of interest or willingness

b) is not available d) not convinced on the benefit

Other reasons ____

If your reason is lack of interest, why? ________________________________

9.4.3 What do you think about time of chemical fertilizer delivery?
a) On time b) late

9.5 Weed killer /Herbicide
a) I apply regularly until now d) I did not utilized at all
b) I apply some times e) Restarted
c) Discontinued

9.5.1 If you utilized, what kind of herbicide? ___________________________________

9.5.2 If you had not utilized or discontinued using herbicide, what were the main reasons?
a) is expensive c) lack of interest or willingness
b) is not available d) not convinced on the benefit
e) I use family labor for weeding
Other reasons ____
If your reason is lack of interest, why? __________________________________

9.6 Pesticide
a) I apply regularly until now d) I did not utiliz at all
b) I apply some times e) Restarted
c) Discontinued

9.6.1 If you utilized, what kind of pesticide? __________________________________

9.6.2 If you had not utilized or discontinued using pesticides, what were the main reasons?
a) is expensive c) lack of interest or willingness
b) is not available d) not convinced on the benefit
Other reasons ____
If your reason is lack of interest, why? __________________________________

9.7 Have you utilized fertilizer or improved seeds during the last crop season (2007/2008EC)
a) Yes b) No

9.7.1 If yes, please fill in the following blank spaces provided

Crop type	Size of land (ha)	Fertilizer used kg/ha		Improved seeds kg/ha	Total yield kg/ha
		DAP	UREA		
Wheat					
Teff					
Maize					

9.7.2. If your answer (9.7) is no please fill in the following blank spaces provided

Unfertilized crop	Size of land (ha)	Total yield obtained kg / ha
Wheat		
Teff		

Maize		

9.7.3 How do you think the effect of chemical fertilizer on the yield of crops?

a) Increased yield c) decrease yield
b) No change

9.7.4 If you have ever used fertilizer, does it require you additional labor (work) to sow, weed, harvest or thresh? a) Yes b) No

9.7.5 What do you think about your application status or the amount of input utilized per unit area in your crop production?

a) Very low b) sufficient c) I do not know

9.7.6 If your state of application rate has declined than before, what is the reason behind?

a) Are expensive and I can't afford
b) Absence of sufficient supply
Other reasons ____

9.7.7 If you think your application is limited to only few of the crops of which you cultivated please indicate these crops _________________,________________&_________________

9.7.9 Do you think that you have got any advantage, due to the utilization of any of the modern agricultural inputs? a) Yes b) No

9.7.10 If your answer is yes or no; state your reason behind_______________________________

10. Credit

10.1 would you like to take improved form inputs on credit to improve your farm?
a) Yes b) No

10.2 Do you have credit problem? a) Yes b) No

10.3 From where do you get credit?

a) Oromia credit and saving institution
b) Local lender c) bank d) other _______________________

10.4. Have you taken credit for wheat during 2007/2008 E.C production year?

a) Yes b) no

If no why

a) High interest rate d) Had no money for repayment for the previous loan
b) Not available e) Fear of indebtedness
c) No lender in the area f) disqualified from getting credit in 2007/08

11. Extension service

11.1. Do you have access to extension information? a) Yes b) No

11.2. Did you contact with agricultural extension agents in 2007/08 production year?

a) Yes b) no

11.3. How many agricultural extension workers are there in your rural kebele?______

11.4. On average how many days during the month or the year did the extension agents visit your farm during the last crop season (2007/08 E.C.?)

a) never d) fortinightly
b) seldom e) weekly
c) monthly

11.5. Have you ever visited any demonstration plots prepared by the extension agents?
a) Yes b) no
11.6. Have you ever attended a formal agricultural training?
a) Yes b) no

13. Labor input (circle your response(s)

13.1 did you experience any labor shortage during 2007/2008 E.C crop year?

a) Yes b) No

13.2 If yes, during which of the following farm operation did you have shortages?

a) Planting and application of fertilizer b) Weeding
c) Harvesting and threshing d) Ploughing

