

The nexus of crop and income diversification, commercialisation and household welfare: empirical evidence from Ethiopia

By

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ABSTRACT

Agriculture is a key economic sector playing an important role in an endeavour to realize the country's development objectives and overcome rural poverty. It is a source of livelihoods and employment for most of the population living in rural areas of Ethiopia. However, the sector is dominated by subsistence smallholders heavily characterized by rain-fed farming and poverty. Adverse events because of unpredictable weather conditions e.g. periodic droughts, declining landholding and fragmentation, lack of institutional services, input and output price fluctuations and population pressure significantly influence the livelihoods of rural households. Smallholders are pursuing various adaptation strategies to develop the resilience that helps them overcome these challenges guided by the resources, information, intrinsic values and motivation. Accordingly, crop and income diversifications are among the decisions followed to spread risk over multiple activities and make economically rational choices. On the other hand, the government is striving to undertake economic transformation which mainly encourages specialized farming. Thus, the analysis of crop and income diversification and the consequence on a household welfare is relevant to design and execute an appropriate mix of policies that recognizes the integration of subsistence and commercial farming. The study was conducted in nine selected districts from three administrative regional states of Ethiopia representing the major maize-legume production systems. Balanced panel data of 854 respondents (1708 observations) generated in two round survey were analyzed.

Econometric models were chosen to empirically analyze the data, guided by economic theory, literature and the nature of the response variables. The fractional probit and Pseudo Fixed-effect (PFE) models were used to analyze the determinants of crop diversification and its effects on crop productivity, respectively. The fractional probit model was employed to analyze the determinants of income diversification and poverty gap while the PFE was used for income and vulnerability analysis. Finally, a logit transformation model was employed to analyze smallholders' commercialization behaviour and the influence of crop and income diversification on smallholders' commercialization. Before the estimation of the models, necessary heteroscedasticity and endogeneity tests were conducted so that a consistent and efficient estimations are achieved.

The result suggested that dependency ratio, farm size, livestock endowment, credit access, access to extension services and the use of crop rotation practices are positive drivers of crop diversification. Membership of market groups is negatively associated with the level of crop diversification. Moreover, diversification is greater in sub-humid high-potential agroecological areas than in semiarid agro-ecologies. Concerning crop productivity,

livestock, assets, market group membership, inter-cropping and soil quality are found to positively influence crop productivity, while farming experience, dependency ratio, plot size and agroecology showed a negative influence on the productivity. The study suggests the need for relevant intervention options to address issues related to diversification and productivity. Promotion and maintenance of cultivars suitable for specific production objectives and environments are important areas of intervention in semi-arid agricultural production areas. The number of crops that a farm household can effectively manage need to be determined using empirical studies to minimize the efficiency loss. Improving crop-livestock integration is pertinent to improve the economic performance of rural households.

The study also found that income diversification has increased between 2010 and 2013. It is also found that crop production, livestock, and non-farm businesses are the most important income sources in that order. The fractional probit regression model estimates revealed the association between farming experience and diversification to be non-linear. Female-headed households and households with more years of formal education were found to diversify income more while farm size is negatively influencing diversification. Female-headed households and those with better education achievements were also found to be more vulnerable to poverty. Hence, income diversification is assumed to be driven by push factors (resource constraints and risks) than pull factors (infrastructure development, technology, new markets and demand drivers). Income diversification is found to positively influence household income while it is observed to reduce the propensity of poverty. Furthermore, variables such as farming experience, dependency ratio, cultivated land size, livestock, crop diversification and agroecology are important factors influencing household income, vulnerability and poverty status. Interventions in addressing factors constraining crop and livestock productivity, access to farmland (land markets), crop diversification and family planning are important in promoting the welfare of rural households. Creating conducive environment through the expansion of a labor-intensive farm and nonfarm investment projects as well as relevant institutions could address the prevailing vulnerability and poverty in the area especially for women and households with better education achievement.

The study also examined smallholders' commercialization behaviour. The result indicates that the level of both input and output commercialization to be very low, though a trend of increment is observed over the years. The econometric results reveal input market participation to be positively influenced by income diversification, market-oriented production, the level of output market participation, access to credit, livestock, group

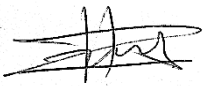
membership and adoption of intercropping practices while it is negatively associated with crop rotation. On the other hand, output market participation was positively influenced by the level of input market participation, crop diversification, livestock ownership, farm size under cultivation, intercropping and crop rotation practices. In general, crop diversification is a factor found to influence output market participation with the highest coefficient estimate. This could imply that smallholders diversify from the staple food crops production to species with higher market value. On the contrary, farming experience and education level were negatively associated with the level of output market participation. The implication is that, intervention in the areas of entrepreneurial skills development, the formation of market groups, farmland. and livestock productivity enhancement, credit access, and inclusion of cropping practices (crop diversification, crop rotation and intercropping) in the agricultural extension technology packaging are highly important to ensure sustainable productivity that enhance market participation.

In general, the results reinforce the role of cropping systems (crop diversification, intercropping and crop rotation) to sustainable crop production and productivity market supply and hence, overall welfare. Income diversification is also found to be a relevant factor in influencing productivity-enhancing input market participation that further contributes to positive change in household income as well as minimizing the level of poverty. Besides, dependency ratio, operated farm and livestock size and credit and cropping systems are important cross-cutting issues worth due consideration.

DECLARATION 1: PLAGIARISM

I, Mekonnen Sime Kidane, declare that:

- 1) the research reported in this thesis, except where otherwise indicated or acknowledged, is my original work;
- 2) this thesis has not been submitted in full or in part for any degree or examination to any other university;
- 3) this thesis does not contain other persons' data, pictures, graphs or other information unless specifically acknowledged as being sourced from other persons;
- 4) this thesis does not contain other persons' writing unless specifically acknowledged as being sourced from other researchers. Where other written sources have been quoted, then:
 - a) their words have been re-written, but the general information attributed to them has been referenced;
 - b) where their exact words have been used, their writing has been placed inside
- 5) this thesis does not contain text, graphics or tables copied and pasted from the internet, unless specifically acknowledged, and the source being detailed in the References.



Date: 10 April 2019

Signed: Mekonnen Sime

Date: _____

Signed: Prof. Edilegnaw Wale (Supervisor)

DECLARATION 2: PUBLICATIONS

The following papers emanating from the thesis have been published, submitted and are under review:

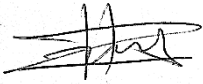
Publication 1- Chapter three of the thesis

Mekonnen Sime Kidane & Edilegnaw Wale Zegeye. 2018. Crop diversification and productivity in semiarid and sub-humid maize-legume production systems of Ethiopia, *Agroecology and Sustainable Food Systems*, 42 (10):2018.

Publication 2- Chapter four of the thesis

Mekonnen Sime Kidane & Edilegnaw Wale Zegeye. 2019. The nexus of income diversification and welfare: Empirical evidence from Ethiopia, *African Journal of Science, Technology, Innovation and Development* 11(5): 2-11.

Data analysis and write-up of the above publications were carried out by Mekonnen Sime Kidane with the technical advice and inputs from Prof. E.W. Zegeye. All Figures and Tables were produced by the same unless referenced.



_____ Date: 10 April 2019

Signed: Mekonnen Sime

_____ Date: _____

Signed: Prof. Edilegnaw Wale (Supervisor)

DEDICATION

This thesis is dedicated to the memory of my parents.

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First, I would like to thank almighty God for giving me health, protection, guidance and endurance throughout the valleys and mountains of life to accomplish this journey.

This thesis is the outcome of contributions from many individuals and institutions (directly or indirectly) within and outside of the university whom I would like to gratefully acknowledge. Without supports from these individuals and organizations, this thesis would not have been completed.

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LIST OF ACRONYMS

APE	Average Partial Effects
CIA	Centreal Intelegence Agency, USA
CIMMYT	International Wheat and Maize Research Centre
CPI	Consumer Price Index
CRE	Correlated Random Effect
EIAR	Ethiopian Institute of Agricultural Research
ETB	Ethiopian Birr
FE	Fixed Effects
FGLS	Feasible Generalized Least Squares
FGT	Foster–Greer–Thorbecke
GDP	Gross Domestic Product
GLM	Generalized Linear Models
GOFT	Goodness-of-Functional Form Test
GTP	Growth and Transformation Programme
IR	Inverse Relationship
MoA	Ministry of Agriculture
MoFED	Minstry of Finace and Economic developement
NPA	National Planning Agency
PFE	Pseudo Fixed Effect
RE	Random Effect
RESET	Ramsey’s Regression Specification Error Test
SID	Simpson Index

SNNP	Southern Nations, Nationalities, and People's Region
TFP	Total Factor Productivity
TLU	Tropical Livestock Unit
UN	United Nations
VEP	Vulnerability to Expected Poverty
WB	World Bank

Chapter 1: INTRODUCTION

1.1 Background and justification

The two commonly mentioned reasons for the policy emphasis on smallholders' agriculture in Sub-Saharan African countries including Ethiopia are: 1) to exploit the huge natural resources available in the region and feed the growing population of the region and the world at large, and 2) poverty being most persistent in the rural areas, improving productivity offers the shortest path in reducing the extent of poverty in the area (Larson *et al.*, 2016). Similarly, agriculture plays important role in Ethiopia's economy in achieving the national development goals. It is the source of livelihoods and employment for most people in the rural areas. It plays a crucial role in poverty reduction and promoting national as well as household food security. Over 40% of the national GDP and 90% of exports are from the agricultural sector, fulfilling households' basic needs and income to 90% of the population (Yu *et al.*, 2011). It is an employment source for over 77% of the population (Moller, 2015). The sector is dominated by resource-poor subsistence farmers producing 90 to 95% of all cereals, grains, pulses, and oilseeds (Alene *et al.*, 2008). The lion share of Ethiopian's agricultural production is from crop production and contributes a significant share to the GDP accounting for about 31.5 percent of the national GDP in 2010/11 and 30.4 percent in 2011/12 (MoFED, 2013). Consequently, the agricultural sector has continued to be the centre of national development policy of Ethiopia in an endeavour to realize food security, export earnings and sustainable supply of raw materials although the production and productivity are very low.

Nonetheless, the production of agricultural output in the country is largely reliant on rain-fed systems and characterized as poor in terms of productivity. Such production system is highly sensitive to the continuing climate variability or changes evident by the level and frequency of extreme climatic conditions, average temperature, quantity and pattern of rainfall distribution (Kotir, 2011). The country has experienced frequent major droughts including several sporadic droughts. The frequent occurrence of droughts results in poverty traps for millions of households and deters efforts towards the buildup of assets and increased income. Harvest failure, because of frequent droughts, in Ethiopian smallholder

farmers' is a major challenge (Di Falco and Chavas 2009). In semiarid low-potential and sub-humid high-potential maize¹ production systems in the country, crop production and productivity are highly variable due to biophysical factors that increase the seasonal risk of food insecurity (Alemu *et al.*, 2014).

Widespread market failures (price uncertainties) is also one of the important limiting factors in resource allocation and productivity (Dillon and Barrett, 2017). In the absence of well-functioning markets, the production objective of smallholders is to sustain the supply of household consumption needs. Although market-based risk management strategies are relevant, experiences showed that most of the formal risk management options are either not in place or not well developed in sub-Saharan African countries (Antonaci *et al.*, 2014). In general, production and price risks are important factors reducing smallholders' incentives to invest in productivity-enhancing inputs and profitable technologies and hence, perpetuating subsistence farming and poverty (Mulat *et al.*, 2016). Failure to device coping strategies with prevailing risks can lead to consumption fluctuations which further affects nutrition, health and education status of the household as well as resulting in unequal and inefficient intra-household allocation (Dercon, 2002). The prediction made by Patt *et al.* (2009) indicates that least developed countries will be highly vulnerable to extreme climate events in the next two decades. This calls for the development of appropriate and urgent adaptation strategies. Furthermore, the limited adaptation capacity of smallholders to climate change and related production risks due to the level of poverty is becoming an important international concern (Mertz *et al.*, 2009).

In this context, the implementation of adaptation strategies which include market mechanisms and government interventions to respond to the threats and opportunities of risks and stabilize income and consumption is critical (Mulat *et al.*, 2016). Adaptation has existed since the beginning of human existence although risks from severe climate

¹ Maize producing areas can be regarded as maize-legume-based farming systems, since it involves practices such as intercropping, rotation or crop sequencing of maize with soybean in mid-altitude sub-humid areas, common bean, pigeon pea, cowpea and groundnut in dry land areas, cowpea in low-altitude sub-humid and faba bean and chickpea in highlands agroecologies (Wegary *et al.*, 2011).

variability increased over time jeopardizing smallholders' adaptation capacity (Kotir, 2011). As indicated by Mulat *et al.* (2016), appropriate risk management strategies help producers to (1) invest in resilient and dynamic farming systems; (2) invest in activities with more payoff than low risk and low return; (3) undertake long-term investment (land improvement and infrastructure) and access financial loans for future investments. Having low access to those government and market-based risk management options, smallholders in less developed countries consider different informal risk management strategies ranging from diversification activities to risk sharing strategies which include social capital and network mechanisms as coping mechanisms (Antonaci *et al.*, 2014).

Accordingly, diversification is one of the decisions followed to spread risks over multiple activities and make an economically optimal choice (Bowman and Zilberman, 2013; Arslan *et al.*, 2018). Crop and income diversification are among the adopted livelihood strategies (activities)² which are adopted at the farm or household level as short or long-term risk and vulnerability management strategies. In situations where farmers are facing the prospect of crop failure, crop or varietal diversity is one of the possible adaptation strategies (Di Falco and Chavas 2009) through which the genetic diversity of each crop species can support productivity and risk management strategies (Smale *et al.* 1998).

Similarly, income source diversification which is the reallocation of available physical and human resources among various income generating schemes (Abdulai and CroleRees, 2001) or choices of feasible activities as a function of asset stocks (Barrett *et al.*, 2001b) is another diversification strategy employed by smallholder farmers. Diversification³ helps to minimize income variability (vulnerability) and risks of failure in imperfect insurance and credit market situations (Alderman and Paxson, 1992). Choosing a production portfolio with high, quick and regular returns to investment based on the available family labour and resources uniquely characterizes smallholder farmers (Joshi *et al.*, 2006). Hence, crop and income diversification which are the focus of this study are among the economic

² Livelihood strategy (activities) includes the range (combination) of activities and/or choices made to achieve the desired livelihood goals/objectives (Scoones, 2009).

³ Diversification, in this case, refers to crop/income diversification by households.

diversification strategies adopted at the farm or household level as short- or long-term risk and vulnerability management strategies (Smit and Skinner, 2002).

On the other hand, it is well known that Ethiopia is following a five-year national growth and transformation programme (GTP) since 2010 as a driving force of rapid economic growth in the country. The transformation of subsistence, low-input and low-productivity smallholder farming toward commercialization is the main development agenda of the country. Currently, the country is in the second phase of economic transformation period (GTP II- 2015/16-2019/20) as a continuation of GTP I (2010/11-2014/15) (NPA, 2016).

Based on Asian experience, Timmer (1997) classified agricultural transformation into three interrelated phases: diversification, commercialization and transformation. The first phase is production mainly for subsistence with greater diversification or little specialization under imperfect market and absence of risk management tools. Following the market development and expansion of financial institutions providing risk management tools and household income increase above subsistence level, household tends to follow commercial (specialized) economic activities: shifting from the production of “inferior” staple crops because of low production cost to market oriented production or high cost commodities.

Accordingly, smallholders’ commercialization involves market-oriented production decision behavior of households as well as active participation of input and output markets. Higher market orientation leads to smallholders’ use of purchased inputs (mainly improved production technologies) instead of own produced. Hence, the transformation requires a production shift from diversified, subsistent production to highly specialized and market-oriented production systems (Timmer, 1997; Kimenju and Tschirley, 2009). Thus, economic transformation involves more specialization over diversification. Nonetheless, studies reported that diversification in subsistent farming system can lead to commercialization especially at the initial stages of commercialization (Pingali and Rosegrant, 1995; Timmer, 1997).

According to Mellor and Dorosh (2010), attaining high level of commercialization requires accelerated improved seed and fertilizer use to achieve GTP objectives. To this end, efforts

were made in improving access to public services by expanding extension service provision and input supply to support commercial transformation. However, farmers' market participation remain to be very low due to various prevailing limiting factors (Knowler and Bradshaw, 2007; Silva *et al.*, 2016).

1.2 Problem statement

The concept of diversification has been given due emphasis since the acceptance of sustainable livelihood concept in the 1990s as an approach in rural poverty reduction strategies of developing countries (Ellis, 2000). As suggested by Barbieri and Mahoney (2009), the complex set of diversification objectives of stallholders include: 1) minimizing the downside risk exposure (a price or crop failure); 2) maximizing benefits from market opportunities or market expansion, and 3) improving household revenue.

Crop diversification is one of the practices that give smallholder farmers an option to produce a variety of potential crop types for the market, enhancing ecosystems and to minimize risks that emanate from climate variability and price fluctuations. It can also provide access to alternative market opportunities and also introducing new production techniques to smallholders and hence, improving adaptive capacity to adverse effects of market and/or climatic events (McCord *et al.*, 2015). It has been also reported that crop diversification improves agricultural productivity while promoting *in situ* biological crop species diversity conservation and allowing farmers to mitigate negative consequences of harsh weather and environmental conditions (Di Falco and Chavas, 2009; Bangwayo-Skeete *et al.*, 2012). Diversification in a subsistent farming system can also lead to commercialization especially at the initial stages of commercialization (Pingali and Rosegrant, 1995; Timmer, 1997). Similarly, a study conducted in Kenya revealed that crop diversification provides an opportunity to select and identify crop or crop species for commercial production (Dorsey, 1999). Hence, crop diversification could be associated with various management and production strategies (risk management, sustainability, the introduction of crop species with higher market demand and others).

To this effect, different studies were conducted in different parts of Ethiopia to analyse crop diversification and/or its impact on household welfare (Di Falco and Chavas, 2009; Di Falco *et al.*, 2010; Bangwayo-Skeete *et al.*, 2012; Mussema *et al.*, 2015). However, most of them used cross-sectional data and focused on intra-crop specific diversification (Bangwayo-Skeete *et al.*, 2012). Besides, the majority of these studies (Di Falco and Chavas, 2009; Di Falco *et al.*, 2010; Bangwayo-Skeete *et al.*, 2012; Mussema *et al.*, 2015) were mainly conducted in specific agro-ecologies or districts that are similar in relative terms and fail to capture environmental variability. Furthermore, limited studies have captured the relationship between crop diversification and crop productivity (Di Falco and Chavas, 2009; Bangwayo-Skeete *et al.*, 2012). Limited research efforts were also made to capture the association between crop diversification and smallholders' input and output market participation.

As indicated earlier, income diversification is also another risk management strategy used by most of the African smallholders. It encompasses household income-driven from both agricultural diversification as well as off/non-farm income sources (Bryceson, 2002). Following Abdulai and CroleRees (2001), income diversification in this paper is considered as the allocation of resources among various on-farm and off/non-farm income-generating activities. Income from diverse sources influences smallholders' production or consumption decision in two aspects: relaxing household investment constraints in agricultural production as farm input can depend on both farm and nonfarm income and smoothening household consumption at times of production or market risks (Woldehanna, 2000; Asfaw *et al.*, 2012). On the other hand, studies from Ethiopia (Woldeyohanes *et al.*, 2017) and Georgia (Kan *et al.*, 2006) reported that off-farm income negatively influences the level of household product market participation since it encourages household consumption.

Although empirical literature on income diversification in rural Sub-Saharan African countries are available, the majority are based on cross-sectional data while its influence on rural livelihoods is not well understood (Alobo Loison, 2015). More recently, Khai *et al.* (2013); Akaakohol and Aye (2014) and Ayieko (2015) have conducted studies on the current diversification trends, determinants, and contribution towards household welfare.

However, vulnerability and poverty are yet not sufficiently studied although limited studies (Hung *et al.*, 2010; Asfaw *et al.*, 2015a) were carried out on the effects of diversification on vulnerability and level of poverty.

Overall, under the Ethiopian condition, limited/no efforts were made in empirically evaluating the contribution of crop and income diversification on the household welfare such as productivity, level of commercialization, vulnerability, and propensity to poverty. Filling the gaps between producers' diversification intention and the long-term commercialization (specialization) strategy is a major policy challenge for the Ethiopian government. Considering the government's aspiration towards poverty reduction and improvement in wellbeing, this study is relevant to design and execute a proper mix of policies and programme that recognizes the integration of both traditional subsistence and commercial oriented economy. Accordingly, this thesis contributes to the existing knowledge by addressing the following research questions for informed decision.

1.3 Research questions

1. What factors influence crop diversification behaviour of smallholders? What is the influence of crop diversification on smallholders' crop productivity?
2. What are the determinants of income diversification? How does income diversification influence household welfare (income, vulnerability to expected poverty, and a propensity to poverty)?
3. What are the determinants of smallholders' commercialization behaviour? How is commercialization associated with income and cropping systems (crop diversification, inter-cropping and crop rotation)?

1.4 Research objectives

The aim of the study is, therefore, to empirically examine the nexus of crop and income diversification and household welfare. The specific objectives are to:

- (i) examine crop diversification and its effects on crop productivity;

- (ii) analyse the level of income diversification and effects on household income, vulnerability to future poverty as well as the intensity of poverty; and
- (iii) investigate smallholders' commercialization behaviour and how crop and income diversification influence it

1.5 General Methodology

1.5.1 Description of the study areas

Study sites and respondents were identified using a multistage sampling procedure that involves a combination of purposive and random sampling methods. The major maize-legume producing regions, districts, and sub-districts (*Kebeles*) were identified purposively since the focus of the programme⁴ was on maize-based farming system. Hence, the current production of maize and potential was used as important selection criteria. Based on this, three regional states (Benushangul-Gumuz, Oromia and Southern Nations, Nationalities, and People's State (SNNP) were selected. In Oromia region, five districts: Bako Tibe, Gubuesyo, Shalla, Dudga and Adami Tullu; Benushangul-Gumuz region: Pawe district and from SNNP region three districts namely Mesrak Badawacho, Meskan and Hawaasa Zuria were selected (see figure 1.1).

⁴ The data were collected through the "Sustainable Intensification of Maize-Legume Cropping Systems in Eastern and Southern Africa (SIMLESA)" programme supported by the Australian Centre for International Agricultural Research (ACIAR). The data were collected as baseline information for programme impact evaluation.

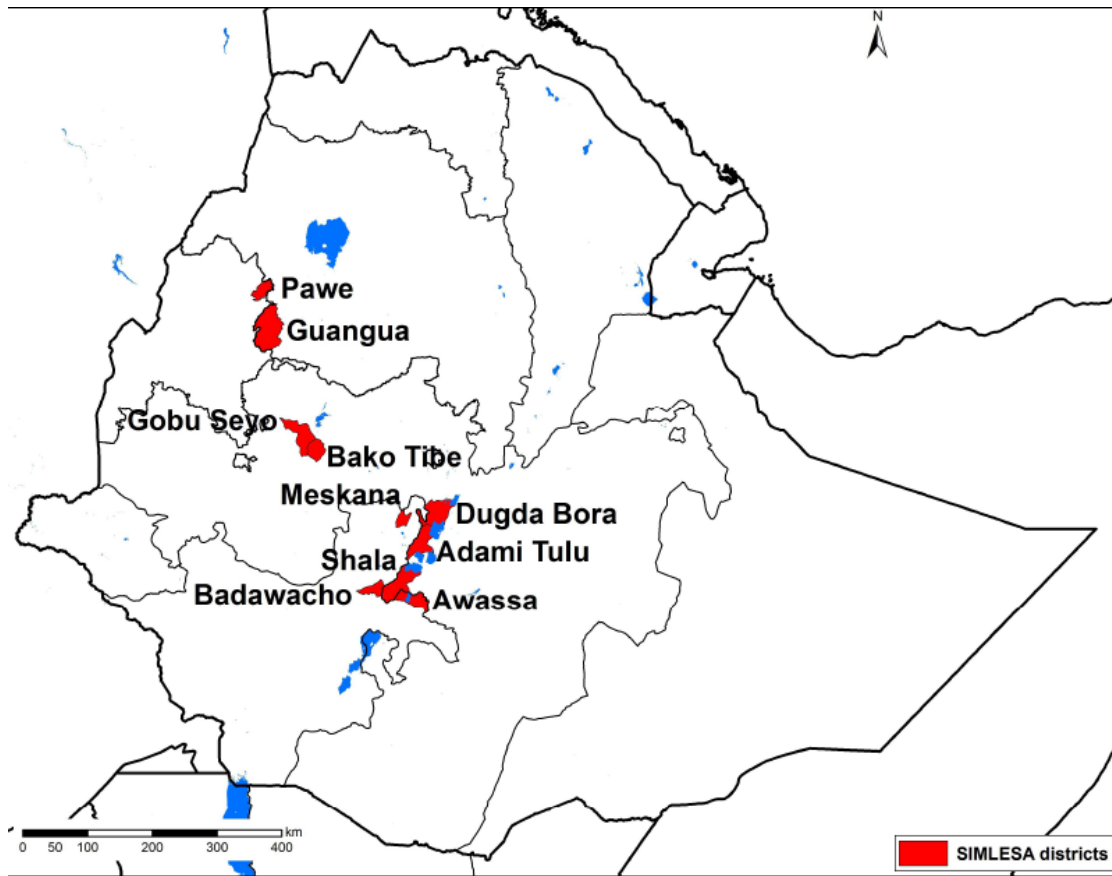


Figure 1-1 A map showing research sites

Among these, six districts (Shalla, Dudga and Adami Tullu, Mesrak Badawacho, Meskan, and Hawaasa Zuria) were from the country’s Central and Southern Rift Valley representing the low potential and risk-prone agroecological zone (semi-arid) that experiences low and erratic rainfall distribution. Erratic rainfall distribution limits crops and livestock production. The other districts are in the north-western part of the country representing relatively high potential (sub-humid) maize producing areas of the country and mostly experiencing adequate rainfall distribution. Description of the two agroecological zones is presented in Table 1-1.

Table 1-1 Description of semi-arid and sub-humid agro-ecologies.

Characteristics	Semi-arid	Sub humid
Growing period (days)	61-120	181-240
Rainfall (mm)	650 - 700	1000–1800
Elevation (masl ⁵)	1400-2000	1000–2200
Rainfall variability (%)	25-30	15-30
Constraints	moisture, soil depth,	erosion, deforestation
Drought probability	0.5	0.1 - 0.4

Source: Compiled from MoA (Ministry of Agriculture) (1998)

In the study area, most of the population is residing in rural areas and agriculture is the main livelihood source. The farming system is characterized by subsistence and mixed (crop-livestock) practices. Livestock ownership is generally regarded as a key component of rural livelihoods. The main reason for the existence of such a mixed production system is to spread production risk and to use an animal waste from livestock as fertilizer for crop production. Moreover, livestock is also considered as an asset and wealth status indicator. In turn, crop residues are used as a source of animal feed. In relative terms, outputs from livestock are season-independent and benefiting the household at any season in the year unlike the benefits from crop production which is season-specific. Livestock production in the study area mainly includes cattle, sheep, goats, equines, and chickens. Major crops grown in the areas based area allocated, in decreasing order, are maize, teff, haricot bean, wheat, sorghum, pepper, and finger millet. Maize features first in both the share of cultivated area and total production, except for Dugda district where it takes the second position in terms of share of area cultivated.

1.5.2 Data collection and sampling procedures

Following the selection of regions and districts, probability proportional to size sampling procedure was used in selecting 3-6 *kebeles* per district. A total of 69 *kebeles* were selected. About 16-24 farm households per *kebele* were selected from a complete household list provided by local authorities. A total of 900 households were randomly selected and interviewed face-to-face in 2010. During the second survey period (2013), 864 respondents

⁵ Meter above sea level

were re-interviewed face-to-face using the same questionnaire. The attrition level was less than 5%. Table 1 below presents the summary of respondents by district and year.

Table 1-2: Sample distribution by district and survey period

District	Frequency	Percentage	Frequency	Percentage
	Round I (2010)		Round II (2013)	
Gubuesyo	50	5.56	49	5.67
Bako Tibe	149	16.56	141	16.32
Shalla	99	11.00	93	10.76
Mesrak Badawacho	101	11.22	100	11.57
Meskan	100	11.11	99	11.46
Hawasa Zurya	100	11.11	96	11.11
Dugda	100	11.11	93	10.76
Adami Tulu	100	11.11	94	10.88
Pawe	101	11.22	99	11.46
Total	900	100	864	100

Source: CIMMYT/EIAR survey data (2010/2013)

A structured questionnaire was prepared and pre-tested for further modification to ensure the validity of all questions. The questionnaire was designed to capture socio-economic characteristics, wealth, access to market and institutional services, livestock and crop production and other related information. Finally, the survey was executed under the close supervision of researchers from the Ethiopian Institute of Agricultural Research (EIAR) and the International Wheat and Maize Research Centre (CIMMYT⁶). The questionnaires were administered by experienced enumerators. A training was organized for enumerators

⁶ CIMMYT is an international research institutes commissioned to coordinate SIMLESA programme in the Eastern and Southern African countries. The data were collected by researchers from EIAR and CIMMYT.

before launching the survey. A thorough data cleaning was carried out before the analysis. Stata 13 software programme was used for data processing.

1.5.3 Overview of data analysis methods

The use of panel data helps to monitor the progress over a period. However, attrition bias can be a concern in panel data analysis and there is no regression-based test for the attrition bias for two-period short panel data (Smale and Mason 2014). The study employed a balanced panel data using a total of 1708 observations (854 from each year) which is relatively large as compared to the majority of past similar studies. As stated above, this study tries to assess the determinants of crop diversification and its influence on crop productivity, income diversification and its influences on household income, vulnerability to expected poverty and propensity of poverty as well as the association between diversification (crop and income) and commercialization behaviour of smallholder farmers in two relatively contrasting maize-legume based farming systems of Ethiopia.

The response variables across the objectives are grouped into two: proportional and continuous variables. Crop and income diversifications, the propensity of poverty and commercialization (input and output) were proportional response variables while crop productivity, income, and vulnerability to expected poverty were categorized under continuous variables.

The analysis employed both descriptive and econometric approaches. The percentage, average, standard deviation, t-test statistics were employed in the descriptive statistical analysis. Chapter three employed a correlated random effect (CRE) fractional probit and Correlated Random Effect (Pseudo Fixed Effect) models to analyze the determinants of crop diversification and its impact on crop productivity. Chapter four employed CRE fractional probit and pseudo-fixed-effect models for fractional and continuous response variables, respectively. The last empirical chapter employs a transformed logit model (Generalized Linear Models (glm)).

1.6 Outline of the thesis structure

The rest of the chapters are organized as follows. The following chapter presents the literature review which lays the foundation for the remaining chapters. This chapter summarizes the concepts and applications and the key empirical findings of the literature on crop and income diversification, commercialization and impacts on welfare promotion. Theoretical review deals with the concepts and application of smallholder farming, crop, and income diversification as well as commercialization while the empirical literature discusses on the determinants of diversification (crop and income), commercialization and the welfare impact.

Following the literature review, the empirical chapters (3 to 5) are presented. Each empirical chapter covers the analytical (conceptual) framework, methods, findings, and discussion as well as summary.

Chapter 2: LITERATURE REVIEW

2.1 Introduction

This chapter presents a review of literature on the concepts and its application and empirical findings of crop and income diversification and impacts on commercialization behaviour and welfare promotion. The review on concepts and its application deals with the concepts and application of terminologies such as smallholder farming, crop, and income diversification as well as commercialization while the empirical literature review discusses on factors influencing agricultural diversification (crop and income) and commercialization. Besides, the welfare effects of diversification on household welfare are discussed as outlined below.

2.2 Concepts and application of terminologies

2.2.1 Features of smallholder farmers

Agricultural production is the leading source of employment and means of livelihood in the world's poor countries of which Ethiopia is an example. The agricultural productivity of these countries is very low (Doss, 2006). The role of smallholder farmers is immense in the sector. The world's smallholders contribute to a large share (70%) of food production (Fairtrade International, 2013; United Nations, 2015). However, due to lack of clarity, the term 'smallholder farmers' has been defined in various ways (e.g. family farms, small-scale farmers, resource-poor farmers, smallholders, subsistent farmers, peasant households and so on) depending on their specific classification criteria namely ecology, farm size, resource endowment and so on (Heidhues and Brüntrup, 2003). According to Netting (1993), smallholders are rural cultivators engaged in intensive, permanent, diversified agriculture practices relatively on small farm size and densely populated areas. According to the author, household (family) is the major corporate social unit for mobilizing, organizing and managing the production resources including labour.

As discussed by Wall (2007) and United Nations (2015), common features of smallholder farmers among others include low access to financial capital (services) and the production

objective is mainly to achieve family food requirements. Smallholders are mainly risk-averse and rely on mixed crop/livestock systems with limited land and other resources. They mainly rely on family labour, animal traction and/or small tractors for draught power. They have a strong community or social relationships/networks with weaker links outside of the community, having less formal education than large-scale or commercial farmers and are located in marginal areas in relation to rainfall and topography, usually have unwarranted land tenure (Wall, 2007; United Nations, 2015). The farm size operated by 70% of small farms in low-income countries (including Sub-Saharan) is less than 2 ha (Lowder *et al.*, 2016).

Smallholder farmers are also heterogeneous in many dimensions such as demography (age, sex, education level etc.), physical resource (farm size/quality, and resources, geographical locations (climatic variability and distance from service centres such as markets), economic, socio-cultural dimensions, social capital (networks), access to institutions and so on with maximizing or satisfying objectives. Such factors influence households to follow different livelihood strategies and resource management systems (Pender *et al.*, 1999; Ruben and Pender, 2004).

Similarly, agriculture in Ethiopia is dominated by small-scale farmers who engaged in mixed farming (crop and livestock) production and share the above features. The lion share of national agricultural production is from small-scale producers. For example, in 2017, more than 79.6 % of Ethiopia's population is from rural areas engaged in agriculture (FAO, 2018). Hence, the role of smallholders remains crucial under the Ethiopian context where the agricultural transformation and livelihood development can't be considered without smallholders. Therefore, policy supports that promote the sustainable production and productivity of smallholders are relevant to overcome the challenges in the dynamic local and global environments.

2.2.2 Agricultural diversification

Diversification is one of the concepts frequently used in the field of agriculture. However, the message it conveys vary (Singh *et al.*, 2006). At the macro level, it indicates a structural

transformation which is an economic wide phenomenon characterized by a shift from agricultural output and employment to industrialization, urbanization and demographic changes (from high population growth and death rate to lower population growth and death rate (Timmer, 2007). Diversification can also occur in each sector and sub-sector following economic development (Rao *et al.*, 2004). According to the authors, agricultural diversification can take place in the crop, livestock, forestry and others.

As stated by Woodward *et al.* (1998), farming is considered to be diversified if it involves intentional functional biological diversification at multiple spatial and/or temporal scales, using practices developed via traditional and/or agroecological based scientific knowledge. According to Tirimba and Macharia (2014), it is an allocation of resources including labour from the agriculture sector to the industry and service sectors as a process of structural transformation at national level while it can be considered as a shift of production resources from a given crop or livestock to a number of crops or livestock with an intention to minimize risks and increased expected returns for optimum portfolio income at regional and farm level. Damtoft *et al.* (2008) also described agricultural diversification as an approach to broaden the aggregate mix of farm enterprises, activities, and outputs within the defined areas for the diverse market at national or regional scales.

Agricultural diversification can be categorized as 1) shift of resources from farming activities to non-farming activities; 2) resource reallocation within the farming activities such as from less profitable crop (enterprise) to more profitable crop (enterprise); 3). resource use in diverse but complimentary activities (Vyas, 1996). According to the author, agricultural diversification involves a shift from a regional dominant crop to another crop, from one enterprise (e.g. crop) to another (livestock) or to be involved in other complementary activities (including crop, livestock, and non-farm). Joshi *et al.* (2004) also described diversification as (i) undertaking a mix of diverse and complementary activities within the agricultural sector; (ii) reallocation of resources from low-value activities/commodities to high-value activities/commodities; and (iii) resource shifting from farming to non-farming activities.

Vyas (1996), highlighted that specialization or commercialization can take place following the expansion of product and financial markets. Under favourable policy environment that helps smallholders in identifying and using the crops or enterprises that are efficiently produced for higher profit, diversification is the starting point of economic competitiveness (Kamiya and Ali, 2004). At the early stage of transformation (subsistence production stage), diversification is higher, followed by diversity at the national level and specialization at the farm level and regional level (Timmer, 1997). As a result, various studies analyzed the linkage between diversification and commercialization as diversification representing a change in the farming system including farming practices and products to be more associated with the social, economic, and environmental contexts as well as the existing opportunities and constraints at farm level (Shawki, 2004). Accordingly, based on the above premises, agricultural diversification can be analyzed as 1) crop diversification, 2) livestock diversification and 3) income diversification (crop, livestock, and non-farm). In this study, the focus is on crop and income diversification and discussed as follows.

2.2.2.1 Crop diversification

Various definitions have been used to describe crop diversification by different scholars. It is one of the practices adopted as a strategy that helps to maximize utility subject to certain constraints as a result of the complementary and supplementary relationships of crops under production and also to minimize risks of crop failure and price fluctuations (Ghadim and Pannell, 1999; Reddy and Suresh, 2009). According to Kamau (2011), diversification of farm crops refers to firstly, the cultivation of multiple crop species and secondly, the production of multiple varieties and ecotypes of the same crop to try and optimize outcomes of primary products. Buguk *et al.* (2003) also indicated that farmers grow crop species that are genetically diverse to manage production risk and ensure survival.

According to Dequech (2007), diversification involves broadening of farm crop composition, activities, and outputs within the defined space and time (Kamau, 2011). As indicated by Khawar (1997), diversification is an addition of new or additional crop species/varieties and enterprises at the farm level. However, the mixed farming systems

expected to give way to specialized production systems through time as it is designed to respond to the rapidly growing market price and quality inputs as commercial orientation increases (Pingali and Rosegrant, 1995; Khawar, 1997).

Hence, crop diversification, in this case, can be considered as the re-allocation of farm resources, such as land, capital, labour, and farm equipment to new or different crops of relatively high value (profitable) or more stress-tolerant crop species from susceptible crop species. Crop diversification has also been used as an adaptation strategy by an individual household or groups to reduce the level of vulnerability emanating from adverse policy and climatic impacts (Dequech, 2007). Ethiopian stallholders also grow crop species that are genetically diverse to meet the diverse socioeconomic needs as well as to withstand risks of the market and climatic variability.

2.2.2.2 Income diversification

Most African smallholder farmers earn their income from diverse sources namely agriculture and off/non-farm activities (Ellis, 2000). Hence, different households (individuals and groups) are expected to have diverse income sources and hence, participation in such sources can play income distribution and poverty reduction role (Ellis, 1998). Thus, diversification is a social and economic process, used to manage various challenges and opportunities in the rural economy (Ellis, 1998). Income diversification has been considered as one of the possible adaptation approaches followed by smallholders to minimize income volatility and risks of failure under imperfect insurance and credit markets (Alderman and Paxson, 1992).

Rural households with numerous income sources are assumed to experience less income variability than specialized households. Under high-risk agriculture and poverty conditions, poorer smallholders may be pushed to seek alternative income from different sources by engaging in low-return but low-risk non/off-farm activities (Barrett *et al.*, 2001a). Diversification can also help as a strategy to realize the complementarities between diverse economic activities namely; crop-livestock integration, milling, and hog production, seeking for wage-earning opportunities, trading and so on (Ellis, 2000; Barrett

et al., 2001b). Accordingly, household actions are guided by the resources, information and intrinsic values and motivation (Gasson, 1973; Ilbery, 1983).

Ellis (1998) defined income diversity as the composition of household incomes in a given period and is an active social process including households in highly complex ranges of activities over time. Income diversification is a widely used livelihood strategy in developing countries where livelihood encompassing both cash and in-kind income, as well as social capital and networks, gender relations, and property rights required to improve a given household's living conditions (Ellis, 1998). Overall, diversification is considered to be changing the nature of a single full-time occupation to multiple families or individual occupations (Ellis, 2000). Accordingly, diversification has increased in sub-Saharan Africa over time in response to changes in risks and incentives (Ellis, 1998; Barrett *et al.*, 2001b).

Economic studies grouped sources of income portfolios into different categories or sub-categories. Kassie *et al.* (2017) analyzed diversification classifying into two namely; as a farm or non-farm sector and as wage or self-employment (function). Income diversification (in this case) refers to the number of sources and share of each source. Barrett *et al.* (2000) also categorized rural household livelihood strategies into four groups: households exclusively dependent on own agricultural production (animal or crop) "full-time farmer" strategy; the second group are those who combine on/farm production and wage-labor (farmer and wage labour); while the third combines farm and non-farm incomes. The fourth strategy is a mixture of the three basic elements: agricultural production, unskilled non/off-farm wage employment, and incomes from trades, commerce, and skilled (salaried) employment. In this study, income diversification index is constructed using incomes from various sources such as crop, livestock, remittance, salary, casual labour, income from aid, sales of fuelwood (charcoal), non-farm business and income from property rent) following the classification made by Barrett *et al.* (2000).

Ethiopian smallholders undertake their livelihood activities under complex, diverse, and risky environmental conditions. Adverse events because of unpredictable weather conditions and periodic droughts, declining landholding and fragmentation, lack of institutional services, the fluctuation of input and output prices and population pressure

significantly impact on household welfare. Declining farm size and soil fertility, erratic rainfall distribution and recurrent drought are the main contributors to food insecurity and vulnerability of smallholders in the country (Tesfaye and Seifu, 2016). These challenges can be the push factors towards diversification while the ongoing infrastructures (roads, telecommunication, electricity and so on) development and expansion can be considered as pull factors.

2.2.3 *Smallholder commercialization*

Agriculture plays a vital role in reducing poverty and promoting food security. Transformation of smallholders' production towards commercialization has been viewed as a stimulant for economic growth and development in less developed countries whose economies are mainly dependent on farm income to a large extent (Timmer, 1997; Pingali, 2007). According to von Braun *et al.* (1994), smallholders' commercialization is understood to be one of the overall development processes which result in income increase, food security and improved nutritional status. Commercialization indicates a farm household shifts of production decision away from traditional self-sufficiency goals to profit and income maximizing decision making as farm output becomes more market-oriented or a shift to a predominantly purchased input production system from the system that requires high family labor (von Braun *et al.*, 1994; Pingali and Rosegrant, 1995; Pingali *et al.*, 2005).

Agricultural commercialization is a process of increasing the quantity and quality of the agricultural product that can be sold by the households (Pradhan *et al.*, 2010). According to Gebremedhin and Jaleta (2010b), agricultural commercialization is a production decision that is guided by market signals. On the other hand, it is described as a production decision that goes beyond the production of cash crop by smallholder as it occurs on output or input side of the production (Gebremedhin and Jaleta, 2010a; Martey *et al.*, 2012). Following Strasberg *et al.* (1999) and Jaleta *et al.* (2009), commercialization (household market orientation) is measured as the ratio of outputs sold and inputs purchased (increased transaction) overtime at the household level. Commercialization pathways may vary depending on the existing farming systems, market institutions and specific policy contexts

(Olwande *et al.*, 2015). Finnis (2006) argued that commercialization is a local level farm decision making based on the experiences associated with environmental change, economic aspirations, infrastructural developments namely road, irrigation schemes, and labour availabilities supporting the objectives of production decisions and commodity choice that is guided by the households' financial aspirations and economic conditions.

Commercialization involves the movement of the production system from subsistent-oriented production decision to market-oriented while the market is assumed to facilitate the process as it allows the households to increase their income by producing high-value commodities and use the cash to buy consumable commodities (Timmer, 1997). As the household economy improves, the household likely tends to move from the traditional food self-sufficiency production decisions towards profit maximization and market orientation. The returns to intensively subsistent production systems that necessitate high family labour decline comparative to the market-oriented production decisions with the use of dominantly hired labour (Pingali and Rosegrant, 1995). The proportion of farm income to the total household income declines as family members find more lucrative non-agricultural employment opportunities. On the other hand, commercialization, while leading to increasing the diversity of marketable agricultural products at the national level, it also leads to the regional and farm level specialization. Commercialization also facilitates the linkages between input and output markets as the demand for improved technologies facilitating the development and advancement of technological innovations representing input market while adoption or use of improved production technologies, in turn, resulting in higher production and productivity that increases the marketable output (Jaleta *et al.*, 2009). Following the review of literature on the concepts and applications of crop and income diversification as well as commercialisation, the empirical findings on the determinants of crop and income diversification as well as well welfare impacts are also reviewed below.

2.3 Determinants of crop and income diversification, and commercialisation

2.3.1 Determinants of crop diversification

Earlier studies confirmed that diversification from staple food crop towards cash crop and/or varieties with a desired agronomic and market attributes is triggered by the diversity that exists among the farming households. In this section, factors expected to explain crop diversification and intensity include farming experience, the gender of a farmer, area of a plot owned, access to extension and credit services, social-capital of the household and the agroecology. Justifications for hypothesizing the effect of these factors is explained in the following paragraphs.

Past studies confirmed that accumulated knowledge and skills in farming can enhance or constrain the uptake of innovations (Ainembabazi and Mugisha, 2014). Based on the analysis of past 31 studies, Knowler and Bradshaw (2007) revealed that both positive and non-significant correlations reported by the papers between farming experience and smallholders' innovation adoptions. A study conducted in Uganda using cross-sectional and panel data reported the mixed (inverted- U shape) relationship between banana, coffee and maize technology uptake and farming experience. According to the authors, farmers can abandon the use of the technologies especially if it is more labour demanding and requiring of farm size expansion based on their experience. In this study also, the farming experience is expected to influence crop diversification negatively or positively.

Another household characteristic which is more considered in smallholders' decision behaviour studies is the gender of the household head as it plays an important role in development programme implementation and evaluation. A study conducted in Kenya reported that the male-headed household is found to diversify more as compared to female-headed (Kanyua *et al.*, 2013). The underlying assumption of less adoption by female-headed households is attributed to the socio-cultural factors wherein most of the societies, female-headed households have less access to institutional services including agricultural extension, land, education, and other social services as compared to male-headed households. Hence, male-headed households are expected to diversify more while female-

headed households are expected to focus on the production of staple cereals to meet household food requirements. However, diversification being an adaptation mechanism to risks of crop failure or price fluctuation, female-headed households can also engage in diversification practices.

Dependency (ratio) implies the consumption requirements of the households to sustain the members' subsistence leaving. Crop diversification is one of the production risk management options being employed by small rural households with an intention to sustain household food security and livelihood. Study in Uganda reported a positive association between the dependency ratio and crop diversity (richness and evenness) (Veljanoska 2014). The growth in knowledge of producers also facilitates the understanding of knowledge or information embodied into the technology being disseminated as well as improving the ability of efficient resource allocation. Accordingly, the more education achievement of the households, the more they may opt to be more profitable or market-oriented and prefer to specialize in selected crop species production with high market value for higher market supply. Hitayezu, Zegeye and Ortmann (2016) reported that crop diversification was negatively influenced by the level of educational achievement of the household head in the midlands of KwaZulu-Natal.

On the other hand, smallholders in the least developed countries are characterized by low income, low savings and consequently low capital formation and continual dependence on government assistance (Sogo-Temi and Olubiyo, 2004). Hence, they rely on government assistance for the procurement of inputs that are necessary to increase productivity and modernizing farming practices. A study conducted in Ghana revealed that access to credit services found to encourage crop diversification practices (Aneani *et al.*, 2011). An analysis using Tobit model on diversification of cropping pattern also revealed that access to institutional credit services significantly and positively influenced crop diversification especially towards the high-value crop by facilitating the use of improved technologies and all the necessary production factors (Mandal and Bezbaruah, 2013). Accordingly, credit is assumed to capacitate smallholders to practice crop diversification by reducing liquidity constraints as most of the farmers are small and subsistence that is limited by the financial shortage. Although crop diversification is a strategy to reduce risks encountered by

household, its adoption may be less due to its implication of achieving economies of scale and the costs it involves especially under unpredictable climatic conditions as compared to off/non-farm income (Bradshaw *et al.*, 2004). Accordingly, smallholders may opt to prefer off/non-farm income to overcome farm business risks. Therefore, off/non-farm income from other sources are anticipated to compete with crop diversification and hence, assumed to negatively influence the level of crop diversification. On the other hand, income from another source is expected to be used to finance input for the production of diverse and new crop species introduction as a result of income diversification.