13.3 How did you solve the above problem?

a) By using family labor c) Through mutual aid teams

b) Hiring daily labors d) Hiring permanent labor

other means, specify ____

14**. Market price of the crop output (product) and price of farm inputs.**

14.1. Do you get better prices for your crops?
a) yes b) no if yes how?_________________ if no why?____________________

14.2 To whom did you sell crops during the last (2007/2008) crop season?

a) Merchants b) Consumers c) Agricultural marketing co-operations

14.3 How much and at what price did you sell the following crops during the last (2007/2008) crop season (January and February)

Crop	AMC		Merchant		Consumer	
	quintals	Birr/Qt	Quintals	Birr/Qt	Quintals	Birr/Qt
Teff						
Wheat						
Maize						

14.4 In general do you think that you have received a fair price for your crop sold compared to price of inputs that you bought

A) Yes B) No

14.5 Do you have off-farm jobs during the last 2007/2008 E.C Crop year?

A) Yes B) No

If your answer to the above question is yes____________________per month

14.6 Type of off-farm activities you engaged in during the last 2007/08 EC crop season

A) Carpenter B) Handcraft activity

C) Selling labor D) Hales of fire wood

E) Petty trade F) Weaving

G) Other _________________________total_______________

14.7 Member of a family do off-farm job? a) Yes b) No

14.8 Do you use off- farm income to buy modern farm inputs?

a) Yes b) No

15. Personally, which of these factors (below) do you think are a major problem limiting or preventing you from the application of modern agricultural inputs?

A. shortage or absence of sufficient supply of them
B. the high cost of the input
C. lack of finance and capacity to purchase
D. time lag of the supply of the inputs to the period of sowing
F. if other reasons, please specify ____

16. What do you prefer to be done to improve your status of crop production and productivity condition?

____

____

____

Thank you!!!!!!!

Appendix 2. Guidelines for Focus Group Discussion

1. The difficulty in meeting smallholder farmers transport demand including peak times at harvest

2. Community isolation from all weather road networks involving long and difficult walks sometimes carrying heavy loads of agriculture produce to markets or taking a sick person to hospital.

3. The problem of poor provision and inadequate funding of road maintenance

4. The problem of infrequent (or non-existent), unsafe and high priced local transport services

5. A lack of complementary investment and facilities to assist with the post harvest storage and marketing of agricultural produce

6. Existing Challenge of rural transport in the district and related crop productivity outcome

7. The challenge of transporting crop output to market

8. The role of lack local means of transport like animal carts and pack animals for transport

9. The function and progress of farmers' cooperatives or associations in the area

10. Major physical, socio-economic, transport related obstacles to crop output market participation

11. Rural women and men's' travel pattern and their use of traditional and motorized transport means.

12. The nature of gender power relation and its effect on women and men's' agricultural production.

Appendix 3. Guidelines for key informant interview

1. When and where do you contact extension workers?
2. Why some smallholder farmers fail to get credit in 2007/08 crop season?
3. What are the main reasons for the delayed delivery of agricultural inputs (chemical fertilizer, agrochemicals and improved seed varieties)?
4. What looks like on the access to agricultural input and output markets during rainy season?
5. How do you see accessibility of rural roads and time spent by rural women on household chores?
6. What is the particular burden on women in meeting household transport needs?
7. What is the role of community participation/stakeholders to ensure the long term benefits from roads?
8. How do you evaluate the problems that smallholder farmers face in waiting vehicles at roads side during harvesting period?
9. Why smallholder farmers are compelled to sell their agricultural produce at low price?
10. The status of road that connects rural areas with urban centers
11. The nature of gender power relation and its effect on women and men's' agricultural production.
12. The role ownership of IMT as a means of transport in reduces costs of transporting crop to market
13. The role of joining farmers' cooperatives or associations
14. Factors affecting market participation decision of smallholder farmers
15. Travel and transport condition of men and women in rural area

Appendix 3.1: Participation information sheet for structured questionnaire participation information sheet

Dear Obbo/Adde: Thank you for considering being involved in this research study. This information sheet provides more details of the research I am undertaking and what participation in the research includes. Once you have read or somebody read for you through the information sheet and have corroborated that you would like to participate, please sign the consent form attached and keep a copy for your reference.