Agricultural extension service is also playing a vital role especially in boosting the transfer of information and knowledge from innovation centres (institutions) and enabling the smallholders to clarify own goals and alternatives. Access to information and advice on cropping systems and agricultural commodity prices and means of transportation was found to positively affect diversification behaviour of smallholders (Bigsten and Tengstam, 2011). A study conducted in India also revealed that access to extension services contributing to the crop diversification level in flood-affected areas of India (Mandal and Bezbaruah, 2013). Similar results were reported from studies conducted in Ethiopia (Mesfin *et al.*, 2011; Mussema *et al.*, 2015).

Marketing group (input and output) commonly referred as cooperatives, local enterprises, producers' associations towards common purpose can benefit smallholder farmers (Wandschneider and Yen, 2007; Collins, 2011). Farmers, especially those who live in a scattered village, may cooperate and bulking their produce to improve access to input or output market (Giel, 2010) and hence increase income and efficiency (Robbins *et al.*, 2004). In this case, marketing group is hypothesized to encourage specialization and, hence negatively influence crop diversification.

Social capital (which captures social bonds/connectedness and norms/institutions) is also considered to facilitate corporation among members and reduces the transaction and transformation costs involved significantly (Pretty and Ward, 2001; Pretty and Smith, 2004; Poole *et al.*, 2013). Hence, social capital plays an important role in biodiversity and livelihood outcomes (Pretty and Smith, 2004). Moreover, smallholders' decisions are

influenced by group and community values and culture within the framework of incentives and constraints. Heterogeneity within households should also be considered in dealing with social capital aspects which involves significant organizational and individual learning besides to the traditional capitals such as land, asset and human capital (Poole *et al.*, 2013). Accordingly, social capital and membership in organized groups are assumed to positively influence smallholders' crop diversification decision.

The size of landholding has been one of the primary factors facilitating the process of agricultural growth, crop diversification and the intensity of diversification (Acharya *et al.*, 2011; Sichoongwe *et al.*, 2014). A study by Ashfaq *et al.* (2008) noted that the size of landholding found to influence crop diversification. In India, landholding was identified as one of the crucial factors influencing the level of diversification positively in different districts of West Bengal and Assam Plains (De and Chattopadhyay, 2010; Mandal and Bezbaruah, 2013). Studies from Ethiopia also reported that landholding size found to positively encourage diversification (Abay *et al.*, 2009; Mesfin *et al.*, 2011; Mussema *et al.*, 2013). Similar studies also reported that livestock positively influences livelihood diversification. The reason for the positive association between livestock ownership and diversification could be that the production of certain species enhances the supply of animal feed (Sanderson *et al.* 2013). Integrated crop-livestock also provides smallholders income stability during stresses or shocks (World Bank, 2018).

Ethiopia being a large country in terms of geographical coverage (about 1.1 million ha) has a wide range of agroecological zones and soil conditions that support a large variety of crops production (Bittinger, 2010). Thus, study conducted in Ethiopia confirmed that the farm physical characteristics have a significant influence on smallholders' crop diversification decision or livelihood strategy which in turn is determined by the agroecology (Benin *et al.* 2004; Deressa *et al.* .2009). Another study conducted in Northern Ethiopia reported that agroclimatic features of the site (altitude, rainfall, temperature) had a significant and positive impact on diversity and area allocation of barley (Abay *et al.*, 2009). According to Freeman *et al.* (2014), diversification practices are more robust in intermediate rainfall and variability areas and suggest crop diversification to be followed in an environment of high uncertain productivity. Crop rotation (crop sequencing) is also

a practice used by smallholders to improve the soil quality and biodiversity as well as suppressing plant pathogens (Eisenhauer, 2016). According to the author, the practice involves the planting of different crops in a given period and location increases crop diversity as well as yield. Hence, the use of crop rotation is assumed to be associated positively to crop diversification.

2.3.2 Determinants of income diversification

Though they are mainly peasants, the majority of rural households in Ethiopia drive income from diverse sources as a coping mechanism to various risks and escape poverty or income variability. The motives and opportunities (push or pull factors) for diversification significantly varies across the farming communities. Farming experience, years of education, gender (female-headed), access to extension services, and asset owned were found to be associated with household income diversification in Western Ghana (Agyeman *et al.*, 2014). According to the authors, the influence of age is negative while the others were positive drivers of diversification. A study conducted in Vietnam also shows that age (which stands for farming experience), gender (male-headed), household size, education, access to credit and distance from the market are positively influencing income diversification (Hung *et al.*, 2010). Stifel (2010) also reported that education, formal credit and information technology influencing income diversification positively in Madagascar. Agricultural shocks also motivate the household to participate in non-agricultural earnings (Porter, 2012).

Large farm size was also found to be positively influencing household income diversification (Wanyama *et al.*, 2010). Institutional factors such as land ownership and security as well as membership in cooperatives significantly influencing income diversification of households in Ethiopia (Kassie *et al.*, 2017). The other study from Ethiopia shows that dependency ratio, female-headed, owing to the poor quality of land found to be associated with low participation in off-farm activities (Lemi, 2009). Female-headed with more family size were found to diversify their source of income (Javed *et al.*, 2015). Another study also confirmed that households' asset endowments, demographic factors, access to rural towns and perceptions on food security status were important factors

influencing diversification (Alobo Loison, 2015). Gender (male), education and access to credit found to increase the possibility of income diversification in Nigeria while farming experience and access to market acting against diversification (Akaakohol and Aye, 2014).

Income diversification (participation in non/farm employment) is found to be influenced by gender, age, size of active labour, education achievement of the household head, livestock and cultivated farm size, proximity to market (Demissie and Legesse, 2013). Age and gender were found to be important determinants of household participation in non-farm income activities (Ogbonna Chinwe, 2015). A study from Peru indicated that education, credit, and access to the road are important variables that influence the participation of household in non-farm income (Escobal, 2001). Similar finding from Kenya also shows that education level, access to credit and membership in associations are important factors determining household income diversification behaviour of fishing communities (Olale and Henson, 2012). Other researchers also identified that diversification is driven by limited resources (labour and land) to generate income that sustains livelihood (Minot, 2006); to reduce risks associated with missing financial markets (Barrett *et al.*, 2005); to exploit the complementarities between enterprises or activities; and to generate cash income to overcome liquidity constraints as a result of credit shortage or financial market failures (Barrett *et al.*, 2001b). As indicated by Abdulai and CroleRees (2001), households in remote areas have low opportunity to participate in non-crop than their counterparts, while education is positively contributing to the participation in non-farm income-generating activities.

In general, households or individual's income and activity diversification decisions are driven by multiple forces which are categorized as "push or pull" factors (Barrett *et al.*, 2001b). According to the authors, the push factors are the reaction to various risks including liquidity constraints, transaction costs, climatic uncertainties, diminishing returns to factors such as family labour as a result of limited access to farming land emanating from the increasing population size and/or fragmented landholdings. The pull factors include household's motivation to realize strategic complementarities that exist between activities including crop-livestock integration, milling and hog production or technological, skill and endowments.

2.3.3 Determinants of commercialization

Commercialization occurs in the form of marketable surplus output production as well as increased use of purchased input (von Braun *et al.*, 1994; Pingali and Rosegrant, 1995). At the farm level, the movement from subsistence to commercial-oriented production is influenced by various socio-economic, institutional and agroecological factors. Most of past studies emphasized that smallholders' commercialization level is mainly linked with household characteristics, institutional factors, access to urban centres (market places), access to financial services (credit), conducive production environment and access to production inputs such as (labour, fertilizer, and farm size).

According to Nepal and Thapa (2009), farmers' personal characteristics which include education, gender and ownership of production assets are among forerunner factors influencing smallholders' commercialization. The market participation of female farmers is lower than their male counterparts (Carletto *et al.*, 2017). Mmbando *et al.* (2015) based on a study conducted in Tanzania reported that market participation and the marketed surplus is greater for male farmers. Education also plays a crucial role in improving farmers' negotiation capacity (Zivenge and Karavina, 2012; Tufa *et al.*, 2014). A study from Ethiopia and Tanzania revealed that education positively influencing smallholders' market participation (Omiti *et al.*, 2009; Gebremedhin and Jaleta, 2010b; Mmbando *et al.*, 2015). Farming experience is also one of the factors influencing household output market participation. Farmers with more experience have better accounts of the prevailing climatic patterns and, hence, may prioritize on ensuring household food security and may emphasis on the production of major food crops. According to Stuver *et al.* (2004), farming experience helps to balance agricultural change processes towards desired outcomes. Studies from Madagascar and Nigeria reported the positive influence of farming experience on smallholders' commercialization behaviour (Agwu *et al.*, 2013; Okoye *et al.*, 2016). The relationship between commercialization and dependency ratio is negative since the household is expected to require more to consume rather than what they supply to the market (Randela *et al.*, 2008). A similar study from Ethiopia reported that dependency ratio is negatively associated with household commercialization (Bekele and Alemu, 2015).

Availability of improved agricultural technologies (improved seeds and agronomic practices) are key factors that facilitate agricultural commercialization process (von Braun *et al.*, 1994; Van Dusen and Taylor, 2005; Nepal and Thapa, 2009). On the other hand, unaffordability of production inputs remains a challenge to smallholders. In line with this, credit access is one of the important factors to relax liquidity constraint to finance investment in productivity-enhancing agricultural inputs. Finding by Gebremedhin *et al.* (2009) and Abafita *et al.* (2016) reported the positive association between access to credit on household fertilizer and other chemical use. A study conducted in Kenya also reported that availability of credit increases household horticultural crops export market participation (Muriithi and Matz, 2014).

A study from Ethiopia uncovered that productive assets such as land, livestock and value of other durable assets endowments improving the production, probability and extent of food crops marketing participation by reducing the shadow price of food (Pender and Alemu, 2007b). Land size is one of the key physical production resources found to enhance household market participation (Zivenge and Karavina, 2012; Tufa *et al.*, 2014; Abafita *et al.*, 2016). A study from Ethiopia shows that livestock ownership positively contributing to market participation level of household (Tufa *et al.*, 2014). Land and livestock are important factors enabling the production and productivity of smallholders and teff and maize output market participation in Ethiopia (Pender and Alemu, 2007; Bekele and Alemu, 2015). According to Barrett (2008), land, livestock, capital and improved technologies are important to produce surplus outputs for the market. Besides, the value of an asset is found to positively influence the household's commercialization initiatives (Chirwa and Matita, 2012; Olwande and Mathenge, 2012).

Income from various sources also plays an important role in overcoming a household's financial limitations. It serves as a financial intermediary to relax liquidity constraints of the household and keep stock of the current produce until the price gets better. It can also increase smallholders' consumption being used to smooth consumption and risk management (Bekele *et al.*, 2011; Okoye *et al.*, 2016; Woldeyohanes *et al.*, 2017). Hence, it is assumed to influence the household commercialization behaviour either positively as it reduces the financial constraints or negatively as it also increases household consumption

level. Similarly, Alene *et al.* (2008) noted that non-farm income can contribute to market participation if invested in productivity-enhancing technologies. Ethiopian smallholders live in remote and dispersed villages with low access to infrastructure and weak institutions that further results in high transaction costs and influencing surplus production and market-participation decisions. Some of the transaction costs include physical costs namely transportation and packaging costs while other costs are related to informational asymmetries and contract enforcement problems (Pingali *et al.*, 2005). Transaction costs (in this case captured by market distance) is negatively associated with smallholders' market participation and commercialization (Key *et al.*, 2000; Barrett, 2008; Mmbando *et al.*, 2015).

Those with adequate assets, access to infrastructure and faced with potential market incentives engage actively in markets (categorized into fixed and variable transaction costs) while those who do not have one or more of the three factors do not (Barrett, 2008; Barrett *et al.*, 2012). According to Jaleta (2007), access to market outlets and market information are important factors to influence smallholders' labour and land allocation decision towards cash crop production in Ethiopia. Distance from nearest market centres is found to result in lower market participation (Omiti *et al.*, 2009; Gebremedhin and Jaleta, 2010b; Mmbando *et al.*, 2015; Okoye *et al.*, 2016). Hence, distance from market centres is assumed to influence smallholders' commercialization behaviour negatively.

Reduced transaction costs can also influence the size of the market for agricultural input distributors and retailers that further enhance smallholders' production and productivity (Pingali *et al.*, 2005). Membership in farmers' organizations (defined earlier) have been considered to be one of the possible strategies to minimize the challenges and inefficiencies in the rapidly changing market environment (Markelova *et al.*, 2009; Muriithi and Matz, 2014). Membership of cooperatives was one of the factors that facilitate stallholders' cassava market participation in Madagascar (Olwande *et al.*, 2015; Okoye *et al.*, 2016).

A qualitative data analysis result from Ghana uncovered that with the right attitude and exposure, there was a probability for small-scale farmers to increase their farm size and level of market participants irrespective of initial farm size (Chapoto *et al.*, 2013). Market

orientation behaviour, therefore, is found to be one important factor deriving smallholders input market participation (Gebremedhin and Jaleta, 2010a; Abafita *et al.*, 2016). A study conducted in Ethiopia revealed that extension service found to be effective in promoting market orientation since it is instrumental to promote improved production and productivity by improving access to information on improved technologies, the supply of market information, improving farmer skills through training, and facilitating the farmer-buyer linkages (Gebremedhin and Jaleta, 2010a). Accordingly, access to agricultural extension services is expected to enhance the production and productivity of market surplus.

Another important factor influencing smallholder market participation can be the use of cropping systems (crop diversification, intercropping and crop rotation). As indicated earlier, crop diversification is the movement of smallholders' production decision from producing major food crops to crop species that have high market value. Intercropping and crop rotation are also important cultural practices that can contribute to sustainable crop production and productivity. A study conducted in Bolivia found that the cropping systems are associated with household output market participation level (Vadez *et al.*, 2004). Another study revealed that diversification gives smallholders to select crop type to produce for a given growing season and hence, can lead commercial production (Dorsey, 1999).

2.4 Welfare impacts of crop and income diversification

Crop diversification has been used as an adaptation strategy to explore opportunities, minimize risks of income variability (smoothing consumption) and improve households' welfare (Ellis, 2000; Akaakohol and Aye, 2014). Accordingly, studies that have been conducted to examine the influence of crop and income diversification on individual household welfare are discussed below.

In terms of crop diversification impacts on household welfare, studies show that the relationship between the level of crop diversification and the probability of being in poverty is found to be low although the effect declines after a given threshold of diversification

level (Lin, 2011; Birtal *et al.*, 2015). Introduction of crop diversification (inclusion of potato, mungbean, clover and rapeseed) into a wheat-rice system resulted in high productivity and profitability of the household over the rice-wheat system (Sharma and Sharma, 2005). Crop diversification has resulted in attractive financial return particularly to smallholders in Thailand and South East Asia (Kasem and Thapa, 2011).

Makate *et al.* (2016) using data from 500 respondents estimated the effect of crop diversification on two important outcomes namely productivity and adaptation to climate change. According to the authors, diversification is viable climate-smart agriculture significantly enhancing productivity and improving the resilience of smallholders. Analysis of crop diversification effect on rural household's nutrition (dietary diversity) and income in eight developing countries was found to be positive (Pellegrini and Tasciotti, 2014). Studies from Ethiopia also reported diversification positively contributing to productivity and reducing yield variation (Di Falco and Chavas, 2009; Di Falco *et al.*, 2010; Bangwayo-Skeete *et al.*, 2012). However, diversification doesn't seem to reduce yield-related downside risks (Bangwayo-Skeete *et al.*, 2012).

Diversification can also contribute to sustaining crop and livestock production as well as ecosystem services such as biodiversity conservation and efficient nutrient cycling (Sanderson *et al.*, 2013). Michler and Josephson (2017) using panel data from Ethiopia reported that growing diverse crops reduces the probability of being poor, falling into poverty and remaining poor as compared to specialization. Crop diversification can also provide smallholders with an opportunity to identify a crop or crops with higher market demand for production (Dorsey, 1999; Tipraqsa and Schreinemachers, 2009) and increases the volume of crop sale (Pellegrini and Tasciotti, 2014). In general, diversification increases initially as the market increases followed by specialization after market size reaching a certain level of threshold (Pingali and Rosegrant, 1995; Timmer, 1997; Emran and Shilpi, 2008). Other studies also reported that crop diversification enhances technical efficiency implying that it increases intensification (Coelli and Fleming, 2004; Haji, 2007; Ogundari, 2013; Nguyen, 2017).

In contrast, Czyżewski and Smędzik-Ambroży (2015) and Rahman (2009) argued that diversified farming is more environmentally sustainable with lower economic efficiency as compared to specialization. Another finding also supports a substantial reduction of technical efficiency due to crop diversification (Llewelyn and Williams, 1996; Haji, 2007; Nguyen, 2014). These mixed results indicate the effect of crop diversification on smallholders' agricultural productivity to vary across locations. Besides, most of the past studies were based on small sample size, limited geographical areas (mainly in highland areas) and cross-sectional data.

Farm income diversification has also become one of the important determinants of farm household well-being. Households diversify their income in response to farm income risks by engaging in non-farm activities (Jetté-Nantel *et al.*, 2010). The study also suggested that farm income diversification is an important policy instrument towards income stabilization as alternative risk management strategy. Another study by Wan *et al.* (2016) in China shows that income diversification plays an important role in enhancing the resilience of smallholders to drought and stabilize livelihood systems. In Nigeria, income diversification is positively associated with household welfare (Akaakohol and Aye, 2014; Daud *et al.*, 2017). The non-farm income also plays an important role to smoothen household consumption during agricultural shocks (Porter, 2012). The study from Nigeria found that household income diversification can play both risk management and income enhancing role (Babatunde and Qaim, 2009).

A study which analyses the change and implications of income diversification in Zimbabwe using two round national survey data reported that households with a more income diversification are more resilient to the unfavourable weather shocks and policy changes (Ersado, 2003; Ersado, 2006). The study further indicated that better-off households were found to diversify more as compared to the poor households who are more vulnerable to economic changes. A study conducted in Ethiopia reveals that poor households relatively rely more on non-farm income with low earning activities due to entry barriers as compared to non-poor who participate in more profitable off-farm income sources (Sisay, 2010). The result further implies that the poor participate in non-farm income-generating schemes due to the push factors while the relatively reach households

participate in better earnings because of the pull factors or opportunities. Accordingly, the off-farm income activities are being followed as a strategy to minimize risks (safety-net) by the poor households due to entry barriers while the highly educated or skilled individuals are involved in high paid jobs or becoming self-employed in rural non-farm activities with high return (Woldehanna and Oskam, 2001). A similar result was reported by Block and Webb (2001) indicating that better-off households found to diversify their sources of income that result in greater income and calorie intake. Having access to non-farm employment had resulted in a higher and positive effect on household income in the highlands of Ethiopia (Holden *et al.*, 2004). In contrary, the authors reported that improved access to non-farm income has resulted in reduced farm input use and low crop and livestock production resulting in low motivation of the household to invest in soil conservation practices which further leads to soil loss and land degradation. A study from Madagascar reported that high return to non-farm income is an important means to be out of poverty (Stifel, 2010).

Income diversification can also play a role in smallholders' commercialization process. Off-farm income was identified as an important source of the smallholders' agricultural commercialization process (Alene *et al.*, 2008; Okezie *et al.*, 2012). Bezu *et al.* (2012) also reported a positive association between non-farm and household consumption expenditure. It is assumed to play a positive role in on-farm investment as it can be used to overcome the challenges of the imperfect rural and agricultural financial market (Oseni and Winters, 2009). On the other hand, Woldeyohanes *et al.* (2017) and Kan *et al.* (2006) reported that non-farm income negatively influencing output market participation implying that household uses the non-farm income for consumption smoothing than overcoming liquidity constraint to invest in agricultural production that increases market surplus.

Non-farm income was also found to be positively impacting on household livestock investments of market-oriented households in Albania which are more capital intensive (Kilic *et al.*, 2009). It can also compensate for the poor harvest and enabling stability of household consumption and income under risk conditions since it is not subject to covariant risks associated with agricultural sector (Barrett *et al.*, 2001b). This is in line with the theory that suggests non-farm earnings leads to low relatively risk aversion behaviour

leading to high-return/high-risk activities and also providing liquidity for farm expenditure in the absence of credit and insurance market for long term investment (Kilic *et al.*, 2009).

As discussed above, empirical studies were conducted to examine the role of agricultural diversification (crop and income diversification) and the effects on household welfare. The findings revealed that crop diversification can play a positive role in improving crop productivity. Similarly, income diversification is expected to play an important role in smallholders' welfare improvement (income increase and reduction of vulnerability). However, the findings have revealed mixed outcome as diversification can play an important role in risk management and welfare improvements of rural households, it can also affect the motivation to invest in farm production enhancing inputs. Most studies made also used the share of nonfarm income as a proxy indicator of income diversification. The majority of literature is also outdated and were carried out mainly using cross-sectional data and/or small sample size on the welfare impacts of diversification in relation to income variability, economic transformation (commercialization) and vulnerability to shocks. Hence, this study tries to analyze the factors determining diversification (crop and income) as well as the impact of diversification on welfare measured in crop productivity, income and income variability (vulnerability) and commercialization behaviour. Section 2.5 below discuss on the exogenous and endogenous drivers of diversification and commercialization behavior of smallholder farmers.

2.5 Conceptual framework of the study

Rural households follow different livelihood strategies based on their circumstances. The livelihood strategies can result in different outcomes such as food security, income stability (low vulnerability to shocks), sustainable and natural resource management (Scoones, 2009). According to Scoones, the livelihood strategies can take the form of agricultural intensification/extensification, diversification and/or involvement in wage employment (agricultural or non-farm), own business (petty trading, small-scale production, migration and others). As explained above, the livelihood strategy choice of the rural household is driven by the complex relationship between the exogenous and endogenous factors. Figure 2-1 briefly presents the summary of smallholders' livelihood drivers.

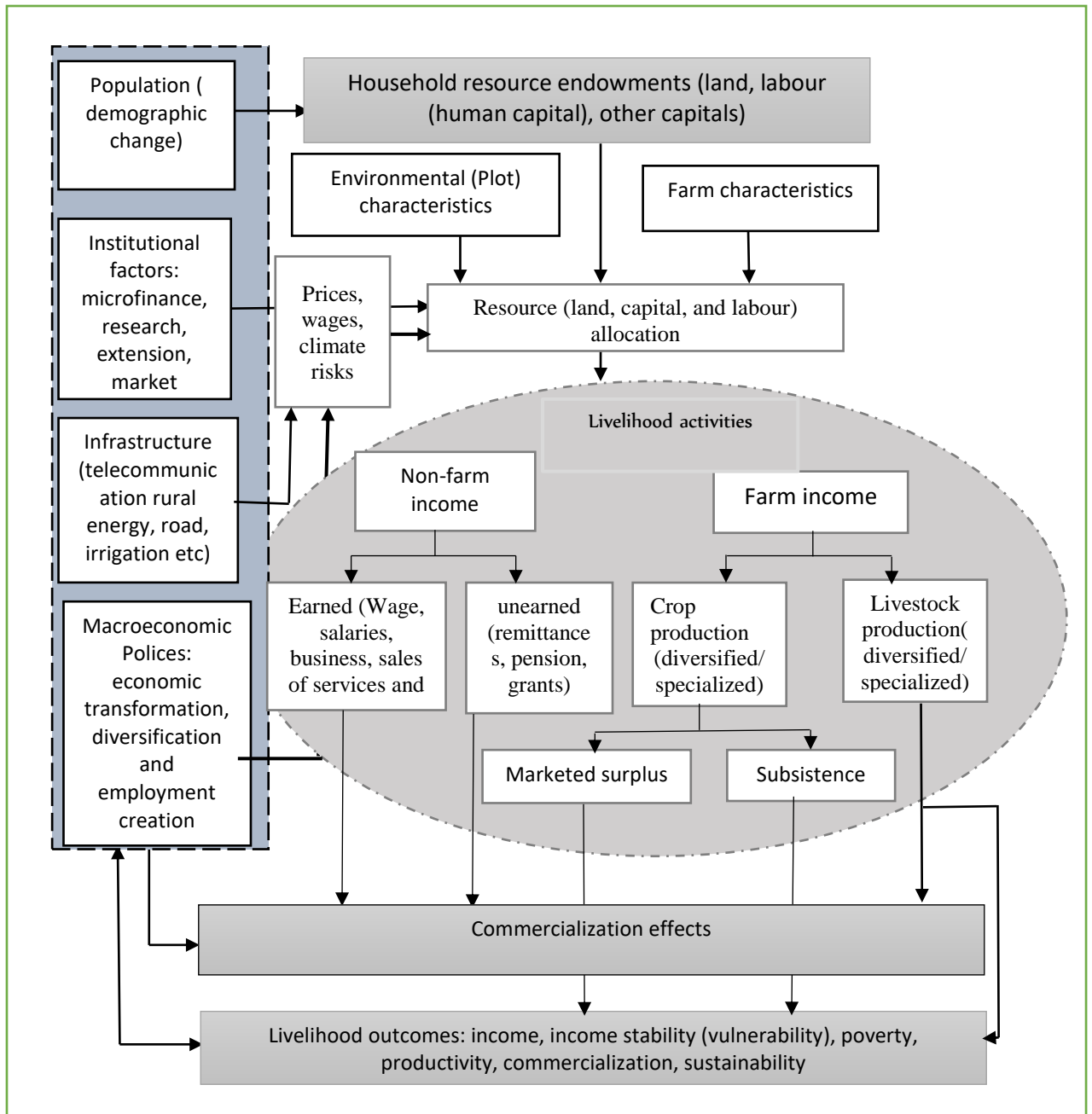


Figure 2-1: The link between diversification, commercialization and welfare
 Source: Adapted from Scoones (1998) and von Braun *et al.* (1994)

The exogenous factors namely population (demographic) change, institutional factors (research, extension, financial and market), infrastructure and policies that influence household decisions are listed in the left side of the figure and briefly discussed below. Some of the factors may have immediate influences on the rural livelihood while others may have long term influences (von Braun *et al.*, 1994). On the other hand, household

characteristics which include farming experience, education, gender, family size (dependency ratio), production objective (subsistent or market-oriented, social capital and wealth status) are considered to be endogenous factors affecting household decision making as discussed earlier.

Population (demographic) changes are one of the key factors determining smallholders' decision and livelihood strategies. The population change implies the possible expansion of land for cultivation which is currently a rare possibility and influencing demand for agricultural output (von Braun *et al.*, 1994; Josephson *et al.*, 2014). According to the authors, the increased population to land ratio may also result in declined farm income and increased demand for alternative income sources to sustain household food security. It can also result in increased intensification and fertilizer use which increases production costs. Increased population growth is also associated with the increased value of land which further results in tenure insecurity (Josephson *et al.*, 2014).

The other exogenous factor which constrains smallholder's agricultural production and livelihood strategies is the development and access to rural infrastructures. The development and access to infrastructures such as irrigation schemes, road, communication facilities, rural energy and others play important role in facilitating smallholders' activities and access to input and output market that enhances the production and productivity. It further results in market-oriented production (production of high-value crops) and broadening ranges of products for market supply (Satish, 2007). According to the author, the expansion of rural infrastructures contributes to substantial production cost and poverty reduction. The expansion of rural infrastructure also leads to the development and expansion of non-farm income-generating activities, and hence, promoting the backward and forward linkages for optimal resource use.

Rural development policies are also exogenous factors and mainly intended to provide an enabling environment and resources to the success of rural development projects or programme (von Braun *et al.*, 1994; Miller, 1995). Trade, employment creation, land and labour markets, exchange rate, national development goals (for example economic transformation), production and export diversification, social security, sustainable

agricultural production and natural resource conservation are among the macro/agricultural sector policies influencing and shaping rural economic performances (Vink, 2010). The policies aim at institutionalizing the development programme and improving the level of credibility and legitimacy for sustainability (Miller, 1995). Accordingly, the policies play an important role in defining smallholders' livelihood perspectives (sustainability: stability, resilience, durability and robustness) and strategies (Scoones, 2009). In general, policies play an important role in reinforcing and speeding up the changes in rural areas including the technological development, diffusion, and improving the overall institutional performances. Accordingly, smallholders' income and crop diversification and commercialization behaviour are determined by those endogenous and exogenous factors as outline above.

2.6 Summary

The literature reviewed above discussed the concepts of smallholders, diversification (crop and income) and commercialization. Besides, assessment of empirical findings (mainly from developing countries) was made on the determinants of diversification and commercialization as well as the relevance of diversification to household welfare. The reviewed literatures indicated that several factors including household characteristics (experience, education, gender, dependency ratio/family size), access to credit, market and extension services, assets (livestock, land and other household assets ownership), social capital (farm organizations), and agroecological factors to be important in influencing diversification and commercialization. Empirical evidence further showed that both crop and income diversification have a substantial contribution to risk management and welfare improvement of rural households. However, it has been noted that diversification can be negatively associated with household welfare. In general, income and crop diversification as well as commercialization of smallholders are driven by a complex relationship between exogenous and endogenous factors.

The following three chapters present the research procedures and empirical findings of this study aiming to address the three specified research objectives.

Chapter 3: CROP DIVERSIFICATION AND PRODUCTIVITY IN SEMIARID AND SUB-HUMID MAIZE-LEGUME PRODUCTION SYSTEMS OF ETHIOPIA

3.1 Introduction

This chapter analyses crop diversification and its influence on household crop productivity. The CRE fractional probit and pseudo fixed effect model (PFE) models employed to analyze diversification and crop productivity, respectively. The results give an insight on the focus areas in promoting crop diversification efforts and improving its contribution to productivity.

The rest of the paper is structured as follows: the following section (3.2) gives an overview of the analytical framework; Section 3.3 discusses the research methodology followed by the empirical results and discussion (3.4); while the last section (3.5) is summarizing the chapter.

3.2 Analytical framework

Agricultural production is subject to complex socioeconomic and environmental constraints. Households' decision is to ensure a balance between production, consumption and labour input (Singh *et al.*, 1986). As stated by Alene *et al.* (2000), based on past empirical evidence and microeconomic theory, household production and consumption decisions are non-separable, implying that farm households cannot independently maximize profits as a producer and utility as a consumer. Smallholders use their agricultural products for own consumption and sell the remainder for the procurement of non-agricultural items. According to Singh *et al.* (1986), market failure is the main reason for the non-separable decisions of households.

Smallholders in the study area simultaneously grow various combinations of crop species of both improved and locally adapted varieties of maize, legumes, teff, wheat, and other cereals and horticultural crops. Farmers' production decision objectives go beyond profit maximization, comprising multiple objectives, namely profit, risk and crop complexity

(Van Dusen and Taylor, 2005). As stated by Singh *et al.* (1986), the objective of smallholder agriculture households is to maximize utility as consumers, unlike the traditional theory of profit maximization.

The model specification for this study follows Cavatassi *et al.* (2012) and Hitayezu Hitayezu *et al.* (2016) who derived it from crop diversification in relation to various production constraints. Farm household utility maximization (U) can be modelled by using the consumption from own production of crops X_i , where $X_i = X_1, X_2, \dots, X_n$, and purchased products, N_{gs} , leisure time, L_h (equation 3.1). Accordingly, the optimization model within a year is as follows:

$$\begin{aligned} \text{Max} U &= U((X_p, N_{gs}, L_h) \\ &Q_x, Y, L, A, u_i \end{aligned} \quad (3.1)$$

$$Y = f(y + P_x(Q_{xi} - X_i) + P_c, N_{gs}) \quad (3.2)$$

$$Q_x = f(L, A, z^{hh}, z^s, z^i, z^p, z^e) \quad (3.3)$$

where Y is the expenditure of goods and services (consumption expenditure); y is nonfarm income ($y = y_1, y_2 \dots y_n$); P_x is price of produced output, and P_c is price of purchased goods. Maximized household utility is subject to budget constraint (equation 3.2), which is a total of consumption of own-produced marketable product (X_i), purchased non-agricultural products (N_{gs}), income from non-farm labour (y), as well as production constraints (equation 3.3), where the quantity produced (Q_x) by the household is a function of endowed labour (L) and land (A) (assuming non-functioning labour and land markets), unobservable household characteristics (z^{hh}), socioeconomic factors (z^s), institutional factors (z^i), plot characteristics (z^p) and production environment (z^e).

Based on Cavatassi *et al.* (2012) and Hitayezu Hitayezu *et al.* (2016), the optimum labour and land allocated for crop production are defined as (equation 3.4):

$$L_i = L_i^*(L, A, P_x, P_c, z^{hh}, z^s, z^i, z^p, z^e) \quad (3.4)$$

$$A_i = A_i^* (\bar{L}, \bar{A}, P_x, P_c, P_{hh}, z^s, z^i, z^p, z^e) \quad (3.5)$$

The optimal level of resources (land and labour) is the function of initial endowments, prices, individual household characteristics, production environment, non-agricultural economy, and social capital. The optimum level of output (Q^*), using input (land and labour) and other factors, is:

$$Q_i = Q_i^* (\bar{L}, \bar{A}, P_k, P_1, \dots, P_n, z^{hh}, z^s, z^i, z^p, z^e) \quad (3.6)$$

According to Van Dusen and Taylor (2005) and Cavatassi *et al.* (2012), households do not value diversity as it is. Crop diversification is valued based on its contribution in minimizing crop failure and price risks for sustainable productivity. The outcome from diversity is the consequence of individual household behaviour in relation to resource choices and allocation to different crops of interest. Accordingly, diversification (D), as a derived demand, is expressed as follows (*equation 3.7*):

$$CDI_i = CDI_i^* (\bar{L}, \bar{A}, P_k, P_1, \dots, P_n, z^{hh}, z^s, z^i, z^p, z^e) \quad (3.7)$$

The results from the model described above indicate that crop diversification and crop productivity are determined by initial resource endowments (land and labour), output and input prices, farm household characteristics, formal and informal institutional setups, non-agricultural economy, plot characteristics and agroecological conditions.

3.3 Research methodology

3.3.1 Measuring the response variables

The dependent variables of the study are crop diversification and crop productivity. Two main approaches (counting the number of crops/species grown on the farm and the concentration/diversification indices) could be used to measure the first dependent variable (level of crop diversification). However, diversification was mostly measured by way of diversification indices. The choice of indices depends on the nature of the research

questions, of which the commonly used measurement indices include Simpson (Joshi *et al.*, 2004), Ogive and Composite Entropy Indexes (De and Chattopadhyay, 2010), Modified Entropy (Mesfin *et al.*, 2011), Shannon-Weaver or Entropy (Hitayezu *et al.*, 2016) and others.

Compared to counting the number of income sources, the two methods capture both the balance and sources of income (Ersado, 2006). For this study, the Simpson indices (SID) which measures both acreage proportion and crop species, was employed (Malik and Singh, 2002). Following Kurosaki (2003) and Malik and Singh (2002), crop diversification index (CDI) measurement process is outlined as follows:

$$CDI_{it} = 1 - HI \quad (3.8)$$

where CDI_{it} is the Simpson indices of crop diversification (CDI) by the i^{th} farmer at time t ; and HI is calculated as:

$$HI = \sum_{i=1}^n P_{it}^2 \quad (3.9)$$

where P_{it} stands for the proportion of the i^{th} crop area of the total cropped land. The value of CDI_{it} is expected to vary between 0 and 1. As the values get closer to one, the level of diversification increases, while values approaching zero indicates an increase in specialization.

Partial productivity is considered to measure the crop productivity instead of the total factor productivity (TFP) where the land productivity alone is considered. Productivity can be estimated directly or indirectly. The direct estimation is measured as the ratio of quantity produced to the total plot area operated (Yao, 1996; Pingali and Heisey, 2001; Di Falco *et al.*, 2010), while the indirect measurement is the ratio of monetary value of crop produced to total plot area operated (Dayal, 1984; Gebremedhin *et al.*, 2009; Davis *et al.*, 2012). Each approach has its own limitations and strengths. In this study, the log function of the total value of crop produced per hectare (ha) is used, as it reflects the ultimate welfare impact on households and is easier to compute. The price was adjusted by using the

consumer price index with 2010 as foundation year, based on the respective year consumer price index (World Bank, 2016).

3.3.2 *Econometric estimation approaches*

The analytical approach for the crop diversification and productivity are discussed below under section 3.3.2.1 and 3.3.2.2.

3.3.2.1 Fractional probit model

Crop diversification is a fractional response variable having the value bounded between 0 and 1. Bounded continuous variables are usually estimated using censored models, mainly the Tobit model. The Tobit model estimation result is consistent under the assumption of normally distributed random error (Loudermilk, 2007). However, the use of the Tobit model is not appropriate as it may generate predicted value greater than one in the presence of excess ones and hence could result in inconsistent estimation (Baum, 2008; Schwiebert and Wagner 2015). For consistent and relatively efficient estimation, Papke and Wooldridge (2008) suggest a fractional Probit model over a fractional logit model for short panel data with large cross-sectional observation for consistent and efficient estimation, while allowing for time-constant unobserved effects to be correlated with explanatory variables. Hence, in this paper, a fractional correlated probit model is applied. Following Papke and Wooldridge (2008), the equations are structured as follows:

$$E(CDI_{it} | X_{it}, C_i) = \Phi(X_{it}\beta + C_i) \quad (3.10)$$

where $i = 1, 2, 3 \dots n$; and $t = 1, 2$

$$C_i = \alpha_i + \mu_i, \text{ and } \mu_i | X_{it} \sim \text{Normal}(0, \delta^2) \text{ and } \delta^2 = \text{var}(C_i | X_{it}) \quad (3.11)$$

where CDI_{it} , representing crop diversification index, takes the value $0 \leq D_{it} \leq 1$; X is a vector that includes time-constant observed variables across i as well as variables that vary across i and t ; and $\Phi(\cdot)$ is a standard normal distribution function; C_i is capturing unobserved heterogeneity among the households; α_i is an intercept; and β is a vector of unknown parameters to be estimated.

The partial effects, known as average partial effects (APE), are estimated as:

$$\frac{\partial E(D_{it} | X_{it}, C_i)}{\partial X_{it}} = \Phi(X_{it} \beta + C_i) \quad (3.12)$$

for continuous variables; and

$$\Phi(X_{it}^{(1)} \beta + \alpha_i) - \Phi(X_{it}^{(0)} \beta + C_i) \quad (3.13)$$

for discrete variables where $x^{(1)}$ and $x^{(0)}$ are different values of the covariate.

3.3.2.2 Correlated random effects (CRE) model

On the other hand, crop productivity variable takes a continuous value and can be estimated using standard panel data estimators. Crop productivity is a function of crop diversification (index), demographic, socioeconomic and plot characteristics, and institutional factors. Based on Wooldridge (2010), the structural equation takes the following form:

$$Y_{it} = x_{it}\beta + \bar{x}\Psi + D_{it}\gamma + C_i \quad (3.14)$$

$$C_i = \alpha_i + \bar{x}\gamma + \mu_i \quad (3.15)$$

where the outcome variable Y_{it} represents crop productivity in the linear logarithmic functional form; CDI_{it} the crop diversification index; X_{it} a vector of exogenous explanatory variables (household demographics, economics, geographic, access to institutional services, and other related factors such as human capital, social capital and plot characteristics); β the vector of parameter estimates; γ the coefficient of diversification index; C_i the unobserved heterogeneity among households; \bar{x} the mean of time-varying variables (used to restrict the distribution of C_i); α_i an intercept; β a vector of unknown parameters to be estimated; Ψ a coefficient for the mean of time-varying variables; and u_{it} the idiosyncratic errors. The structural equation assumes the strict exogeneity of explanatory variables. However, D_{it} (the diversification index) was suspected to be an endogenous variable. To test the endogeneity of crop diversification, a control function approach suggested by Vella and Verbeek (1993) was employed. The approach involves a two-stage estimation processes: (1) the reduced equation for crop diversification (equation

3.10), which included the instrumental variable (credit access), was estimated using the fractional Probit model, and (2) the residual from the estimated reduced equation and the variable under test for endogeneity were included in the structural equation as indicated above (equation 3.14) for testing and control of endogeneity problem. The statistical significance of the coefficient (greater than zero) of the included residual confirms the endogeneity (alternative hypothesis) over the exogeneity (null hypothesis).

Should the endogeneity assumption be rejected, the structural equation can be estimated, as it uses standard linear panel data estimators, namely, Fixed Effect (FE) or Random Effect (RE) estimators. However, there is a trade-off in choosing between FE and RE estimators. In situations where the sample size is large and time (t) is short, the choice between the two models depends on the sample distribution assumption (Gujarati and Porter, 2009). In the case of FE, C_i is allowed to correlate with explanatory variables, while it is assumed to be uncorrelated in RE (Wooldridge, 2010).

However, in recent years, the correlated random effects (CRE), also called the pseudo-FE model, has become popular, since it allows for correlation between observed explanatory variables and unobserved individual effects. The CRE estimation approach, introduced by Mundlak (1978) and expanded by Chamberlain (1984), was followed by including the mean of time-varying independent variables in the regression equation as additional variables. The approach converges the FE and RE estimation techniques (Wooldridge, 2015). Accordingly, the two dependent variables were estimated using the CRE model, since it helps to estimate the coefficient of time-invariant variables.

3.3.2.3 Explanatory variables

Depending on empirical evidence, the following explanatory variables were included in the analysis of crop diversification and productivity. The descriptive statistics are presented in Table 3.1 while the detailed discussions and expected effects of each variable are presented below.

Demographic characteristics: gender (GENDER), farming experience (FARMEXP), farming experience square (FARMEXPSQ), the dependency ratio (DEPRAT), education

achievement (EDUCA) and social capital (SOCCAP) were used to capture individual-level heterogeneity. The relationship between household gender and diversification can take both signs (negative or positive). Considering diversification as one of the risk minimization strategies, female-headed are expected to diversify more like an adaption strategy to various risks emanating from policy changes or climate variability. On the other hand, male-headed households are found to diversify more (Kanyua *et al.*, 2013) which may be due to their access to information and services than female-headed.

The dependency ratio, capturing the number of household members below or above working age (age < 14 and age > 64) is also another factor anticipated to drive the production objectives towards diversification to minimize risks of food security. As crop diversification is one of the risk management strategies to sustain household livelihood and food security, a household with more dependency ratio is expected to diversify to sustain the household food security demand. Besides, it is also hypothesized to influence productivity negatively as household income is expected to be focusing mainly on household consumption than investing in production and productivity-enhancing inputs. Household education achievement (in years) is one of the important household characteristics influencing the capacity of information accessing, processing and use.

Accordingly, more education achievement could lead to specialization as the production objective is expected to be more market-oriented and productive. Experience in farming (in years) may help households to understand the risks and opportunities in agricultural production. Their decision is mainly ensuring the sustainability of production and supply. On the other hand, they are also expected to possess the skills and experience accumulated over the years and can be easily translated into productivity. Hence, in this study also experience is assumed to be positively associated with crop diversification and productivity. Social capital is used to capture the household social network measured in the number of memberships in an organized formal and informal social group. The role of social capital is also critical in resource and experience sharing among the farming community. It plays an important role in bioresources conservation and exchange among the society members and, hence, it is expected to influence diversification and productivity positively.

Access to institutional services: access to agricultural extension (FREXCONT) and credit services (CREDITA) as well as membership in organized input or output market groups (MEMBMG) are considered to capture access to institutional services. Regarding access to extension service (measured in frequency of extension contact), it is hypothesized to facilitate access to information on required crop species suitable for desired production objectives (diversification) or capacitating smallholders' production techniques/skills towards commercial production (specialization). Thus, access to extension services can have positively or negatively influence crop diversification. Access to credit service also plays an important role in curbing smallholders' financial constraints for production investment. Accordingly, access to credit service is assumed to improve the required production inputs and crop species. It is assumed to influence diversification towards high-value crops. On the other hand, membership in organized input and output market groups is also expected to improve access to information and exposure to input and output market which further encourage smallholders' market orientation production or specialization. Therefore, being a member of input or output market groups is anticipated to negatively influence crop diversification practice. The variables are also expected to be positively associated with crop productivity.

Production capitals: The study also hypothesizes that land (PAHO) and livestock (TLU) are key production assets influencing household production decisions. Larger farm size provides smallholders freedom of land allocation to different crop species. Some of the crop species might also be important animal feed and encourage farmers to diversify into forage crop species. Furthermore, income from livestock might also be used to finance the required production inputs for crop production. Livestock plays a multiple role in the livelihood of Ethiopian smallholder farmers as wealth indicator, wealth storage, and income generation role. Hence, operated land and livestock size are hypothesized to influence crop diversification positively. Non-farm income (OTHERINC) can play an important role in financing diversification towards high-value crops. It can also compete with diversification since it is one of the alternatives to overcome farm business risks. Hence, the association can be positive or negative.

Environmental factors: Agroecology (AGECO) represents various aspects of farming including physical and biological characteristics. Accordingly, agroecology is expected to influence the crop and species choices. Diversification is greater in an environment with high production risks environment since the production objective is mainly minimizing risks of production. Accordingly, AGECO is expected to negatively influence crop diversification. Crop rotation (ROTATION) is also one of the conventional farming practices towards pest and soil management practices. It is expected to influence crop diversification positively. Besides, asset value in the log-function form (LNASVAEQ), intercropping (INCROP), soil quality index (TSFS) are hypothesized to influence crop productivity and included in the productivity equation.

3.4 The results and discussion

3.4.1 Descriptive statistics of variables used in econometric estimation

Table 3.1 below reports on the definitions of variables and descriptive statistics of demographic, socioeconomic, institutional and farm characteristics, and environmental factors that are hypothesized to explain crop diversification and productivity. Annual descriptive statistics were given for continuous variables (Appendix 3.1).

Demographic characteristics

As indicated in Table 3.1, about 88% of the sampled respondent households were male-headed households indicating that the farming community are dominated by male-headed households. The average age of the respondents is about 41.6 years with a standard deviation of 13.6 while the farming experience is about 19.56 years. The average number of years of education was 3.12 for respondents and 1.21 for their spouses. This shows that male is more educated as compared to the female. The average household size of respondents was about 7 individuals, with an active labour force age between 14 and 64 and the average dependency ratio of 1.23. Regarding the social capital of the respondent households, a respondent is found to be a member of about three organized social groups on average. This further encourages smallholders' trust building and regular information and production resource exchanges.

Household wealth

The average number of livestock owned by sample households was about 6.4 in Tropical Livestock Unit (TLU). This shows that livestock is an integral part of the farming system. Landholding is also one of the important production factors that influences the livelihood of the farming community. The households in the study area own an operated farm size of about 2.23 hectares (ha) on average. This implies that the farming system in the area is mostly dominated by smallholders. Average crop value per hectare (ha) of respondents was about 6333 Ethiopian Birr (ETB) with standard deviation of about 6716 which indicates huge variability among the respondents in terms of productivity. On average the respondent households own an average asset value of about 10338 ETB with a standard deviation of about 71687. This also shows a significant variation among the households in terms of wealth status. Besides, about 38% of the respondents reported to own and use cellphone which could further facilitate smallholders' access to agricultural information. About 70% of the respondents have income from other sources (non/off-farm income).

Access to institutional services

Access to extension service is also vital in improving smallholders' access to agricultural technologies or public services. The result indicates that the respondent households have on average 20 contacts per annum with a standard deviation of 26. In measuring access to credit, respondents were asked whether credit is obtained for farming operation or not. Accordingly, only 23% of the respondents have access to production credit. This further entails that credit service provision is weak in the country. Only about 25% of the respondents are members of organized input and/or output market groups such as cooperatives. The market groups are expected to reduce transaction costs of market participation.

The result also revealed that smallholders' market access is limited. It takes about 100 walking minutes, on average, to reach the nearest main market centers which tells the level of transaction costs associated with input and output marketing.