Research Overview: I am a PhD Candidate at Addis Ababa University. As part of my PHD degree course, I am undertaking a research study leading to a dissertation. The study aims to develop our understanding of the impact of rural transport infrastructure on smallholder farmers' agricultural productivity among smallholder farmers of Horro Guduru Wollega Zone. This study is an exploration of your experiences, ideas and feelings about the impact of rural transport infrastructure on smallholder farmers' agricultural productivity. This study is mainly concerned with your perceptions and experiences and is not an assessment of your skills or knowledge as well as it is not to audit or register your asset. By participating in this research you and other participants will be contributing to the better understanding of the impact of rural transport infrastructure on smallholder farmers' agricultural productivity in your area.

Participation: Participation in this study will involve the completion of structured questionnaire. This the impact of rural transport infrastructure on smallholder farmers' agricultural productivity questionnaire will ask you to answer questions about you and your opinions on your farming activities and the availability of rural transport infrastructure facilities. The questionnaire will take approximately 40-60 minutes to complete. Participation in this study is based on voluntary. You are free to choose to participate and can withdraw your participation at any time without providing any reason.

Research Responses: Responses collected will form the basis of my PHD research study and will be put into a written dissertation. Outputs of the research study may also be published in peer reviewed journals and conference presentations.

Confidentiality: Your participation in this particular study will be treated with the greatest confidentiality and your anonymity is assured. No material which could personally name you will be used in any reports for this study. Only grouped responses will be presented in the research findings. No other person, other than the researcher and trained data collectors directly involved in the study, will have access to the responses provided by you.

Further Information: I am very happy to answer any questions you may have about participating in this study. I will also be available to respond to any questions throughout the research process. I can be contacted by telephone number +251917819331.

Appendix 3.2: Consent form for questionnaire

Please answer each statement concerning the collection and use of the research data. Tick (√) as appropriate.

statement	Yes	No
I have understood the information		
I understand that I have full right to withdraw at any time I like		
I have given the opportunity to ask any question I like regarding the response I give		
I understand that the information I give will be kept confidential		
I agree to participate in the research as a respondent		

Participant's signature: …………………………………..
Date:..

Appendix 3.4: Jarque-Bera normality test that show residuals of truncated regression model follows the normal distribution

Jarque-Bera normality test: 1.493 Chi(2) .4741

Jarque-Bera test for Ho: normality:

Appendix 3.5: Shapiro-Wilk W test for normal data

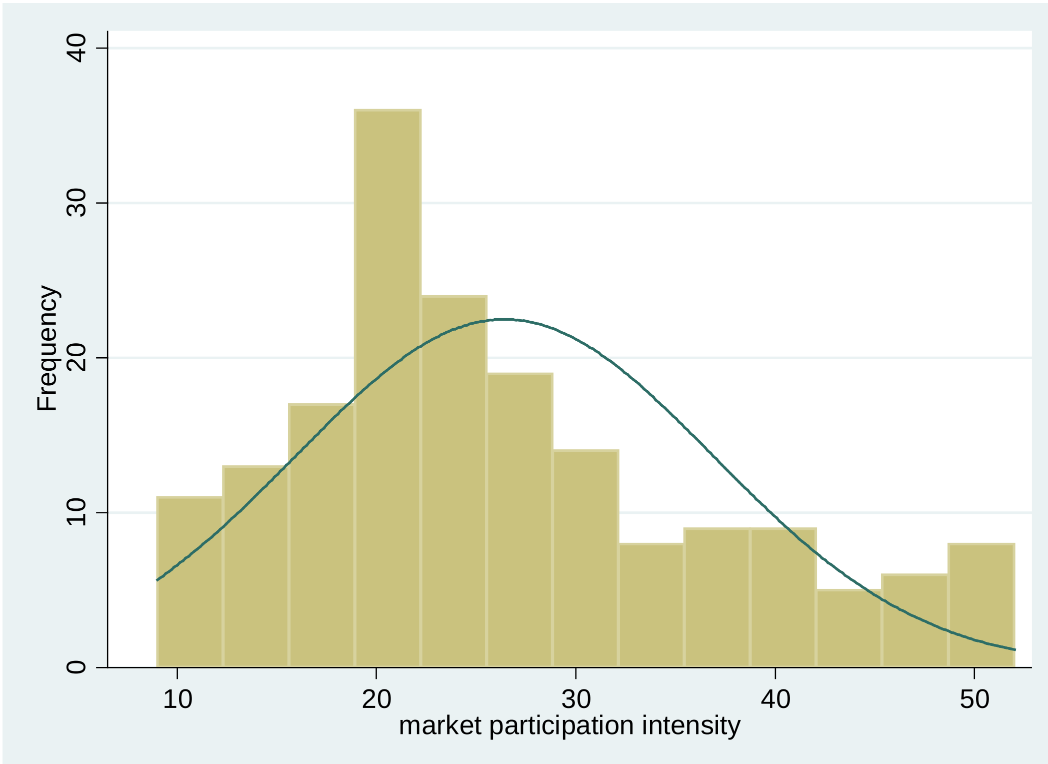
Variable	Obs	W	V	z	Prob>z
resid2	179	0.99319	0.923	-0.184	0.57306