Table 3-1. Variable definition and descriptive statistics

Variable	Description	Expected sign		Mean	SD
Dependent variables					
CDI	Diversification index [proportion data between 0 and 1]	-/+		0.57	0.20
LNCRPRCPI *	The total value of crop produced per ha			6333.55	6715.93
Explanatory variables					
AGE	Age of the household head (year)			41.60	13.62
FARMEXP	Farming experience of the household in years	+	+	19.36	11.88
GENDER	Gender of household head (male=1 and female=0)	-	+	0.88	0.31
DEPRAT	Dependency ratio of nonworking (age < 14 and age > 64)	+	-	1.23	0.86
EDUCA	Education of household head, year of school attendance	-	+	3.12	3.34
TLU	Total livestock owned in tropical livestock unit	+	+	6.38	0.17
SOCCAP ^a	Social capital: number of groups in which the household head is a member	+		2.67	0.03
PAHO	Plot area operated by the household in ha	+	-	2.23	0.05
FREXCONT	Access to extension service: frequency of contact with extension workers	-/+	+	19.6	26.00
CREDITA	Smallholders access to credit for agricultural input procurement during the season (1 = Yes, 0 = otherwise)	+	+	0.23	0.42
ROTATION	Household practicing cereal-legume rotation practice (1 = Yes, 0 = otherwise)	+		0.45	0.50
LNASVAEQ	The total value of an asset owned by household (linear logarithmic form)		+	10338.43	71686.72
OTHERINC	Income from other sources (dummy, 1 = Yes, 0 = otherwise)	-/+	-/+	0.70	0.47
MKTDIST	Distance to market in walking distance (walking minutes)	+	-	107.64	96.61
INCROP	Households practicing intercropping (1 = Yes, 0 = otherwise)		+	0.17	0.38
MOB	Ownerships of cell phone (1 = Yes, 0 = otherwise)		+	0.38	0.48
MEMBMG	Membership of input/output market group (1 = Yes, 0 = otherwise)	-	+	0.25	0.44
TSFS ^b	Soil fertility index (weighted mean)		+	1.73	0.915
YEAR ^b	Year dummy, 1 if 2013 and 0 if 2010	+	-/+		
AGECO	Agroecology (1 if sub-humid and 0 if semi-arid)	-	+	0.33	0.47

Note: Adult equivalent was measured following Dercon (1998). * indicates that total value of crop produced per ha is converted to log functional form in econometric estimation.

Source: Compiled by the author

Cropping systems and location dummy

Inter-cropping and crop rotation systems are also observed to be practiced by respondents. Accordingly, 17 and 45% of the respondents are found to practice inter-cropping and crop rotation, respectively. Furthermore, soil fertility index⁷ (weighted mean) is found to be 1.73, on average. Location dummy variable was included to capture the unobserved variation of agroecological effects that could affect household welfare. Out of the total respondents, about 66.6% are drawn from low moisture agroecological areas while the remaining are from high potential sub-humid agroecological zone.

3.4.2 Level of crop diversification

Based on the percentage of respondents, the five major crops are grown in 2010 in the study area (in decreasing order) were maize, teff, common bean, sorghum and wheat and, in 2013, it was maize, teff, common bean, and pepper. Maize covered 55% and 56% of the total plots in 2010 and 2013, respectively. Diversification was a conventional farming practice used as a mechanism for risk minimization, with little or no planned policy intervention. Depending on the level of diversification, households were grouped into four quartiles, as per their crop diversification (Table 3.2).

Table 3-2. Crop diversification level of sampled households

Crop diversification index	2010	2013	Total
Below 0.5	402 (47.07)	121 (14.17)	523 (30.62)
0.5 - 0.62	152 (17.8)	179 (20.96)	331 (19.38)
0.62 - 0.71	168 (19.67)	259 (30.33)	427 (25)
Above 0.71	132 (15.46)	295 (34.54)	427 (25)
Total	854 (100)	854 (100)	1708 (100)

Note: Numbers in parenthesis are the percentage of total sample

Source: computed from survey data

⁷ Soil quality index is constructed based on respondents' rating of their soil as poor, medium and good. Soil fertility, slope and soil depth were considered to capture soil quality.

Accordingly, 30.62% of respondents were found in the lower diversification category (the first quartile), 19.38% between the lower quartile and median, 25% between the median and third quartile, and the remaining 25% in the higher (above the third quartiles) diversification index. Furthermore, the diversity of crop species under production showed an increment during the second survey round (2013) as compared to the base year. This confirmed that the trend of crop diversification was increasing, which might be a consequence of the variety and frequency of production risks.

3.4.3 Econometric results and discussions

This section presents the results and discussions on factors determining crop diversification and its influence on crop productivity using CRE fractional probit and pseudo-FE regression models. Repeated model specifications were carried out, starting with full model and dropping non-significant explanatory variables to identify the best fit model. Functional form tests were done to detect the general functional form misspecification of the models, using Ramsey's regression specification error test (RESET) for the linear model, and a goodness-of-functional form test (GOFF-I and GOFF-II) for testing fractional probit regression model (Ramalho *et al.*, 2011). Given that the GOFF-I and GOFF-II tests do not reject the fractional probit model at a significance level at less than 10%, the probit model is maintained as a preferred model.

3.4.3.1 Factors determining crop diversification

The result of the fractional probit model (using equation 3.10) is presented below. Most of the estimated coefficients reflect the expected signs. The heteroscedasticity test carried out using Breusch-Pagan /Cook-Weisberg test shows the presence of heteroscedasticity at less than 1% significance level. The robust standard errors were used to adjust for heteroscedasticity. The overall test statistics show that the model used to estimate the crop diversification and its determinants fitted the data well, with $\chi^2(18) = 260.44$ and $P = 0.000$. The estimated result shows that diversification of crop/varieties of the desired attributes is triggered by heterogeneity of the farming systems and farmers' characteristics. Table 3.3 shows that the coefficient estimates of education, gender, farming experience, membership

of market groups and income from other sources have negative signs, while the remaining variables have a positive influence on diversification. Out of the variables found to have significantly influenced diversification, agroecology coefficients has sign opposite to the prior expectation.

Table 3-3. Determinants of crop diversification

CDI	Coef.	Average marginal effect (dy/dx)	Robust Err.	Std. z	P>z
FARMEXP	-0.0016	-0.0006	0.0010	-1.510	0.131
FARMEXPSQ ⁸	2.00E-05	9.00E-06	5.95E-05	0.37	0.708
EDUCA	-0.0010	-0.0004	0.0035	-0.290	0.770
GENDER	-0.0088	-0.0034	0.0384	-0.230	0.819
DEPRAT	0.5009***	0.1929	0.0835	6.000	0.000
SOCCAP	0.0069	0.0027	0.0091	0.760	0.445
PAHO	0.0300***	0.0116	0.0068	4.430	0.000
TLU	0.0092***	0.0035	0.0017	5.380	0.000
FREXCONT	0.0026***	0.0010	0.0007	3.840	0.000
CREDITA	0.0948**	0.0365	0.0397	2.390	0.017
MEMBMG	-0.0515*	-0.0198	0.0288	-1.790	0.074
OTHERINC	-0.0370	-0.0143	0.0251	-1.470	0.141
ROTATION	0.1700***	0.0655	0.0447	3.800	0.000
AGECOL	0.1057***	0.0407	0.0265	3.990	0.000
CONS	-0.0793		0.0627	-1.270	0.206
Observation	1708				
Wald chi2	260.46				

Notes: N = 1708. * p<0.05, ** p<0.01, *** p<0.001. Coefficients of CRE are not reported.
Source: CIMMYT/EIAR survey data (2010/2013)

Dependency ratio is also found to influence household crop diversification level positively, at a significance level of less than 1%, implying that households with more nonworking members are more prone to risk. As the nonworking member increase per household, the diversification level increases by about 19.3%. The result is in line with a study in Uganda

⁸ The square of the farming experience included in the estimated models to test whether the relationships are linear or non-linear. The coefficients of experience square appear to be opposite to experience showing that the relationship is non-linear.

where a positive association was found between dependency ratio and crop diversity (richness and evenness) (Veljanoska, 2014).

The size of the plot area operated by a household was found to significantly influence crop diversification ($t = 4.4$) with a positive marginal increment of 1.2% for every unit change. The freedom of using larger plot sizes for different crops is consistent with the study of Di Falco *et al.* (2010). The other factor found to influence crop diversification in the study area was ownership of livestock. Livestock is found to support the level of diversification at a significance level of less than 1%. A unit increase in livestock ownership in TLU resulted in a 0.3% average increment in crop diversification. Livestock plays an important role in the study area as a source of income, asset, traction power, means of transport and livelihood diversification. It also contributes to soil fertility improvement or compost production. The other reason for the positive relationship between livestock ownership and diversification might be that the production of certain species enhances the supply of animal feed (Sanderson *et al.*, 2013).

Access to extension service, measured in frequency of contacts made with extension service providers, was also one of the important factors found to influence a household's decision to diversify, *i.e.* every contact with the extension service provider is related to about 0.1% increment of crop diversification on average. This shows that access to extension services influence crop diversification positively. Different studies reported contrasting results on the direction of extension service influence on crop diversification. Makate *et al.* (2016) and Mussema *et al.* (2015) reported that access to extension services influenced crop diversification positively. This is in contrast with the findings of Abay *et al.* (2009) and Mesfin *et al.* (2011) who associates extension service with specialization. However, this study suggests that extension services can also facilitate response farming by providing technologies or crop species that are adaptive to specific environment or needs.

Smallholder farmers' access to credit service was also found to significantly influence crop diversification. Households who have access to credit diversification level is higher by about 3.6% as compared to those with no access, *ceteris paribus*. Access to credit might

have helped to introduce crop species with a higher market value being a source of cash for financing the inputs required to produce introduced species. The result is in line with similar studies which confirmed the critical role of credit availability or access to crop diversification (Mandal and Bezbaruah, 2013). Membership in the marketing group is found to negatively influence the household level of crop diversification. The reason could be membership in the market group is one of the strategies followed by households to improve access to input and out markets. It helps to reduce the transaction costs associated with marketing. It helps also as platform where various production and market information is communicated. Hence, there might be a tendency by households to specialize in selected crops with high market demand and value based on exposures and comparative advantages.

Crop rotation is one of the traditional ecosystems and soil fertility enhancement practices used by smallholders (Altieri, 2002). It was found to significantly influence the level of crop diversification at less than 1%. The diversification level for crop rotation practice users is higher by about 6.6% as compared to non-users, *ceteris paribus*. The reason could be crop rotation is one of the options to maintain biodiversity to minimize the consequence of mono-cropping that degrades the soil ecosystem and functions (McDaniel *et al.*, 2014). The other important factor found to influence crop diversification was agroecology, with an average partial effect of 4%. Agroecology represents various aspects of the farming characteristics, including physical and biological characteristics. According to Freeman *et al.* (2014), diversification practices are more robust in intermediate rainfall and variability areas and suggest crop diversification to be followed in an environment of high uncertain productivity. In contrast, households from sub-humid high-potential agroecology were found to diversify their crop production more than farmers in moisture-stressed areas. The reason for the low level of crop diversification in moisture-stressed areas could be due to the limited number of suitable species available in rain-fed areas and specialization in high-value crops in pocket irrigation areas. In contrast, the sub-humid agro-ecological zone is more suitable for production of various crop species.

3.4.3.2 Crop diversification and productivity

The analysis starts by diagnosing the endogeneity of crop diversification in the structural equation of crop productivity. The test was carried out by including the residuals estimated by CRE fractional probit in equation 13 above as a regressor. The estimated coefficient of the included variable was found to be non-significant ($p = 0.263$) and failed to reject the null hypothesis of exogeneity (see Appendix 3.2) and hence, the original variable diversification index (CDI_{it}) was treated as an exogenous variable in the structural equation. The validity of credit used as an instrument was supported by the fact that the coefficient was statistically highly significant at less than 1% level of in the diversification equation, while the coefficient in the productivity equation was not significant ($p = 0.275$). The robust standard error is used to control for heteroscedasticity.

Table 3-4 Impact of crop diversification on household crop productivity

LNCRPRCPI	Coef.	Robust Std. Err.	z	P > z
CDI	-0.0937	0.1006	-0.9300	0.3520
FARMEXP	-0.0170***	0.0053	-3.2000	0.0010
FARMEXPSQ	0.0002**	0.0001	2.4300	0.0150
GENDER	0.0663	0.0637	1.0400	0.2980
DEPRAT	-0.0439*	0.0230	-1.9100	0.0560
EDUCA	-0.0048	0.0059	-0.8000	0.4220
FREXCONT	0.0007	0.0007	1.0000	0.3160
PAHO	-0.1560***	0.0203	-7.7000	0.0000
TLU	0.0180***	0.0066	2.7000	0.0070
LNASVAEQ	0.0670***	0.0133	5.0400	0.0000
MKTDIST	-0.0004**	0.0002	-2.2700	0.0230
MEMBMG	0.0765*	0.0414	1.8500	0.0650
INCROP	0.1149**	0.0487	2.3600	0.0180
MOB	0.1152*	0.0614	1.8800	0.0610
TSFS	0.1276***	0.0242	5.2800	0.0000
AGECOL	-0.1441***	0.0462	-3.1200	0.0020
YEARLUM	-0.3723***	0.0474	-7.8500	0.0000
Constant	8.2502***	0.1425	57.9100	0.0000
R ²	0.248			
Wald chi2(21)	442.30			

Notes: N = 1708. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Coefficients of CRE are not reported.

Source: CIMMYT/EIAR survey data (2010/2013)

Farming experience is also found to influence productivity negatively at a significance level of less than 1% although the influence becomes positive and significant at less than 5% after a certain number of years of experience. On the other hand, Ainembabazi and Mugisha (2014) reported a mixed relationship between farming experience and technology uptake that enhances household productivity. Households with a larger dependency ratio were found to be less productive. The possible reason could be that the major share of their income might have been used for consumption in terms of food security, rather than investing it for productivity enhancement.

The other variable found to influence crop productivity was the size of the plot area operated. The inverse relationship (IR) between plot area operated and productivity is in line with theory. A recent study by Paul and wa Gĩthĩnji (2017) reports a similar finding from a survey conducted at the national level in Ethiopia which, however, contradicts the findings of Bangwayo-Skeete *et al.* (2012). Livestock ownership was also found to influence productivity positively at a significant level of less than 1%. A unit increment in total livestock units would result in a 2% productivity increment. As previously mentioned, in Ethiopian agriculture, livestock plays a key role as a source of power for crop cultivation, income to finance inputs, source of nutrients and indicator of wealth condition. The result is consistent with the findings of Bangwayo-Skeete *et al.* (2012) who indicate that wealthier households (with more livestock ownership) are more productive. Asset, as another household wealth indicator, is also found to positively influence crop productivity at a significance level of less than 1%. Assets serve as an alternative to buffering risks of failures and they boost the confidence of smallholders to invest in productivity-enhancing technologies.

Distance from the market centre is associated with the transaction costs households incur in accessing input and output markets. Accordingly, access to markets influences the transaction costs associated with input and output market participation. Accordingly, this study found that market distance is negatively associated with crop productivity at less than 5% significance level. Household head membership in input or output market groups contributes positively to crop productivity at a significance level of less than 10%. Being a member of market groups can facilitate household access to input and output markets

which intern leads to the production of specialized high-value crops for market. This study further found the ownership of an information technology device (mobile phone) to have a positive effect on crop productivity. The underlying reason may be that the ownership of a cell phone improves access to input and output information as well as extension advice. It also minimizes the costs of accessing information by minimizing the frequency of travels to urban areas in search of information. The finding is consistent with the study conducted by Lio and Liu (2006), confirming that information and communication technology (ICT) (mobile phone) has a positive and significant influence on agricultural productivity.

The intercropping practice was also found to positively influence crop productivity at a significance level of less than 5%, the possible reason being the additional harvest to the main crop obtained from the same plot. However, the practice should be supported using scientific input and crop population management techniques to minimize nutrient competition among crop species. Moreover, soil quality is also associated positively with crop productivity at a significance level of less than 1% and it plays an important role in sustaining plant productivity and improving household welfare. An improvement in soil quality (weighted average) results in an average productivity increment of 13%. On the other hand, productivity in sub-humid high-potential areas is lower in comparison with that in semiarid moisture-stressed environments. The possible reason might be that some of the villages in the study area produce crop species with a high market value, using irrigation infrastructure that results in more marketable surplus and commercialization. The annual dummy coefficient reflects a negative sign, indicating that productivity was lower in the year 2013. This high production loss might be due to the erratic (late-onset and early dry spell) rain distribution of the 2012 cropping season (Liben *et al.*, 2017).

3.5 Summary

The purpose of this chapter was examining the determinants of crop diversification and its effect on crop productivity. The results from fractional probit regression model indicate a positive association between crop diversification on one hand and dependency ratio, plot size, livestock ownership, access to credit, extension services and the use of crop rotation practices. Membership in market groups is negatively associated with the level of crop

diversification as it can play an important role in facilitating access to market information and improved production inputs. Diversification is found to be more in sub-humid high-potential than in semiarid agroecological areas, implying that higher potential areas are more suitable to grow diversified crop species. As far as crop productivity is concerned, the study documents that factors such as livestock, assets, market group membership, maize-legume inter-cropping, and soil quality were found to positively influence crop productivity while farming experience, dependency ratio, plot size and agroecology showed a negative association with crop productivity. Policy interventions in the areas of access to credit, research and extension service are relevant to promote smallholders' crop-livestock integration and productivity. Improved integration and productivity of crop-livestock sectors can play an important role in smallholders' crop diversification practices as well as contributing to crop productivity. With agrobiodiversity being a strategy to mitigate risks of market and climate fluctuations, emphasis should be placed on risk-prone environments (semiarid low-potential) in promoting the cultivation and maintenance of diverse crop species with better adaptive capacity. In addition, the application of these practices needs to be supported by science-based findings, specifically in determining crop sequencing in the case of rotation, determination of the number of crops/combinations the household can manage are important to reverse the negative relationship between crop productivity and crop diversification, and level of input used to avoid nutrient competition among crops in the case of intercropping.

Chapter 4: DETERMINANTS OF INCOME DIVERSIFICATION AND ITS INFLUENCE HOUSEHOLD WELFARE

4.1 Introduction

The chapter discusses the determinants of income diversification and its influence on smallholders' welfare (measured in terms of income, vulnerability, and intensity of poverty). It employed a CRE fractional probit model to estimate the determinants of income diversification and intensity of poverty while PFE model was employed to analyze household income and vulnerability.

The rest of this chapter is structured as follows: Section 4.2 outlines the theoretical framework which discusses the relationship between income diversification and welfare indicators. Section 4.3 describes the data collection procedures and empirical approaches followed. Section 4.4 presents descriptive statistics, tests of robustness and the empirical results with the discussion. Section 4.5 provides a conclusion and portrays policy implications.

4.2 Conceptual framework

The conceptual framework of this chapter is imbedded in Figure 2.1 (chapter 2). As discussed earlier, Figure 2.1 illustrates the rural household resources allocation in the face of biophysical and policy environment and its implications to livelihood strategies (crop and income diversification and commercialization) and environmental/natural resource outcomes. Ethiopian smallholders undertake their livelihood activities under such complex, diverse, and risky conditions. Household resource endowments, such as human, social, natural, physical, and financial assets shape livelihood strategies and outcomes (Ellis, 2000).

Farm income is highly volatile due to its association with natural risks Mishra and Goodwin (1997); Mishra and Holthausen (2002). As the prospect of income variability increases, the household propensity to participate in other income sources also increases (Mishra and Goodwin, 1997; Jetté-Nantel *et al.*, 2010). Engaging in a portfolio of income-generating

activities (farm or non-farm) is mainly used to sustain livelihoods and minimize risk during harsh conditions (Alderman and Paxson, 1992). Households use diversification of income either as a necessity to overcome certain shocks or choice to improve their prospects (Ellis, 1998; Ellis, 2000). Income diversification is a survival strategy used by poor rural households is a survival strategy under incomplete markets to smoothen consumption in the event of incomplete markets (Dimova and Sen, 2010). Risk aversion behaviour affects the household decision of income composition and sources to smoothen consumption in imperfect market conditions (Morduch, 1995).

The level of income diversification/specialization is dependent on an individual's preference towards risks, the capacity to smooth the consumption fluctuation and the cost of diversification (Alderman and Paxson, 1992). Moreover, incentives and constraints are diverse due to the variation in transaction costs and market prices that lead to cross-sectional heterogeneity (Barrett *et al.*, 2005), resulting in different patterns of livelihood diversifications. As described above, income diversification drivers can be categorized as a push or pull factors where the push factors emanate from household's intention to reduce risks associated with liquidity, labour and land constraints while the pull factors are related to opportunities that promote income diversification such as proximity to market centres.

Diversification as a result of push factors can lead to deteriorating livelihood while the pull factors can be mainly be associated with market opportunities such as output and labour markets leading to welfare improvement (Asfaw *et al.*, 2015b). This indicates that diversification dominated by push factors more likely leads to further deteriorating welfare, whereas, if induced by pull factors more likely leads to welfare improvement (Dimova and Sen, 2010; Asfaw *et al.*, 2015b). As noted by Khai *et al.* (2013) and Ellis (2000), income diversification has the potential to improve income stability and overall welfare of households under the conditions where poor households diversify into low return activities that result in poverty trap compared to the wealthy households that can invest in high return production activities. Rural rich households can invest the capital generated by agriculture into more profitable non-farm activities (Dimova and Sen, 2010). In sum, on-farm decisions and activities, influenced by various factors can also be a subject of necessity (survival) or choices (accumulation) (Dimova and Sen, 2010).

4.3 Research methodology

4.3.1 Measuring response variables

The measurement and estimation procedures of some variables, namely, income diversification, income, and vulnerability are discussed next.

Income diversification

Similar to chapter three of the thesis, Simpson index is used in measuring to calculate income diversification index and computed as (Ersado, 2006):

$$IDI = 1 - \sum_{i=1}^n k_{it}^2 \quad (4.1)$$

where *IDI* is the Simpson index, k_{it} is the proportion of the i^{th} income (crop, livestock, remittance, salary, casual labour, income from aid, sales of fuelwood (charcoal), non-farm business and income from property rent). This index measures the level of household income diversification using the value between 0 and 1 where the higher values indicating more diversification than specialization.

Determination of income, vulnerability, and poverty gap (propensity)

Given the difficulty to measure and represent well-being, different analysts have employed different proxies, namely, income, consumption, food in/security, poverty, health, nutrition, and other variables. The multi-dimensionality of welfare is conceptually and practically is the most important reason for this difficulty. In this study, household income, vulnerability to expected future poverty and level of poverty (gap) are given due emphasis.

In this case, the household income is a summation of gross crop and livestock value, remittance, salary, casual labour, income from aid, sales of firewood (charcoal), non-farm business, income from property rent and share dividends per adult equivalent (PAE)⁹ calculated on the basis of Dercon and Pramila (1998) procedure. Poverty is a measure of

⁹ PAE is calculated as follows: adult equivalent unit (aeu) = 1.04*male adults + 0.80*female adults + 0.76*male child + 0.69*female child.

current status with respect to socially determined income or expenditure level (*ex-post*) while vulnerability is the *ex-ante* risk of remaining poor if currently poor or becoming poor if currently non-poor in terms of a given poverty measure (Chaudhuri *et al.*, 2002; Christiaensen and Subbarao, 2005). There are sizeable lists of poverty measures including the three main families of indices such as Sen's, Clark, Hemming and Ulph (CHU) and Foster–Greer–Thorbecke (FGT) from which the common measures have been derived (De Janvry and Kanbur, 2006). Following Kassie *et al.* (2011), FGT index is used to measure poverty since it has widely used poverty measures since it combines the head-count ratio with poverty gap and squared poverty gap index. Accordingly, the FGT index is computed as (Baffoe, 1992):

$$P_{\alpha} = \frac{1}{n} \sum_{i=1}^q \left[\frac{z - y_{it}}{z} \right]^{\alpha} \quad (4.2)$$

where P_{α} is the weighted poverty index for the i^{th} household; α is a parameter which takes values of 0, 1 and 2 for headcount, level and severity of poverty indices, respectively; q represents the number of people below the poverty line; n denotes the number of people sampled; z signifies the national poverty line; and y_{it} represents income of household per adult equivalent (PAE) at time t .

FGT indices are thus, used to categorize households where P_{α} becomes the headcount ratio when $\alpha = 0$, refers to the poverty gap (propensity to poverty) when $\alpha = 1$ and measures severity (depth) of poverty when $\alpha = 2$. Poverty gap and severity are computed to address the deficiencies of headcount ratio although the poverty gap is econometrically analysed based on convenience for interpretation (Mathenge *et al.*, 2014). The national poverty line which is considered as a benchmark is 3,781¹⁰ Ethiopian Birr (ETB) per year per person which is the minimum amount of money required to cover the minimum calorie requirement (2,200 kilocalories) and necessary non-food items (World Bank, 2015). The

¹⁰ Expenses required to meet food and non-food consumption requirements in 2011 prices equivalent to 1.24 USD PPP.

figures were deflated by the survey year consumer price index (CPI) where 2010 is considered to be the base year to account for the effect of inflation (World Bank, 2016).

Following Chaudhuri *et al.* (2002); Gaiha and Imai (2008); Günther and Harttgen (2009) and Bogale (2012), vulnerability is also considered as the probability of a household to be poor/food insecure in the future expressed as:

$$V_{it} = \Pr(y_{i,t+1} \leq z) \quad (4.3)$$

where V_{it} represents the probability of the i^{th} household falling below the minimum income threshold at, z and $y_{i,t+1}$ (defined above), at time $t + 1$. Equation 4.3 reflects the difference between the concept of poverty and vulnerability as the vulnerability is a forward-looking while poverty is ex-post looking (Chaudhuri *et al.*, 2002).

4.3.2 *Econometric estimation approaches*

The response variables of interest take a fractional and continuous form. Accordingly, income diversification and the poverty gap (propensity) are fractional response variables and estimated by using the fractional response model. Therefore, the estimation of income diversification and the poverty gap was carried out by a means of a fractional probit regression model.

As indicated under the conceptual framework, income diversification is expected to be influenced by the push and pull factors and include household characteristics (experience, education, gender, experience, dependency ratio); institutional factors (credit, market, extension service access); economic factors (livestock, land ownership) and environmental factors (agroecology). The use of the fractional probit regression model is suggested over the fractional logit model due to its consistent and relatively efficient estimation for short panel data with the large cross-sectional observation (Papke and Wooldridge, 2008). Following Papke and Wooldridge (2008) the equation is structured as follows (4.4):

$$E(Y_{it} | X_{it}, C_i) = (X_{it}\beta + \gamma x + C_i + \mu_{it}) \quad (4.4)$$

$$\mu_{it} | X_{it}, c_{it} \sim Normal(0, \delta^2) \quad (4.5)$$

where Y_{it} represents income diversification index or the poverty gap takes values $0 \leq Y_{it} \leq 1$, X_{it} is a vector that includes time-constant observed variables (including income diversification) across i as well as variables that vary across i and t , \bar{X} mean of time-varying variables, c_i captures unobserved heterogeneity among the households, u_{it} is an idiosyncratic random error term, β is a vector of unknown parameters to be estimated; and γ is the coefficient of \bar{X} . The partial effects are known as average partial effects (APE) for continuous and discrete variables, respectively, is estimated as:

$$\frac{\partial E(D_{it} | X_{it}, C_i)}{\partial X_{it}} = \Phi(X_{it} \beta + C_i) \quad (4.6)$$

$$\Phi(X_{it}^{(1)} \beta + \alpha_i) - \Phi(X_{it}^{(0)} \beta + C_i) \quad (4.7)$$

Correlated random effect (CRE) commonly known as the Pseudo Fixed Effect model that allows the interaction between the X_{it} and a_i proposed by Mundlak (1978) and Chamberlain (1984) is used in estimating both income diversification and the poverty gap. CRE application involves the inclusion of the mean of time-varying variables as additional independent variables to control for time-constant unobserved heterogeneity (Wooldridge, 2010; Wooldridge, 2015).

Conversely, the other two response variables (income and vulnerability to expected poverty) are a continuous response variable and estimated by using the linear panel data model. Household income which is a direct measure (indicator) of household welfare at any period of time is dependent on various factors that include current and expected future income and various income shocks (Chaudhuri *et al.*, 2002). This income further depends on overt and covert individual characteristics and socio-economic and natural environments. According to Chaudhuri *et al.* (2002), estimation of household vulnerability involves at minimum estimation of income and income variance. Accordingly, Chaudhuri

et al. (2002); Günther and Harttgen (2009); Capaldo *et al.* (2010) and Bogale (2012) estimated household vulnerability of household income as follows:

$$\log y_{it} = \beta X_{it} + \gamma \bar{x} + c_i + e_{it} \quad \text{where } i=1,2,3\dots n, t=1,2 \quad (4.8)$$

where y_{it} is a log function of PAE income, e_{it} is an idiosyncratic random error term that captures shocks and other factors that contributing to differences in per capita income and the rest as defined above. It is assumed that the variance of unexplained household income (e_{it}) depends on the observable household characteristics:

$$\sigma^2_{e_{it}} = \theta X_{it} + \tau_{it} \quad (4.9)$$

where θ represents the vector of variables estimates and τ represents the vector of the residuals. According to Capaldo *et al.* (2010) and Bogale (2012), the variance predicted from Equation above (4.9) exhibiting undesirable characteristics, namely the correlation between the residuals and the different variance (heteroskedasticity). In order to overcome this problem and capture the systematic variability of the dependent variable, a three-step feasible generalised least squares (3FGLS) approach can be employed. Using the estimates of β , θ and γ (Equations 4.10 and 4.11), the expected household income and the variance for each household are estimated as follows:

$$E[\log y_{it} | X_{it}] = X_{it} \hat{\beta} \quad (4.10)$$

$$V[\log y_{it} | X_{it}] = X_{it} \hat{\theta} \quad (4.11)$$

However, the use of the feasible generalised least square needs large periods equals or greater than the number of panels ($t > n$). This estimation is therefore made by using the PFE model with robust standard error to control for heteroskedasticity. The CRE approach is used to unify the FE and RE estimation approaches (Wooldridge, 2013).

4.3.3 Explanatory variables included in the econometric models

The explanatory variables included in the estimated models are presented in Table 4.1 below. The positive signs show the direction of the expected association between the explanatory variable and the dependent variable (income diversification, income, vulnerability and propensity of poverty) implying that the dependent variables are expected to show an increment for every change in an explanatory variable while the opposite is true for negative signs. Accordingly, gender (GENDER), crop diversification index (CDI) calculated as indicated in chapter 3 above, income diversification index (IDI), farming experience (FARMEXP), the dependency ratio (DEPRAT), education achievement (EDUCA), social capital (SOCCAP), were used to capture individual-level heterogeneity. Distance from extension service centres (EXTDIST) and credit access (CREDITA) were included to capture access to institutional services. Operated plot size (PAHO) and livestock (TLU) are included to capture household production asset (wealth). Environmental factors were captured using agroecology (AGECO)

4.4 The results and discussion

4.4.1 Descriptive statistics

Table 4.1 presents the descriptive statistics of selected variables and the direction of their influence respective to dependent variables. The average annual income from all sources is about 3,547.79 (ETB) PAE. The average level of income diversification is 0.33, ranging between 0 and 1. Discussions on other variables are given in chapter three of the thesis.

Table 4-1: Description of dependent and explanatory variables

Variable code	Variable description	Descriptive statistics		Expected sign			
		Mean	SD	diversification	income	vulnerability	Level of poverty
LogINCOME	Average income PAE*	3,547.79	3,944.21	Response variable			
IDI	Income diversification index	0.33	0.2	+/-	+/-	-	-
CDI	Crop diversification index	0.331	0.205	+/-	+/-	-	-
EXPERIENCE	Farming experience of the household head in years	44.602	13.62	+/-	+	-	-
GENDER	Gender of the household head	0.889	-	+/-	+/-	-	-
EDUC	Education level achieved by the household head	3.129	3.345	+/-	+	-	-
DEPRAT	Dependency ratio	1.23	0.84	+	-	+	+
OPAH	Operated farm size in hectares	2.232	1.717	+/-	+	-	-
TLU	Total livestock units (TLUs)	6.381	6.822	+/-	+	-	-
EXTDIST	Walking distance from extension service centres (in minutes)	28.994	27.55	+	-	+	+
CREDITA	Access to crop production input procurement credit 1 if yes, 0 otherwise	0.232	0.423	+	+	-	-
MATDIST	Walking distance from market centres (in minutes)	99.95	62.58	+	-	+	+
AGECOL	Agroecology zone, dummy (1=high potential areas)	0.334	0.472	+/-	-	+/-	+/-

Source: CIMMYT/EIAR survey data (2010/2013). * log function of income PAE is used in econometric analysis.

4.4.2 Income diversification and poverty

Income diversification is essentially meant to reveal the importance of off-farm employment opportunities and non-farm economic activities to rural livelihoods. As it is evident from Table 4.2 below, crop and livestock enterprises dominate the household

income. Total income comprises about 54% of crop income share followed by about 22% livestock.

Table 4-2: Income diversification and household poverty trend

Income sources	Annual		t-value (difference)	Pooled	
	2010	2013		Mean	SD
Average annual estimated income	3,794.06	3,301.51	2.58	3,547.79	3,944.21
Proportion of income from crop production	0.58	0.50	5.17	0.54	0.3
Proportion of income from livestock production	0.23	0.20	2.20	0.22	0.24
Proportion of off and non-farm businesses	0.07	0.14	-6.71	0.11	0.21
Proportion of income from other unearned income sources (remittance, SafetyNet etc.)	0.12	0.15	-3.11	0.13	0.23
Overall income diversification index – Simpson index	0.29	0.37	-8.71	0.33	0.2
Poverty (head count, %)	0.55	0.21	23.43	0.45	0.49
Poverty gap ($P_{\alpha, \alpha=1}$)	0.18	0.10	10.41	0.14	0.16
Severity of poverty ($P_{\alpha, \alpha=2}$)	0.10	0.06	8.64	0.10	0.11

Source: CIMMYT/EIAR survey data (2010/2013)

The overall share of crop and livestock income thus amounts to about 76% while the remaining 24% is from other sources such as non-farm business, remittance, casual labour, salary income, and other sources. The results suggest a significant increment in income diversification in the second survey period while the share of earnings from crop and livestock sectors are found to be lower in 2013 in comparison with the 2010 survey period. Results further show a positive change (29% to 37%) in the level of income diversification between the survey periods *i.e.* households are diversified more in 2013 than in 2010. The possible reason for the increment in diversification could be associated with frequent occurrence of drought and market price fluctuations as well as the government's effort to

promote rural employment creation schemes as a means of employment generation for the youth. Moreover, the expansion of infrastructure and existing economic transformation policy might also have contributed positively towards income diversification.

On average, about 45% of the respondents' income (income adjusted in income per adult equivalent (PAE)) was below the national poverty line although this number reduced significantly in 2013 from 55% to 21% in 2013. The estimates of P_1 and P_2 indicate that high and severity levels of poverty in the study sites. According to the results, the level of poverty gap and severity levels are 18% and 10%, respectively, indicating that the average income shortfall of the poor below the poverty line is 10% where the average income of the poor is about 18% deeper than the average poverty gap implying that annual incidence of poverty to be quite high in the study area. The t-test values indicate that average annual income, the share of crop and livestock, poverty indicators showing statistically significant reduction as compared to the base year. This indicates that there was a significant reduction in all three the poverty measures in 2013 as compared to 2010 which is encouraging although the gap is yet wide enough. On the other hand, the proportion of non-farm and unearned as well as overall income diversification index showing a statistically significant increment.

4.4.3 The econometric results and discussion

The heteroscedasticity test was conducted for each model using the Breusch-Pagan / Cook-Weisberg test. The test results show the presence of heteroscedasticity at less than 5% significance level for all the estimations in income diversification, vulnerability and level of poverty and hence, robust standard errors were used to adjust for heteroscedasticity. Besides, income diversification is assumed to be a decision variable and correlated with the error term in the income equation. To overcome the endogeneity problem in the equation, a two-stage control function approach employed (Vella and Verbeek, 1993). The approach involves: (1) estimation of the reduced-form equation of income diversification (equation 4.1) using CRE fractional probit model; (2) the residuals generated from the first stage is included in the income equation as an additional explanatory to control for the correlation between error terms, as well as endogeneity of the variables, and generate

consistent estimates of the parameters. Coefficient of the residual with no power indicating the absence of endogeneity problem and hence, income diversification is considered as an exogenous variable (Appendix 4.1).

4.4.3.1 Determinants of income diversification

Table 4.3 presents the fractional probit regression model estimates of income diversification and the determinant factor. The result reveals that a few variables namely gender, education, farming experience, and farm size are found to influence income diversification, the coefficients education leading to greater diversification while gender and cultivated farm size are negatively associated. The coefficient of farming experience indicates that the association between farming experience and diversification is non-linear. The positive coefficient of experience square might be associated with the fact that more experience is associated with the understanding of risks and opportunities in agricultural production. Besides, it is also associated with age where the focus of older household is mainly ensuring the sustainability of production and supply.

The result further reveals that diversification is followed more by female-headed than male-headed households. Traditional women's multiple roles in society and limited access to benefits of development interventions (training, information and related intutional services) are assumed to influence the ability of female-headed households to diversify sources of income in ensuring household livelihood conditions. This implies that female-headed households should focus on reducing the risks of food insecurity as compared to their counterparts. The result agrees with similar finding which reported that female-headed households with larger family sizes were found to diversify their income source (s) as compared to their poor male-headed counterpart with smaller family size (Javed *et al.*, 2015).

Table 4-3 Determinants of household income diversification (fractional probit)

IDI	Coef.	Robust Std. Err.	z	P > z
FARMEXP	-0.0021***	0.0006	-3.270	0.001
EXPSQ	0.00004***	0.00001	3.200	0.001
DEPRAT	0.0024	0.0027	0.880	0.381
GENDER	-0.0140*	0.0074	-1.900	0.057
EDUC	0.0017**	0.0007	2.370	0.018
Soccap	0.0063	0.0156	0.410	0.684
PAHO	-0.0694***	0.0142	-4.880	0.000
TLU	0.0031	0.0052	0.590	0.553
EXTDIST	0.0006	0.0008	0.790	0.429
CREDITA	0.0483	0.0496	0.970	0.330
AGECOL	0.0012	0.0058	0.200	0.843
MATDIST	0.0000	0.0001	0.900	0.369
YD2013	0.2547***	0.0302	8.440	0.000
Constant	-1.6309	0.0244	-66.840	0.000
Observation	1708			
Wald chi2	13554.37			

Notes: N = 1708. * p < 0.05, ** p < 0.01, *** p < 0.001. Coefficients of CRE are not reported.

Source: CIMMYT/EIAR survey data (2010/2013)

Education achieved is also a proxy of human capital expected to play an important role in broadening a household's opportunities to participate in diverse income-generating activities and employment prospects. Similar results were reported by Asfaw *et al.* (2015b) and Agyeman *et al.* (2014) based on the study conducted in Malawi and Ghana. The positive influence of better education could act as a pull factor. However, the existing unemployment situation in Ethiopia and scarce resources might lead educated groups to look for additional income sources as a means of survival strategy and can therefore, equally be a push factor. The land is also one of the important assets of a rural household since larger landholdings encourage their concentration on agriculture. Similar results by a study conducted in Vietnam (Hung *et al.*, 2010) supports the finding. Moreover, coefficient of time dummy also shows that the second survey period's income diversification increased as compared to that of the baseline. This indicates that households diversified more in order to adapt to changing climatic and economic conditions. In general, the result shows that diversification is mainly a consequence of push factors rather than pull factors hence, being followed as a strategy of survival rather than accumulation.

4.4.3.2 Influence of income diversification on income, vulnerability, and propensity of poverty

Table 4.4 presents estimates of household income, vulnerability to expected poverty as well as the poverty gap. The PFE was used to estimate income and vulnerability while the CRE fractional model was used in estimating poverty gap. The results show that income diversification was positively associated with household income at less than 10% significance level. It is also found that income diversification has no influence on income stability (vulnerability to expected poverty), however, it is negatively associated with the intensity of poverty at less than 1% significance level. Crop diversification is also found to play an important role in household welfare improvement as it is associated positively with income at less than 5% significance level. Other studies that also analyzed the influence of crop diversification impact on household welfare it to be negatively associated with the probability of being poor although the effect declines after a given threshold of diversification level (Lin, 2011; Birthal *et al.*, 2015). Based on the study conducted in Ethiopia, Bogale (2012) also reported that crop diversification was found to be positively associated with household consumption expenditure.

Experience in farming is found to be negatively associated with income while the association with expected poverty and intensity of poverty is positive. However, the coefficient of experience square turns to be positive for income and vulnerability and negative for poverty level indicating that the relationship between the three welfare indicators and experience to be non-linear. The negative association of experience at an early stage may be associated with the inaccessibility of land for cultivation as opposed to the older households. To confirm its validity, the model was re-estimated by replacing experience in the equation with the age of household's head. The result showed a similar effect. A possible reason for this finding could be that agricultural land was concentrated in the hands of elders rather than those of younger household heads, as there had not been land reallocation since 1991 (Crewett and Korf, 2008).

Table 4-4: Estimates of income and vulnerability to expected poverty

Explanatory variables	Income PAE (log function)				Vulnerability to poverty (log function)				Poverty gap/ propensity			
	Coef.	Std. Err.	z	P > z	Coef.	Robust Std. Err.	z	P > z	Coef.	Robust Std. Err.	z	P > z
IDI	0.1759*	0.1037	1.700	0.090	0.0004	0.0007	0.600	0.549	-0.3817***	0.1193	-3.200	0.001
CDI	0.2839**	0.1178	2.410	0.016	-0.0010	0.0008	-1.250	0.213	-0.0667	0.1244	-0.540	0.592
FARMEXP	-0.0400***	0.0053	-7.600	0.000	-0.0009***	0.0001	-6.950	0.000	0.0354***	0.0051	6.970	0.000
EXPSQ	0.0004***	0.0001	4.170	0.000	0.00002***	0.0000	8.750	0.000	-0.0004***	0.0001	-3.980	0.000
DEPRAT	-0.0867***	0.0225	-3.850	0.000	0.0028***	0.0007	3.910	0.000	0.0742***	0.0204	3.640	0.000
GENDER	0.0142	0.0631	0.230	0.822	-0.0192***	0.0014	-13.990	0.000	0.1037*	0.0616	1.680	0.092
EDUC	0.0029	0.0059	0.490	0.621	0.0006***	0.0001	4.480	0.000	-0.0065	0.0054	-1.190	0.234
PAHO	0.1151***	0.0172	6.690	0.000	0.0002***	0.0001	1.490	0.137	-0.1539***	0.0265	-5.820	0.000
TLU	0.0303***	0.0056	5.370	0.000	0.00001	0.0000	-0.510	0.611	-0.0325***	0.0086	-3.750	0.000
CREDITA	0.0519	0.0483	1.080	0.282	-0.0002	0.0003	-0.520	0.605	0.0012	0.0560	0.020	0.982
EXTDIST	-0.0005	0.0006	-0.830	0.405	0.0002***	0.0000	11.770	0.000	0.0009	0.0006	1.410	0.159
MATDIST	-0.0003	0.0003	-0.830	0.408	0.0000	0.0000	-0.120	0.906	0.0002	0.0003	0.690	0.492
AGECOL	0.0992**	0.0446	2.230	0.026	0.0028**	0.0013	2.150	0.032	-0.0268	0.0406	-0.660	0.508
YD2013	-0.1903***	0.0335	-5.680	0.000	-0.0006**	0.0003	-1.970	0.049	-0.8393***	0.0465	-18.070	0.000
Constant	7.9855***	0.1326	60.220	0.000	0.0717***	0.0046	15.710	0.000	-1.2154***	0.1328	-9.150	0.000
Wald chi2	548.13				659.36				990.27			
R ²	0.28				0.54							

Notes: N = 1708. * p < 0.05, ** p < 0.01, *** p < 0.001. Coefficients of CRE are not reported.

Source: CIMMYT/EIAR survey data (2010/2013)

Dependency ratio is also observed to be negatively associated with household income and the association with vulnerability to expected poverty and the poverty gap was positive and significant which supports the argument. This might signify that the presence of a large number of under-aged (children under 14 years) or older aged persons (above 64) is exerting more pressure on available resources likely resulting in lower per-capita income (Bigsten et al., 2003). Similar findings were reported by (Andersson *et al.*, 2006; Baiyegunhi and Fraser, 2010; Muyanga and Musyoka, 2014; Demissie and Kasie, 2017).

Conversely, the income of male-headed households is more stable in comparison with that of female-headed households which indicates that female-headed households are more vulnerable to expected poverty. The reason for the finding could be that women are disadvantaged to cultural and economically imposed factors which include the deprivation from access to extension services, land, finance, and education to invest in high returns activities to sustain their production and productivity. The argument is in line with the conclusion given by Awumbila (2006) and Muyanga and Musyoka (2014). Consequently, men have a better opportunity to invest in reasonable income sources that makes their income more stable.

Education is also assumed to be one of the key factors to equip individuals with the necessary skills and knowledge on how to create a better living standard. Interestingly, education is found to be positively correlated with expected poverty, suggesting that the income of households with better education endowment is more variable. Although further investigation is required, the reason for this finding could be that people return to their home village after school due to the prevailing low employment rate too; weak education systems to produce qualified professionals with necessary entrepreneur skills to create and take up opportunities or running own businesses and limited institutional support for job creation. Conversely, the cultivated land area, livestock ownership, and production environments (agroecology) are positively and significantly associated with household income. Land and livestock are fundamental resources for income generation and asset/wealth accumulation in Ethiopian and hence, important in improving household income. The result is in line with the findings reported by Bogale (2012) and Porter (2012) on the positive role of cultivated land and livestock on household welfare.

The findings confirm that rural households are mainly dependent on subsistent crop and livestock production systems.

Access to agricultural extension services is one of the important factors used as an instrument in promoting smallholders' productivity. It involves the transfer of information and knowledge from technology innovation centres (institutions), enabling smallholders to clarify their individual goals and alternatives. Also, in this study, the limited access to extension services (measured in distance from extension service centres) was found to negatively influence household income, contributing to the vulnerability of household expected poverty. A study conducted in Uganda supports this result, confirming that access to agricultural extension services resulted in a significant per-capita agricultural revenue growth of smallholders participating in the programme (Benin *et al.*, 2011).

This study further reveals that households located in high potential agro-ecologies are observed to generate more income as compared to the low potential areas in the study area which is in agreement with another study in Ethiopia (Demissie and Kasie, 2017). Conversely, income in high potential areas is more variable as compared to the low potential environment. The reason for the variability could be that agriculture is mainly dependent on rainfall which is an erratic with a higher adverse effect on sustainable productivity. The decrease and increase of production and productivity could be more significant in high potential areas that depend on environmental factors. The variant in revenue can be significant too. The negative coefficient of year dummy indicates that household income is lower as compared to the base year. In contrast, poverty has found to be lower in the second survey period. The reason for the income to be lower in the second survey could be associated with the erratic rainfall distribution observed in the area during the 2012 main cropping season (Liben *et al.*, 2017) while the reduction in poverty level could be associated with an increment of income diversification.

4.5 Summary

The chapter contributes to the existing knowledge by analyzing determinants of income diversification and its effect on household income, vulnerability to expected poverty and poverty gap.

The descriptive statistics reveal that income diversification has improved between 2010 and 2013. It is also found that the larger share of income is earned through crop production, followed by livestock and non-farm income where the share of agriculture showing a decreasing trend. The reason could be associated with the rural infrastructure expansion and ongoing government efforts to create employment opportunities through the promotion of microenterprises in the urban and rural areas of the country. The results from the estimated fractional probit model indicate that female-headed households and those with better education diversify more while households with relatively larger cultivated farm size diversify less. The results also show the association between farming experience and income diversification, vulnerability, and intensity of poverty to be non-linear. The coefficient of time dummy also shows that the change in diversification over time is positive and significant which could be associated with the reason indicated above.

The econometric results further reveal that income diversification was found to positively influence household income and found to minimize the propensity of poverty. Crop and income diversification, farm size and livestock are important factors found to positively influence household income while the dependency ratio is negatively associated with income. The influence of farming experience is observed to be non-linear as the association changes from negative to positive after a given level of experience. Furthermore, households and households with better education achievement are found to be more vulnerable to poverty. Income diversification, livestock and cultivated land were observed to counteract the poverty gap while the dependency ratio is found to be worsening vulnerability and level of poverty.

The following policy implications can be drawn from the study to improve the contribution of income diversification towards household welfare. Investments that catalyze alternative income sources, for example, awareness creation and skill development (entrepreneurship) on the existing feasible income-generating activities

are critical. Besides, improving access to credit and market services targeting women-headed households and those with better education achievement are crucial and should be emphasized to improve the returns to income diversification. Promotion of labour-intensive farm and nonfarm investment projects could address the challenges of vulnerability and poverty prevailing in the area. Promotion of crop diversification, improving crop and livestock productivity, access to farmland (land markets), availability and access to financial markets and capacity development should be given policy emphasis to improve household income and reducing vulnerability.

Chapter 5: DIVERSIFICATION AND COMMERCIALISATION BEHAVIOUR OF SMALLHOLDER FARMERS IN ETHIOPIA: IMPLICATIONS FOR ECONOMIC TRANSFORMATION

5.1 Introduction

Transformation of subsistent, low-input and low-productivity smallholder farming toward commercialisation is a top priority on the development agenda of the Ethiopian government. The study analyses smallholder commercialisation behaviour in major maize-legume production systems of Ethiopia with an emphasis on crop and income diversification. The fractional logit (generalized linear estimation) approach was used in the empirical analysis.