Appendix 3.6: Skewness/Kurtosis tests for Normality

Skewness/Kurtosis tests for Normality

				------- joint ------	
Variable	Obs	Pr(Skewness)	Pr(Kurtosis)	adj chi2(2)	Prob>chi2
resid2	179	0.3117	0.3491	1.92	0.3821

Appendix 3.7: Histogram of intensity of market participation with frequencies and overlaid normal density curve



Source: own computation, 2016

Appendix 3.8: Breusch-Pagan Lagrange multiplier test for heteroskedasticity

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity

Ho: Constant variance

Variables: age tlu off_farm_in hhsize dist_to_mark tc price_crops credit Animal_cart Time_to_sale No_market_outlet Production_Level2

chi2(12) = 59.20

Prob > chi2 = 0.0873

Appendix 4.1: Multicollinearity check as assessed by variance inflation factor (VIF) and tolerance values

Coefficients[a]

Model		Collinearity Statistics	
		Tolerance	VIF
1	HH size	.458	2.183
	Distance to market	.347	2.880

Transport cost	.482	2.076
Distance to all weather road	.259	3.864
Distance to farm plot	.772	1.296
Gender of HH head	.760	1.317
education status	.615	1.627
Credit condition	.697	1.434
Labour reciperocity	.657	1.521
amount of crop production	.326	3.071
Price of crops	.693	1.442
Storage facility	.760	1.316
Total livestock unit	.326	3.066
Age of HH head	.722	1.386

a. Dependent Variable: Post-harvest loss

Appendix 4.2: Breusch-Pagan formal test statistics of residual heteroskedasticity

Formal test statistics of residual heteroskedasticity check

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity

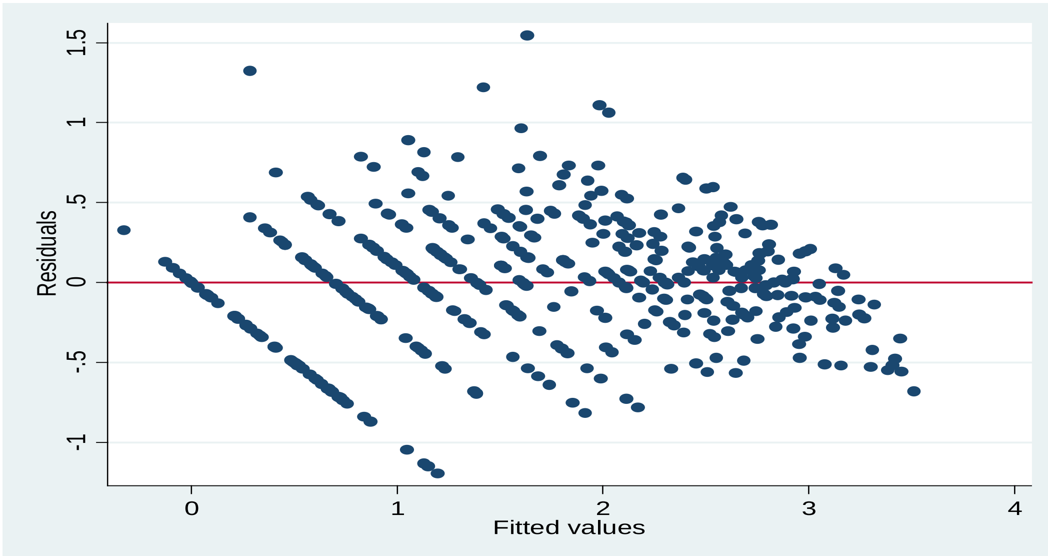
Ho: Constant variance

Variables: hhsize dist_to_mark tc dtawr dis_plot tlu output age sex educ credit lab_recip price_crops storage_facility