The rest of this paper is organised as follows: the following section presents the theoretical framework; Section 5.3 presents the empirical model; section 5.4 discusses the findings of the study, and section 5.5 summarizes the chapter.

5.2 Analytical framework

Ethiopian smallholder production and consumption decisions are interdependent, subject to household characteristics and preferences. The non-separable household model of (Singh *et al.*, 1986), which is a consequence of market failure and recognises the fundamental relationship between household production and consumption decisions, is appropriate to conceptualise smallholder commercialization behaviour. The market fails when the transaction costs result in a situation where increased disutility of household production is more considerable than the gain in utility (De Janvry *et al.*, 1991). Under such uncertain production and market environment, the household production objective is utility maximization that comprises multiple objectives as compared to profit (Singh *et al.*, 1986).

Based on Key *et al.* (2000) and Barrett (2008), a household is expected to make a decision on the quantity of goods $i = 1, 2, 3 \dots n$ at time $t = 1, 2$ to produce (q_{it}), consume (c_{it}), sell agricultural goods (M_{it}^s) or purchase agricultural goods (M_{it}^b) being positive if sold and negative if purchased) and production input used (x_{it}), with the objective of utility maximization (U_{it}). Household consumption (c_{it}), encompasses self-produced

agricultural products, purchased goods, and leisure. Earnings of the household include crop income, livestock (livestock product) sales, non/off-farm income (pension, remittance, wage, salary) and others. Non-crop income, in this case, is considered as exogenous income, E_{it} . The household may also get money through credit (B_I) and repay to the lenders $(1+r)B_1$ after harvest. Household is assumed to be endowed with inelastic family labour (L). Excluding transaction costs, the well-behaved utility function (equation 5.1) is given as a function of quantities consumed (c_{it}) and exogenous utility and quantity shifters: household characteristics (z_u) and institutional and environmental factors (z_q), subject to constraints (equations 5.2-5.5):

$$MxU_{it}(c_{it}, z_{it}, z_q) \quad (5.1)$$

$$\sum_{k=i}^m p_{it}^m M_{it} + E_{it} + A_{it} + B_{it} \geq 0 \quad (5.2)$$

$$q_{it} - x_{it} + A_{it} + E_{it} - M_{it} = 0 \quad (5.3)$$

$$q_{it} = F(A, G, K, x, I) \quad (5.4)$$

$$q_{it}, c_{it}, x_{it} \geq 0 \quad (5.5)$$

where A_{it} representing endowments of goods, p_{it}^m market price (received by sellers) of good i at time t , G production technology including agronomic practices (crop rotation, intercropping and diversification) and relating the production to input (x_{it}), K representing labour, land, livestock, machinery and labour and infrastructures, institutions and public services represented by I . Each crop is produced using crop-specific production technologies and other public resources and services (extension services and infrastructures). Equation 5.2 (income constraints) entails that the purchase of all goods must be less than or equal to the production and exogenous income while equation 5.3 indicating consumed and sold quantity to be less than or equal to production, purchased and endowment. Equation 5.4 relating the input-output function while equation 5.5 indicating non-negativity constraints assumption held for all decision variables.

Market participation also involves both fixed and proportional transaction costs, where the fixed cost (τ_{it}^{fs} for sold goods and τ_{it}^{fp} for purchased goods) is the cost incurred by the household regardless of the quantity transacted, while proportional transaction costs (τ_{it}^{ps} for sold goods and τ_{it}^{pp} for purchased goods) represent the cost incurred as per the volume of the transaction. Income constraint (equation 5.2) that incorporates transaction costs can take the following form:

$$\sum_{k=1}^n M_{it}^s (p_{it}^m - \gamma \tau_{it}^{ps} - \gamma \tau_{it}^{fs}) + A + E + B_{it} \geq \sum_{k=1}^n M_{it}^b (p_{it}^m + \delta \tau_{it}^{fp} + \delta \tau_{it}^{ps}) \quad (5.6)$$

where $\gamma = 1$ if the household participated in the market as a seller and 0 otherwise; and, similarly, $\delta = 1$ if the household participated as a buyer and 0 otherwise. As indicated in equation 6 above, the market price (p_{it}^m) received by the household for the goods sold reduces by the amount of proportional (τ_{it}^{ps}) and fixed (τ_{it}^{fs}) transaction costs that the household incurs for each unit of output sold. On the other hand, the household incurs both proportional (τ_{it}^{pp}) and fixed (τ_{it}^{fp}) costs for the units of goods procured. As confirmed by Goetz (1992) Key *et al.* (2000), the first-order condition maximization constraint of utility yielding the reduced form of market participation, depending on the market participation decision.

Most smallholders are assumed to participate in the agricultural output market as a seller of output than as a buyer. If the household decides to enter to sell a given crop $M_{it}^s = 1$ or $M_{it}^s = 0$ otherwise. Some also may decide to buy a given crop and $M_{it}^b = 1$ if a given crop is purchased or $M_{it}^b = 0$ for other. Household is expected to make decisions to participate in input market ($x_{it} = 1$) or not to participate ($x_{it} = 0$) to maximize their production, qit. The cells or purchase quantity are positive (nonzero) if and only if $M_{it}^s = 1$ and ($x_{it} = 1$), respectively. The household face market price for every crop sells i sold at time t , (p_{it}^m) as well as for every input i purchased at time t , p_{it}^x .

5.3 Research methodology

5.3.1 Measurement of input and output market participation

Input and output commercialisation indicator variables are measured according to the participation level in input and output markets. Indices of input and output commercialization, crop and income diversification, as well as market orientation, were computed using the panel data. The paper employs the von Braun *et al.* (1994) and Strasberg *et al.* (1999) smallholder commercialisation level indexing procedures to construct output commercialization index. Output market participation level (OMP) can, hence, be measured using the ratio of the sales value of all crops to the gross value of all crops produced:

$$OMP = \frac{\sum_{k=i}^j p_{it}^m M_{it}}{\sum_{k=1}^n p_{it}^m q_{it}} * 100 \quad (5.7)$$

The value of the index ranges between zero and 1, zero being absolute subsistent farming, while values closer to value of one representing a higher level of market participation. District-level annual average crop prices were used to compute the values. Similar to the output market participation, the input side market participation (IMP) is measured using the ratio of the value of input purchased, which include hired labour, chemical, fertilizer, hired tractor, chemicals for pest management to the gross value of all crops produced. Regarding the measurement of input side market participation (IMP), the use of purchased input to the total value of input used ratio could have been more appropriate. However, smallholders' record-keeping culture is very low due to the illiteracy and poor culture of doing it. As a result, the use of value of purchased input to the gross value of all crops produced is inevitable as suggested by von Braun *et al.* (1994) and Strasberg *et al.* (1999). Accordingly, IMP is calculated as follows:

$$IMP = \frac{\sum_{k=i}^j p_{it}^x x_{it}^m}{\sum_{k=1}^n p_{it}^m q_{it}} * 100$$

(5.8)

IMP can take any value of from zero to one, a continuum. Many prior studies used the indices as a continuum to measure commercialisation level, for example, Gebremedhin and Jaleta (2010a); Gebremedhin and Jaleta (2012); Martey *et al.* (2012). On the other hand, different authors (Alemu and Bishaw, 2015; Bekele *et al.*, 2011; Wharton, 1969) also categorized households into commercial and semi-commercial subsistence by using subjective cut-off points. However, this type of classification is often arbitrary and misleading. In Ethiopian conditions, it is common to see subsistence farmers selling part of their products for various reasons.

5.3.2 *Econometric estimation approaches*

As discussed earlier above, input and output market participation take values between zero and one. Using equation 5.7 and 5.8, the response variables evaluated to determine the estimation procedure. Accordingly, about 55 (3.2%) and 72 (4.2%) of the observations having zero responses for input and output market participation, respectively. Since the number of zero responses (for both input and output) are very few relative to the number of observation size, the estimation of binary models might not be feasible. Accordingly, the estimation procedures of the data with such nature should take the bound nature of the responses into account (Baum, 2008).

As mentioned by Baum, some researchers employed the Tobit model on the (censored regression model) on the fractional response models containing zero or ones although the strategy is not appropriate as it may generate predicted value greater than one which could result in inconsistent estimation. The Tobit model that zero bounded at lower side can produce a prediction between zero and one although it is not the case in the presence of excess ones resulting in inconsistent estimation (Schwiebert and Wagner, 2015). The Tobit model estimation result is consistent under the assumption of normally distributed random error (Loudermilk, 2007; Ramalho *et al.*, 2011). The use of a linear regression model is also not appropriate as it would not take the decision not to participate (zero responses/lower bound) into account (Baum, 2013).

One approach to handle the fractional response variable in which the zeros, intermediates values and ones appear was recommended by Papke and Wooldridge (1996). The fractional regression model overcomes several limitations in linear and non-linear econometric estimation related to bounded data processing (Gallani and

Krishnan, 2017). The generalized linear model (GLMs) with the use of logit link function (logit transformation of the dependent variable) and binomial distribution is one of the appropriate models to handle the proportional data (Baum, 2008; Ramalho *et al.*, 2010; Ramalho *et al.*, 2011).

GLM uses maximum likelihood on the non-linear regression model and applicable to both homoscedastic and heteroskedasticity data (Marzjarani and Statistics, 2018). In this study, the logit link function is employed to estimate smallholders' commercialization behaviour using a panel data approach. Following Papke and Wooldridge (1996), the conditional mean of the fractional logit response model is specified as:

$$\text{logit}(y_{it} | x_{it}) = \mu_{it} = f(\beta_1 x_{it}') \quad y_{it} \sim \text{is}$$

Bernoulli/binomial

$$\text{or} \quad \ln\left(\frac{\mu_{it}}{1 - \mu_{it}}\right) = f(\beta_1 x_{it}'), \quad \text{the natural log of the odds} \quad (5.9)$$

with y_{it} representing the fractional response variables, $0 \leq y_{it} \leq 1$; x_{it} , representing 1*k explanatory variables, and β is a vector of the regressors. The specification of the conditional mean helps to control for the predicted values of the fractional response variable to be between zero and one (Schwiebert and Wagner, 2015). Assuming that $\mu_{it} = E(y_{it})$ and $\eta = g(\mu_{it})$, the link function $g(\cdot)$ determines the shape of conditional mean relating to the explanatory variables and defined as:

$$g(\mu) = \eta = \ln\left(\frac{\mu_{it}}{1 - \mu_{it}}\right) \quad (5.10)$$

The two variables (input and output market participation) are assumed to have a two-way relationship or simultaneous interaction where the use of one for each endogenous variable, as a unidirectional estimation approach, leads to inconsistent and inefficient results. A two-stage panel data simultaneous-equation estimation procedure, as proposed by Vella and Verbeek (1993), seems to be appropriate to address the simultaneity or endogeneity problem. Following Wooldridge (2015), the input and output market equations do not fulfill the *ceteris paribus*, interpretation criteria as the

two decisions are made by same households and hence, implementation of the simultaneous equation estimation procedure is misleading. Therefore, to address the endogeneity problem, the control function approach can be employed (Vella and Verbeek, 1993). The approach involves two-stage estimations where the first stage is an estimation of the reduced-form equations of the respective response variables using fractional model (generalized estimating equation (1) using the logit link function) model using explanatory variables from the structural equation (equation 5.9) to obtain generalized residuals. One instrumental variable is included in each estimation. Access to credit is used as an instrumental variable for input market participation while the crop diversification index (CDI) is used as an instrumental variable for output market participation. The instrumental variables must be strongly associated with the respective variables and uncorrelated with the standard errors of respective equations.

The second stage is the inclusion of the generalized residuals in the structural equations to obtain a consistent estimate by correcting for the endogeneity. The estimated residuals are included as an explanatory variable in the structural equations to control for the correlation between error terms, as well as endogeneity of the variables, and generate consistent estimates of the parameters. The significant t-test coefficient of the residuals (greater than zero) confirms endogeneity (alternative hypothesis) over the null hypothesis (homogeneity). If the endogeneity assumption is rejected, the structural equation could be estimated considering the respective as explanatory variables.

5.3.3 Explanatory variables

The explanatory variables included in the estimated models are presented in Table 5.1 below. The approaches to construct market orientation, crop and income diversification are presented below while the remaining are explained above.

Crop and income diversification

Crop and income diversification indices were calculated using Simpson Index of Diversification (*SID*) as discussed in earlier chapters:

$$CDI/IDI = 1 - \sum_{i=1}^n k_{it}^2 \quad (5.11)$$

where k_{it} is the proportion of the i^{th} income source or crop enterprises. The values range between 0 and 1, where the lower values indicate a lower crop diversification index (CDI) or income diversification index (IDI), and an increasing diversification as it moves from 0 to 1. In this study, the income diversification index was constructed by considering income from various sources, including crop, livestock, remittance, aid, salary, wage, sales of firewood or charcoal, non-farm business and renting out of property.

Market orientation index

As stated by Kohli and Jaworski (1990), market orientation is the production that responds to market signals. According to the authors, market orientation is a process of organisation-level market intelligence generation and dissemination among various departments with the objective to respond to the current and future consumers' needs to sustain a competitive position. Market orientation of a household, in this case, is measured by using the household land allocation for annual cash crops (crops with high marketability and/or demand). Following Gebremedhin and Jaleta (2012) and Abafita *et al.* (2016), it is computed as follows: the first step is computation of crop-specific marketability aggregated at district level, by taking the ratio of total amount sold to total production each crop:

$$\phi_{dt} = \sum_1^n \frac{QS_{j,it}}{QP_{j,it}} \quad (5.12)$$

where ϕ^1 is the marketability of a given crop in district d at time t , taking value between 0 and 1, indicating a marketability of a given crop (j); n number of crops; QS quantity sold by the farmers in a specific farming system (i) at time t ; and QP quantity produced. The next step is the computation of market orientation index in terms of land allocated for specific crop under production weighted by the marketability index (value), *i.e.*

$$MOI_{it} = \frac{\sum \phi_{j,dt} A_{j,it}}{TA_{j,it}} \quad (5.13)$$

¹ A value close to zero shows lower marketability.

where MOI_{it} ¹ is the market orientation index of household i at time t ; A is the amount of land allocated to crop j by farm; and TA is total cropped land by the household.

5.4 The results and discussion

5.4.1 Descriptive statistics

Table 5.1 presents the definition and direction of the influence of variables of interest. The average market orientation, income and crop diversification indices computed for the sample households were 0.29, 0.33 and 0.56, respectively. The analysis shows that household-level market orientation, income diversifications as well as input and output market participation are generally low, though some positive changes have been observed in the second survey period. This shows that more effort is required to change the situation. The aggregate values of output sold, and production factor purchased to the aggregate value of crop produced in the year were, on average, about 30 and 21%, respectively. Furthermore, the intensity of the level of input and output market participation between 2010 and 2013 has increased from 17.18 to 20.43 and from 42.16 to 49.40, respectively. About 25% of the respondents were found to be members of input or output marketing groups (producer or input supplier cooperatives). The descriptive statistics of the remaining variables were given in chapter three of the thesis.

¹ *The higher the proportion, the more marketable the crops of the household.*

Table 5-1 Variable definition and descriptive statistics

Variables	Description	Mean	SD	Input market	Output market
Dependent variables					
OMP	Index of output market participation [0 to 100]	29.62	35.51	+	
IMP	Index of input market participation [0 to 100]	20.75	25.36		+
Explanatory variables					
MOI	Market orientation index [0 to 1]	0.29	0.14	+	+
CDI	Crop diversification index [0 to 1]	0.56	0.20	+/-	+/-
IDI	Income diversification index	0.33	0.20	+	+/-
GENDER	Gender of household head (1 = male, 0 = female)	0.89	0.31	+	+
FARMEXP	Farming experience (in years)	19.56	11.88	+/-	+/-
EDUCA	Education of household head, year of schooling completed	3.13	3.35	+	+
DEPRAT	Dependency ratio of nonworking (age < 14 and age > 64) to active working age	1.23	0.87	-	-
PAHO	Plot area operated by household in hectares (ha)	2.23	1.89	+	+
TLU	Total livestock owned (in tropical livestock units)	6.38	6.82	+	+
EXTDIST	Walking distance to nearest extension office (in minutes)	28.99	27.55	-	-
MKTDIST	Walking distance to the main market (in minutes)	107.64	96.61	-	-
CREDITA	Access to production credit (1 = Yes)	0.23	0.42	+	+
MEMBEMG	Household membership of input/output marketing group (1 = Yes)	0.25	0.44	+	+
INCROP	Households practising intercropping system (1 = Yes)	0.17	0.38	+	+
ROTATION	Households practicing cereal-legume rotation practice (1 = Yes)	0.45	0.50	-	+
AGECO	Agroecology (1 = sub humid high-potential area = 1, 0 = semi-arid low-potential area)	0.33	0.47	+	+
YEARUM	Year dummy, 1 = 2013, and 0 = otherwise	0.50	0.50	+	+

Source: CIMMYT/EIAR survey data (2010/2013)

5.4.2 Econometric results and discussions

This section begins with a preliminary diagnostic assessment on the relevance of the instrumental variables, endogeneity, and heteroscedasticity of the structural equations. Regarding the validity of the instrumental variables, the result shows that access to credit is positively correlated to the level of input market participation at less than 1% significance level (P-value = 0.001). Similarly, the coefficient of crop diversification is

also positively correlated to the level of output market participation (P-value=0.000). The diagnostic tests of the endogeneity fail to reject the null hypothesis in both estimations. The coefficients of input and output market participation residuals were found to be insignificant, confirming that the endogeneity problem is not an issue in either of the models (see Appendix 5.1). Hence, the estimated general residuals were excluded in estimating the input and output market participation equations.

Household market orientation behaviour was also suspected to be endogenous in the input and output market participation equations, although the test did not show any endogeneity problem. Robust standard error estimation procedure was used to correct for heteroscedasticity in the respective equations. Multicollinearity is not a problem in both models with variance inflation factor (VIF) value of less than 2.5 in both cases which is significantly less than the commonly used threshold value of 10. The estimated marginal-effect results were interpreted for both input and output, as it estimates the corresponding actual value observed in the sample. The estimated results for both input and output market participation are presented in Tables 5.2 and 5.3.

5.4.2.1 Input side commercialization and determinants

As indicated in Table 5.2, household input market participation is found to be influenced by various factors. As it is indicated in the table, the output market participation is found (at less than 10%) to influence the input market participation level. Market orientation is also found to be positively correlated with input market participation. For every 0.1 increments in market orientation index, input market participation increases by 4.6%. The result is consistent with the findings of Gebremedhin and Jaleta (2010a) and Abafita *et al.* (2016). This suggests that agricultural extension services should consider the development of smallholders' entrepreneurship knowledge and skills, in addition to promoting agricultural technologies which have been the core of the country's current extension content.

Table 5-2 Fractional logit model results explaining input market participation

IMP	Coef.	Average marginal effects (dy/dx)	Robust Std. Err.	z	P>z
OMP	0.1775*	0.0268	0.1017	1.7500	0.081
MOI	0.3059**	0.0462	0.1534	1.9900	0.046
IDI	0.4266***	0.0645	0.1205	3.5400	0.000
GENDER	0.1283	0.0194	0.0794	1.6200	0.106
FARMEXP	0.0012	0.0002	0.0065	0.1800	0.859
EXPSEQ	0.0000	0.0000	0.0001	-0.1900	0.853
EDUCA	0.0035	0.0005	0.0073	0.4900	0.626
CREDITA	0.1757***	0.0265	0.0531	3.3000	0.001
MKTDIST	-0.0003	0.0000	0.0002	-1.3500	0.178
DEPRAT	0.0245	0.0037	0.0255	0.9600	0.337
TLU	0.0082**	0.0012	0.0039	2.0900	0.037
PAHO	0.0262	0.0040	0.0161	1.6200	0.104
EXTDIST	-0.0011	-0.0002	0.0010	-1.1700	0.242
MEMBMG	0.1993***	0.0301	0.0514	3.8800	0.000
INCROP	0.1079*	0.0163	0.0621	1.7400	0.083
ROTATION	-0.2347***	-0.0355	0.0497	-4.7300	0.000
AGECOL	-0.0381	-0.0058	0.0603	-0.6300	0.528
YD2013	0.1032**	0.0156	0.0504	2.0500	0.041
Constant	-2.0487		0.1432	-14.3000	0.000
Wald chi2	110.74				

Notes: N = 1708, * p < 0.05, ** p < 0.01, *** p < 0.001. Coefficients of CRE are not reported
Source: CIMMYT/EIAR survey data (2010/2013)

Unaffordability of production inputs remains a challenge to smallholders. Accordingly, the coefficient estimate of income diversification shows a positive association between income diversification and input market participation. The level of input market participation increases by about 6.5% points for every unit change of income diversification. The reason could be that households use the income from various sources to meet household needs as a financial intermediary to relax its liquidity constraint that helps to overcome the unaffordability of production inputs. This is in line with the conclusion reached by Woldehanna (2000) and Asfaw *et al.* (2012).

Similarly, credit access is another important factor via which liquidity constraints can be relaxed to finance investment in production-enhancing agricultural inputs. Accordingly, credit is found to be positively associated with input market participation and increase the magnitude of household participation in the input market. Input market participation level of households who have access to credit is higher by about 0.18 as compared to the participation level of those who have no access. Gebremedhin *et al.*

(2009) also reported the positive contribution of access to credit on household fertilizer and other chemical use.

The coefficient of livestock ownership indicates the positive contribution of livestock in input market participation, given the importance of livestock to the Ethiopian rural economy (draft power, cash income, transportation, and soil fertility). Income from sales of livestock or livestock products relaxes households' financial constraints for the procurement of inputs. Membership in input and/or output marketing groups was also found to positively influence the level of household input market participation. Being a member increases the proportion of input market participation by about 3% as compared to non-members, *ceteris paribus*. The possible reason for the increase could be that smallholders in less-developed countries, including Ethiopia, are living in dispersed villages and hence face various problems, for instance, high transportation costs in marketing their output market, and production factors. Collective action organizations (marketing groups) had been considered to be one of the possible strategies to minimize the challenges and inefficiencies in the rapidly changing market environment (Markelova *et al.*, 2009). Hence, the positive coefficient could be due to the role it plays as a means of getting access to information, serving as a platform for sharing experiences and minimizing transaction costs of marketing.

Adoption of intercropping practices is also found to be positively associated with the level of input market participation at less than 10% significance level. The possible reason could be the household uses more inputs (especially labour and fertilizer) as part of their crop production intensification strategy. The study further shows that the use of cereal-legume crop rotation negatively influences the level of input market participation at less than 1% significance level. Crop rotation also plays an important role in improving soil fertility, control pest incidences and resulting in lower production costs. The input cost incurred by crop rotation users is lower by about 3.6% as compared to non-users, keeping other factors unchanged implying that crop rotation minimizes production costs, including chemical fertilizer and pesticides. The possible reason could be the fact that crop rotation is one of the recommended sustainable cropping systems, as it can play an important role in improving soil fertility and control pest incidences. Input market participation was also found to be higher in 2013 as compared to 2010, suggesting an increase by a proportion of 2.4.

5.4.2.2 Output side commercialization and its determinants

Regarding output market participation (Table 5.3), the input market participation level has a positive and significant influence on smallholders' output commercialisation level. For every 0.1 increments in input use, the level of output market participation increases by 6.6%, other factors kept unchanged. The positive influence of input market participation on the intensity of product market participation is due to the contribution of inputs towards the improved productivity of smallholders. The result is in line with the findings of (Van Dusen and Taylor, 2005) who reported that the level of input use positively influences smallholders' agricultural commercialisation.