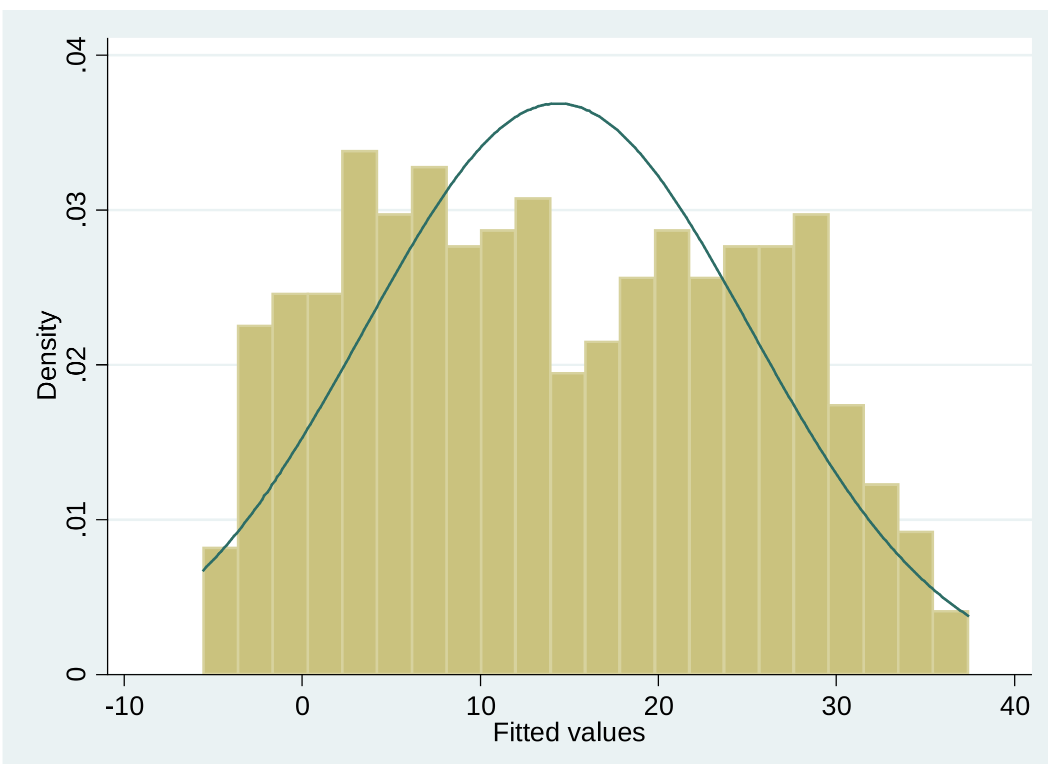
chi2(14) = 88.67

Prob > chi2 = 0.0721

Appendix 4.3: Graphical inspection of residual heteroskedasticity check



Appendix 4.4: Graphical inspection of residual normality check



Appendix 4.5: Shapiro-Wilk test of residual normality check

```
Variable |    Obs       W           V         z       Prob>z
-------------+------------------------------------------------
       resid |    500    0.96329     12.349     6.042    0.0987
```

Appendix 4.6: Durbin-watson test statistic for checking independent residual

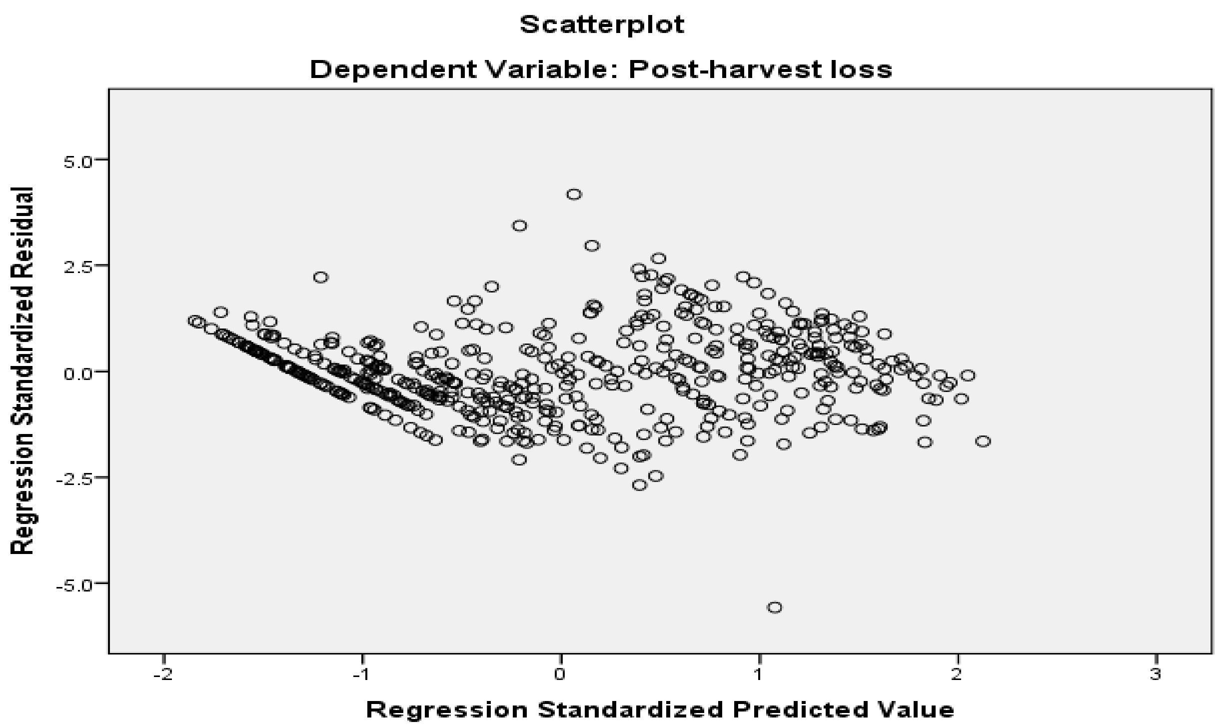
Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.920[a]	.847	.842	4.662314657	1.639

a. Predictors: (Constant), Age of HH head, Gender of HH head, Distance to farm plot, Storage facility, Price of crops, Labour reciperocity, Credit condition, amount of crop production, Transport cost, education status, Distance to market, HH size, Total livestock unit, Distance to all weather road

b. Dependent Variable: Post-harvest loss

Appendix 4.7: Visual inspection for checking the assumptions of independent errors from the scatter plot of standardized predicted value against standardized residual



Appendix 4.8: Extent of cereal crop post-harvest loss at different post-harvest chain

different post-harvest chains

Crop type	Harvesting	Platform drying	Transport to threshing floor	Threshing	Winnowing	Transport to home	Home storage	Transport to market	Marketing	Mean farm level Loss
Wheat	2.6	0.4	1.4	0.9	1.0	0.6	3.4	0.3	0.5	11.0
Maize	3.6	2.7	2.2	1.8	1.3	1.8	6.1	0.3	0.6	20.4
Teff	3.3	0.5	1.0	2.9	3.4	1.3	0.9	0.2	0.4	13.8
Average cereal	3.14	1.21	1.52	1.91	1.88	1.22	3.45	0.26	0.46	16.73

Note: All numbers are in percentages

Source: survey result, 2016

Appendix 4.9: Severity of factors perceived by Smallholder farmers as causing cereal post-harvest losses across the different post-harvest stages