Table 5-3 Fractional logit model results explaining output market participation

OMP	Coef.	Average marginal effects (dy/dx)	Robust Std. Err.	z	P>z
IMP	0.2737*	0.066	0.1643	1.6700	0.096
MOI	0.2536	0.061	0.1570	1.6200	0.106
SID	-0.0749	-0.018	0.1237	-0.6100	0.545
CDI	0.5346***	0.129	0.1461	3.6600	0.000
GENDER	0.0439	0.011	0.0876	0.5000	0.617
FARMEXP	-0.0170**	-0.004	0.0080	-2.1200	0.034
EXPSEQ	0.0002	0.000	0.0002	1.1000	0.270
EDUCA	-0.0136*	-0.003	0.0078	-1.7500	0.081
MKTDIST	0.0002	0.000	0.0002	0.9500	0.341
DEPRAT	-0.0175	-0.004	0.0322	-0.5400	0.587
TLU	0.0149***	0.004	0.0047	3.1500	0.002
PAHO	0.0506**	0.012	0.0216	2.3500	0.019
EXTDIST	-0.0012	0.000	0.0009	-1.3600	0.173
MEMBMG	0.0443	0.011	0.0524	0.8400	0.399
INCROP	0.1398**	0.034	0.0625	2.2400	0.025
ROTATION	0.1882***	0.046	0.0537	3.5000	0.000
AGECOL	-0.0602	-0.015	0.0661	-0.9100	0.363
YD2013	0.2114***	0.051	0.0517	4.0900	0.000
Constant	-0.7142***		0.1683	-4.2400	0.000
Wald chi2	157.59				

Notes: N = 1708, * p < 0.05, ** p < 0.01, *** p < 0.001. Coefficients of CRE are not reported.
Source: CIMMYT/EIAR survey data (2010/2013)

Farming experience is also found to negatively influence household output market participation, although the coefficient of the square estimate of experience is positive, indicating that the relationship to be non-linear. The negative association of experience at an early stage may be associated with the low accessibility of land for cultivation as

opposed to the older households. To confirm its validity, the model was re-estimated by replacing experience with the age of household head in the equation and found to show a similar effect. A possible reason for this finding could be that agricultural land was concentrated in the hands of elders rather than those of younger household heads, as there had not been farmland reallocation since 1991 (Crewett and Korf, 2008).

Interestingly, education is found to be negatively, and significantly, associated with low output market participation. Kan *et al.* (2006) found a similar result. The reason could be that educated households may have alternative sources of income apart from crop sales, or they may be moving away from agriculture to other alternative income-generating economic activities to sustain a livelihood. On the other hand, more educated farmers are relatively younger and own limited farm plot as compared to elders. The later could be the reason for market participation in this case. The plot size operated was found to positively influence the level of output market participation at less than 5% significance level. Land being one of the critical resources, it helps a household to produce a surplus, i.e. the larger the farm size, the higher the supply of the output surplus. The result is consistent with the findings of Abafita *et al.* (2016) and Mmbando *et al.* (2015).

Another important factor found to influence output market participation was a household's level of crop diversification, with the highest coefficient estimate and statistical significance indicating that farmers with more diversified crop enterprises participate more in output markets. The positive coefficient of crop diversification may be associated with the movement of smallholders from the production of staple food crops to the production of crop species with high market value and intensifying their input use for marketable surplus production. For every 0.1 increase in diversification index, output market participation increases by about 13%.

The result further shows that the role of cropping systems are important cultural practices that can contribute to sustainable crop production and productivity and resulting in a marketable surplus. The result is in line with the findings of Vadez *et al.* (2004) and Bybee-Finley and Ryan (2018) showing that cropping systems are important components of recommended sustainable agricultural practices resulting in sustainable

production and productivity and reducing risks of crop failure (Bybee-Finley and Ryan, 2018).

Like input market participation, the estimated coefficient of time dummy variable indicates that the level of output market participation was found to increase over the periods. Overall, the results from the study indicate that both input and output market participation is found to be higher in 2013 as compared to 2010 which could emanate from an improvement in commercialisation behaviour of households (market-oriented production objectives), increasing output market prices, and the expansion of rural infrastructure over time. Furthermore, the country is following a market-oriented production objective as a key driver of economic transformation.

5.5 Summary

This study aims to explain smallholders' commercialization behaviour in terms of both input and output market participation. Unlike past studies, this study analyses smallholders' input and output commercialization behaviour using two-round plot-level panel data. Copping systems (crop diversification, intercropping and crop rotation) and income diversification and market orientation were used as predictors in addition to others. Given the nature of the response variables (proportional), the fractional logit model was estimated.

The study found that the level of both input and output commercialization is very low, although a trend of increment is observed. The incremental trend might be associated with the ongoing market-oriented agricultural development policy of the country. The estimated econometric results reveal that input commercialisation of households was found to be positively and significantly associated with output market participation, market orientation, income diversification, access to credit for input procurement, livestock ownership, membership in organised market groups and adoption of intercropping practices, while crop rotation was found to be associated negatively. On the other hand, the level of output market participation was positively influenced by input market participation, crop diversification, size of livestock and plot area operated and the use of intercropping and crop rotation practices. On the contrary, farming experience and education level of the household head were negatively associated with the level of output market participation.

Thus, to promote commercialization emphasis should be given farmland and livestock productivity improvement, entrepreneurial skills development and promotion of appropriate cropping practices. Providing appropriate policy support, specifically in human capacity development (business skills) towards new business opportunities is also highly important in improving the contribution of income diversification towards commercialisation and economic transformation. Besides, improved access to financial services (credit access) is highly important to encourage smallholders' market participation.

Chapter 6: CONCLUSIONS, RECOMMENDATIONS AND SUGGESTIONS FOR FURTHER RESEARCH

6.1 Re-capping the purpose of the study

Agricultural production in the country is mainly rain-fed. Such production system is highly sensitive to the prevailing climate variability and deterring efforts to towards welfare improvement. Thus, limited adaptation capacity of smallholders to such climate change and related production risks is becoming an important concern. Having low access to government and market-based risk management options, smallholders consider diversification activities and risk sharing as informal risk management strategies. Crop and income diversification activities are often adopted as short or long-term risk and vulnerability management strategies. In general, diversification is used to develop household resilience to unfavourable weather shocks and policy changes.

Considering the government's aspiration towards poverty reduction and transformation objectives, analysis of diversification (in this case crop and income diversification) and the consequences on household welfare (income, vulnerability, poverty, productivity, and commercialization) is important. The aim of the study is, hence, to examine crop diversification and its effect on crop productivity, analyse the level of income diversification and effects on household income, vulnerability to future food insecurity and poverty; and investigate the influence of crop and income diversification on smallholders' commercialization behaviour using short panel data collected in two rounds, 2010 and 2013 from relatively contrasting two agro-ecologies, namely, semi-arid (complex, risky and diverse environment) and sub-humid high potential maize-legume production systems.

These objectives were addressed using different conceptual (analytical) frameworks and econometric approaches. The necessary pre-estimation tests were carried out on heteroscedasticity and endogeneity during the estimation process. The correlated random effect (CRE) models were used to analyze the determinants of crop diversification and its effect on household crop productivity, respectively. The level of income diversification and effects on household welfare were examined using fractional regression model (income diversification and poverty gap) while income and income variance were estimated using PFE model. Finally, input and output market

participation were estimated using generalized linear models (fractional/transformed logit model).

The rest of this chapter will present the conclusions drawn from the findings of the study, forward policy implications, and suggest future research areas.

6.2 Conclusions

6.2.1 *Crop diversification and productivity*

The empirical finding from chapter three implying that households with more non-working (dependent) members found to diversify more to minimize risks of crop failure. Cultivated land size is also significantly influencing households' level of crop diversification indicating that households with larger farm size have the freedom to allocate plots to different crop species. The other important resource contributing to crop diversification in the study area is livestock. The reason for the positive association can also be due to the mutual relationship between the two enterprises. Hence, it is possible to conclude that household resource ownership positively influences household crop diversification.

Agricultural extension services facilitate the use of alternative and suitable (adaptable) crop species by providing information on the technologies and/or crop species that are adaptive to specific environments or needs. Access to agricultural credit services improves the level of crop diversification implying that it improves smallholders' access to agricultural inputs or required crop species with higher market value or adaptation potential. On the other hand, membership in marketing group found to negatively influence crop diversification. Market groups play important role in facilitating household access to input and output information and markets that encourage market-oriented or specialization. Crop rotation practice also significantly influence crop diversification implying that crop rotation can be used as a strategy to reverse the loss of biodiversity and soil ecosystem functions resulting from monocropping. The results further show that crop diversification is greater in relatively high potential production as compared to moisture stressed and more risk-prone areas.

On the other hand, the non-linear effect of farming experience on crop productivity suggests that experience gained over time can be translated into productivity gain at the

later stage. Furthermore, crop productivity is negatively associated with dependency ratio and cultivated farm size. The higher the dependency ratio, the more the household consumption requirement, competing with investment in productivity-enhancing technologies. The negative influence of farm size is in line with the concept of inverse relationship between farm size and productivity. The influence of livestock ownership is also significant indicating the important role livestock plays as income from sales of livestock or livestock products relaxes households' financial constraints. The significant influence of asset value also indicates that accumulated asset is serving as a means of wealth accumulation and hence, used as an alternative to buffer risk of failure and boost the confidence to invest in productivity-enhancing technologies.

The negative influence of distance from marketing centres is an indication of transaction costs associated with input and output marketing. In contrast, membership in input or output market groups significantly contributes to crop productivity as it can facilitate household access markets and agricultural information. This study further found the ownership of an information technology device (mobile phone) to have a positive effect on crop productivity implying that it could be perhaps minimizing costs of accessing information. The significant influence of membership in marketing group, distance from market centres and cellphone ownership might indicate the importance of transaction costs related to accessing agricultural information or market that can significantly influence crop productivity.

Inter-cropping and soil quality are also found to significantly contributing to crop productivity. Inter-cropping results in the additional harvest to the main crop obtained from the same plot. On the other hand, productivity in sub-humid high potential areas is lower as compared to moisture stressed areas. Access to irrigation schemes is relatively better in low moisture stressed areas as compared to high potential areas. Thus, the production of crop species with a high market value resulting in high productivity since the productivity is calculated as the ratio of total value to total area operated. The result also shows that productivity is lower during the second survey period due to the erratic (late-onset and early dry spell) rainfall distribution in 2012 main cropping season.

6.2.2 *Income diversification and welfare*

Regarding income diversification, the study revealed that female-headed households and households with more education achievement tend to diversify more. Women's diversification could be associated with multiple women's role in society and limited access to training, information, and related institutional service. This makes women more disadvantaged group in the society showing that female-headed households are more vulnerable to poverty which could be attributed to the prevailing social and cultural setting. The influence of education could be due to: (1) educated households are assumed to possess knowledge and skills that help them process information related to available income-generating activities and employment opportunities (pull factors); or (2) the existing unemployment situation in the country and scarce resources might also lead the educated groups to look for additional income sources (push factors). The later could be more important in this case.

The results further show that the relationship between farming experience and income diversification is non-linear. The positive coefficient of experience square may be associated with the fact that more experience is associated with more understandings of risks and opportunities in agricultural production. Larger land holding encourages the household to concentrate on agriculture. The time dummy coefficient also shows that income diversification increased during the second survey period as compared to the base year. This shows that households are diversifying more to adapt to the changing climatic and economic conditions.

The study further found that income diversification is positively associated with household income and negatively associated with the intensity of poverty implying that income diversification contributes to household welfare improvement. Crop diversification is also found to play important role in household welfare improvement as it is associated positively with income. Dependency ratio is also observed to be negatively associated with household income while it is positively associated with vulnerability to expected poverty and the poverty gap. On the other hand, the income of male-headed households is more stable compared to agro-ecologies. Interestingly, education is found to be positively associated with poverty. Although further investigation is needed, the reason could be that people return to their home village after

school due to lack of employment opportunity in urban areas. The result further confirms that educated households diversify income due to push factors than the pull factors. Conversely, land and livestock are found to significantly influence household welfare improvement. Income generated in high potential agro-ecologies is found to be greater with high variability compared to the low potential areas. It has been also observed that household income is lower in 2013 as compared to the base year which could be associated with the occurrence of erratic rainfall distribution in the 2012 main cropping season.

6.2.3 Determinants of smallholders' commercialisation

The findings further show that income diversification significantly influences the level of input market participation, implying that income from various sources helps smallholders to meet household needs as a financial intermediary to relax its liquidity constraint. Market-oriented production objective is associated with higher input market involvement of smallholders. Credit access is also found to be positively associated with input market participation as it plays an important role to relax liquidity constraints in financing investment in production-enhancing agricultural inputs.

Livestock ownership also significantly influences input market participation. Income from sales of livestock or livestock products relaxes households' financial constraints for the procurement of crop production inputs. Membership in input and/or output marketing groups is also influencing the level of household input market participation. Inter-cropping is also one of the crop intensification strategies and found to be associated with input market participation. Cereal-legume crop rotation is also found to negatively influence the level of input market participation confirming the important role of crop sequencing in improving soil quality which reduces the cost of production. Input market participation was also found to be higher in 2013 as compared to 2010, suggesting an increase in market-oriented production.

Regarding output market participation, the result reveals that income diversification is negatively associated with output market participation in contrast to input market participation implying that income from various sources encourages household consumption of agricultural products. On the other hand, input market participation level is strongly associated with output commercialisation level. Farming experience is found to negatively influence output market participation as farmers with more

experience ensuring household food security. Interestingly, education is found to be negatively and significantly associated with lower participation in the output market. This further confirms educated households following subsistent production due to limited access to production resources as noted above.

In general, the result across the three empirical chapters indicated that household with better education achievements don't perform well in the agricultural sector and hence needs immediate policy attention. Dependency ratio is also one of the important demographic factors negatively influencing household commercialization behaviour. Larger livestock and farm size ownership were also found to encourage household input and output market participation. Another important factor found to influence output market participation was the level of crop diversification, with the highest coefficient estimate. This may imply that smallholders diversify from the production of staple food crops to the production of crop species with high market value and intensifying their input use for marketable surplus. Furthermore, intercropping and crop rotation are important cultural practices contributing to household input and output market participation. The practices are also important components of sustainable crop production and productivity practices. Time dummy also indicates that the level of income diversification and output market participation increases over the periods confirming an improvement in commercialisation behaviour.

6.3 Policy implications

The conclusions above indicate that some policy implications are cross-cutting while the rest are specific to topics of the examination. As the dependency ratio is seen to be an important factor across the objectives, improving access to health and family planning education and services are important areas that need due consideration. Improving crop and livestock productivity needs to be on top of policy agenda to improve the livelihood of rural society. This may be achieved through the introduction of improved crop varieties and productive breeds as well as improved forage species. In line with this, interventions that support asset building and wealth creation of rural households should be encouraged through relevant extension services and the introduction of improved technologies and improved access to credit.

Promotion of crop diversification is also one of the relevant options in improving household income, reducing vulnerability and encouraging the transition to

commercialization. Agrobiodiversity being a strategy to mitigate risks of climate variability, emphasis should be given to risk-prone environments (semiarid low potential). Introduction of crop species with high market value and demand should be used to both improve diversification and commercialization. Furthermore, emphasis should be given to crop sequences (rotation) and determination of the appropriate level of input use to avoid nutrient competition among crops in the case of intercropping. In Addition to improved crop varieties, fertilizer and other agronomic packages, the inclusion of crop rotation, intercropping and crop diversification are critical in agricultural extension packages formulation to sustain the production and productivity. Using a mobile phone as a means of accessing and disseminating agricultural information (production, market and weather forecast) should be considered as a means to reach more beneficiaries within a possible short time. The use of such technologies can also lower the cost of accessing timely information and hence, resulting in improved crop productivity.

Challenges facing women-headed households and households with better education need to be addressed properly. Investments that enable the creation of alternative income sources, for example, investments in infrastructures, awareness creation on the existing feasible income-generating activities and opportunities are pertinent. Furthermore, to address the efforts of economic transformation and poverty reduction, the government's provision of incentives and assistance, especially in the areas of financial services and skills development. Promotion of labor-intensive farm and non-farm investment projects can also address the challenges of vulnerability and poverty in rural areas.

To promote market-oriented production, the agricultural extension service content should be revised to incorporate entrepreneurial knowledge and a skills development strategy as tools in transforming the agricultural sector. Market group membership is also relevant as it helps to enhance smallholders' bargaining capacity, exchange of technologies and information specifically in the areas where the development of infrastructure is weak. Supports to improve the performance of this social capital by reducing the hurdles encountering the groups, the establishment and capacity development are important areas of intervention to facilitate market-oriented production, market linkage, and technology uptake. Besides, research and extension need to take into consideration the role of age (experience) in designing and

implementation of the development interventions. Accordingly, a specific programme can be designed targeting young and aged households to improve their access to agricultural technologies, credit, and related institutional services. Improved access to government and market-based risk management options (credit and insurance services) are also crucial to encourage smallholders' technology adoption and market participation, especially risk-averse households.

6.4 Suggestions for future research

The following issues deserve further studies in the future. It is useful to conduct further analysis to understand the association that exists between diversification and household efficiency that could impede productivity. To address this knowledge gap, further research needs to be undertaken in determining the optimum crop/income number and combinations that the household can efficiently manage to the full extent without compromising the benefits of diversification, namely, risk and ecosystem/environmental management roles.

Secondly, understanding diversification opportunities, institutional support, and bottlenecks because of evolving and dynamic national and global environments is important to improve the contribution of diversification for sustainable growth and welfare improvement. In line with this, it is also worthy to understand the diversification intentions of households to design intervention strategies and incentive mechanisms since it is pursued with multi-motivational objectives than exclusively basing the evaluation on economic contribution alone that could lead to wrong suppositions. This is important in organizing responsive research and extension services and facilitation of input and service delivery systems that can promote diversification (adoption of new crops or income-generating activities).

Furthermore, the result of this study indicates that educational achievement is found to be positively related to vulnerability to expected poverty and negatively associated with output market participation in contrast to the existing literature. Since no enough information is collected on the prevailing opportunities and constraints (access to production assets, time allocation, employment rate, and institutional services) facing households with better education achievement, detailed assessment needs to be made to come up with appropriate intervention strategies.

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APPENDCIES

Appendix 3.1: Descriptive statistics of selected time-varying variable by year

Variable	Mean	SD	Mean	SD	Mean	SD
	Total sample		2010		2013	
CDI _{it}	0.57	0.20	0.490	0.008	0.636	0.005
LNCRPRCPI	6333.55	6715.93	6504.362	246.586	6162.743	211.7029
TLU	6.381	0.165	6.329	0.225	6.434	0.241
SOCCAP	2.673	0.034	3.076	0.050	2.270	0.043
PAHO	2.232	0.046	2.270	0.064	2.195	0.065
EXTDIST	29.00	27.55	27.772	0.932	30.215	0.952
CREDITA	0.23	0.42	0.224	0.014	0.241	0.015
ROTATION	0.45	0.5	0.492	0.017	0.405	0.017
DEPRAT	1.23	0.86	1.106	0.028	1.351	0.031
LNASVAEQ	0338.43	71686.72	4630.534	467.298	16046.320	3427.447
OTHERINC1	0.70	0.47	0.669	0.016	0.738	0.015
MKTDIST	107.64	96.61	111.267	2.641	104.021	3.856
INCROP	0.17	0.38	0.104	0.010	0.238	0.015
MOB	0.38	0.48	0.231	0.014	0.525	0.017
MEMBMG	0.25	0.44	0.251	0.015	0.258	0.015
YEARDUM	0.56	0.20	0.49	0.23	0.64	0.14

Source: CIMMYT/EIAR survey data (2010/2013)

Appendix 3.2: Endogeneity test: crop diversification

lnCRPRCPI	Coef.	Std. Err.	Z	P>z
CDII	-0.152	0.140	-1.080	0.278
RESIDCDI	0.449	0.401	1.120	0.263
FARMEXP	-0.016***	0.005	-2.970	0.003
FARMEXPSQ	0.000**	0.000	2.480	0.013
SEX	0.054	0.063	0.850	0.393
EDUCA	-0.005	0.006	-0.780	0.433
FREXCONT	0.0001***	0.001	-0.380	0.705
PAHO	-0.165	0.021	-7.900	0.000
TLU	0.017**	0.007	2.480	0.013
LNASVAEQ	0.053***	0.013	3.900	0.000
MKTDIST	0.0001**	0.000	-2.100	0.036
MEMBMG	-0.010	0.056	-0.180	0.858
INCRP	0.121**	0.048	2.500	0.012
DEPRAT	-0.078	0.115	-0.680	0.499
MOB1	0.126**	0.061	2.070	0.039
TSFS	0.061**	0.030	2.020	0.043
AGECOL	-0.137	0.046	-2.950	0.003
YD2013	-0.285***	0.057	-4.970	0.000
Constant	7.835***	0.251	31.210	0.000

Notes: N = 1708, * p < 0.05, ** p < 0.01, *** p < 0.001. Coefficients of CRE are not reported.

Appendix 4.1: Endogeneity of income diversification (CRE)

LogINCOME	Coef.	Std. Err.	z	P>z
IDI	0.0304	0.1021	0.3000	0.7660
RESID	-0.0132	0.0081	-1.6200	0.1050
CDI	-0.0636	0.1027	-0.6200	0.5360
FARMEXP	-0.0392***	0.0053	-7.4500	0.0000
EXPESQ	0.0004***	0.0001	4.1200	0.0000
DEPRAT	-0.1015***	0.0223	-4.5600	0.0000
GENDER	0.0111	0.0630	0.1800	0.8600
EDUC	0.0032	0.0059	0.5400	0.5880
PAHO	0.1186***	0.0175	6.7800	0.0000
TLU	0.0309***	0.0057	5.3900	0.0000
CREDITA	0.0566	0.0491	1.1500	0.2490
EXTDIST	-0.0008	0.0006	-1.2400	0.2160
AGECOL	0.0997**	0.0446	2.2400	0.0250
Constant	7.7531***	0.1447	53.5700	0.0000

Note: N = 1708, * p < 0.05, ** p < 0.01, *** p < 0.001

Appendix 5.1: Input and output market endogeneity test result (transformed logit)

Variables	Input market participation		Output market participation	
	Coef.	P>z	Coef.	P>z
OMP	-0.0802	0.905		
OMPRESID	0.2291	0.733		
IMP			-0.2011	0.857
IMPRESID			0.4841	0.668
MOI	0.2618	0.109	0.2765	0.088*
SID	0.4446***	0.000	-0.0429	0.766
GENDER	0.1411	0.121	0.0537	0.546
FARMEXP	0.0004	0.952	-0.0171	0.034**
FARMEXP SQ	0.0000	0.878	0.0002	0.269
CDI			0.5447	0.000***
EDUCA	0.0026	0.762	-0.0133	0.089*
CREDITA	0.1420***	0.007		
MKTDIST	-0.0002	0.435	0.0002	0.371
CDEPRAT	0.0228	0.419	-0.0158	0.630
PAHO	0.0300*	0.094	0.0524	0.018**
TLU	0.0086*	0.078	0.0157	0.002***
EXTDIST	-0.0013	0.181	-0.0013	0.146
MEMBMG	0.1794***	0.001	0.0599	0.344
INTCROP	0.0981	0.139	0.1484	0.023**
ROTAION	-0.2140***	0.001	0.1719	0.012**
AGECO	-0.0451	0.477	-0.0643	0.337
YD2013	0.1275**	0.040	0.2185	0.000***
CONST	-1.9426***	0.000	-0.6656	0.001***

Note: N = 1708, * p < 0.05, ** p < 0.01, *** p < 0.001

Source: Based on CIMMYT/EIAR survey data (2010/2013)

Appendix 6.1: Similarity index

The nexus of diversification and household welfare: empirical evidence from Ethiopia

ORIGINALITY REPORT

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Appendix 7.1: Ethical clearance



10 August 2017

Mr Mekonnen Sime Kidane (215081063)
School of Agricultural, Earth & Environmental Sciences
Pietermaritzburg Campus

Dear Mr Kidane,

Protocol reference number: HSS/0851/017D

Project title: Common Bean Technology Adoption, Commercialization and impact on Household Welfare

Approval Notification – Expedited Application (SECONDARY DATA)

In response to your application received on 21 June 2017, the Humanities & Social Sciences Research Ethics Committee has considered the abovementioned application and the protocol has been granted **FULL APPROVAL**.

Any alteration/s to the approved research protocol i.e. Questionnaire/Interview Schedule, Informed Consent Form, Title of the Project, Location of the Study, Research Approach and Methods must be reviewed and approved through the amendment/modification prior to its implementation. In case you have further queries, please quote the above reference number.

PLEASE NOTE: Research data should be securely stored in the discipline/department for a period of 5 years.

The ethical clearance certificate is only valid for a period of 3 years from the date of issue. Thereafter Recertification must be applied for on an annual basis.

I take this opportunity of wishing you everything of the best with your study.

Yours faithfully

Dr Shenuka Singh (Chair)

/ms

Cc Supervisor: Professor Edilegnaw Wale Zegeye
Cc Academic Leader Research: Professor O Mutanga
Cc School Administrator: Ms Marsha Manjoo

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