	Bad weather	Wild animals	Delayed harvesting and threshing	Pests	Traditional harvesting and threshing methods	Contamination with foreign matter	Traditional storage facilities	Poor marketing coordination	Strong wind when blowing the chaft	Insufficient transportation	Defects in methods of packing, and handling	Thefts by humans	Damage caused to grains during threshing	Labour shortage during peak season	Livestock animals
Extremely influential	30	21	13	52	25	2	45	17	2	38	3	9	3	5	9
Very influential	29	25	18	24	28	4	27	19	5	30	5	11	4	8	16
Somewhat influential	19	24	24	14	22	16	15	27	14	17	20	18	17	19	23
Slightly influential	13	17	21	7	14	26	8	20	28	10	29	25	29	28	22
Not at all influential	9	13	25	3	11	52	5	17	51	7	43	37	47	40	30

Note: All numbers are in percentages

Source: survey result, 2016

Appendix 10: Tobit model coefficients of factors influencing cereal crop post-harvest loss

Tobit regression		Number of obs	=	500
		LR chi2(14)	=	946.05
		Prob > chi2	=	0.0000
Log likelihood = -1323.0009		Pseudo R2	=	0.2634

phl2	Coef.**	Std. Err.	t	P>|t|	[95% Conf.	Interval]
hhsize	-.268252	.1018541	-2.63	0.009	-.4683809	-.0681232
dist_to_mark	.3053567	.048834	6.25	0.000	.2094048	.4013085
tc	3.07486	.4278651	7.19	0.000	2.234167	3.915554
dtawr	.3682083	.0661426	5.57	0.000	.2382475	.4981692
dis_plot	.3359462	.0779057	4.31	0.000	.1828725	.4890199
1.sex	-2.265492	.8346156	-2.71	0.007	-3.905393	-.6255919
1.educ	-3.831283	.6529821	-5.87	0.000	-5.114299	-2.548266
1.credit	-2.533019	.5412246	-4.68	0.000	-3.596448	-1.46959
1.lab_recip	-3.688236	.5498991	-6.71	0.000	-4.768709	-2.607763
output	.0506163	.0199338	2.54	0.011	.0114491	.0897834
1.price_crops	-2.750246	.5540933	-4.96	0.000	-3.83896	-1.661531
1.storage_faci~y	-2.119892	.5129857	-4.13	0.000	-3.127836	-1.111949
tlu	-.9218051	.2471546	-3.73	0.000	-1.407429	-.4361816
age	.0163081	.0229406	0.71	0.477	-.0287669	.0613832
_cons	6.997679	1.720408	4.07	0.000	3.617322	10.37804
/sigma	4.873434	.1662212			4.546833	5.200035

Obs. summary: 71 left-censored observations at phl2<=0
429 uncensored observations
0 right-censored observations

**The estimated tobit coefficients are the marginal effects of a change in *independent variable* on y*, the unobservable latent variable.

Appendix 4.11: Marginal effects of the tobit model of independent variables on extent of cereal crop post-harvest loss

	dy/dx*	Delta-method Std. Err.	z	P>|z|	[95% Conf.	Interval]
hhsize	-.2675323	.1015714	-2.63	0.008	-.4666086	-.068456
dist_to_mark	.3045374	.04869	6.25	0.000	.2091067	.3999681
tc	3.06661	.4265584	7.19	0.000	2.230571	3.902649
dtawr	.3672204	.0659593	5.57	0.000	.2379426	.4964983
dis_plot	.3350448	.0776941	4.31	0.000	.1827672	.4873225
1.sex	-2.261822	.8338585	-2.71	0.007	-3.896155	-.6274898
1.educ	-3.824499	.6521089	-5.86	0.000	-5.102609	-2.546389
1.credit	-2.526546	.5397998	-4.68	0.000	-3.584534	-1.468558
1.lab_recip	-3.675125	.5469442	-6.72	0.000	-4.747115	-2.603134
output	.0504805	.0198783	2.54	0.011	.0115198	.0894412
1.price_crops	-2.743795	.552861	-4.96	0.000	-3.827383	-1.660207
1.storage_faci~y	-2.113974	.511396	-4.13	0.000	-3.116292	-1.111656
tlu	-.9193318	.2464799	-3.73	0.000	-1.402424	-.43624
age	.0162644	.0228789	0.71	0.477	-.0285775	.0611062

*effect of *independent variables* on the observable ***y*** (or change in the **censored outcome**)