



Crop Diversification, Food and Nutrition Security among wheat producers in Sinana District, Bale zone, Oromia Regional State, Ethiopia

Dereje Derso

A Dissertation Submitted to Center for Rural Development, College of Development studies,

Presented in Fulfillment of Requirements for the Degree of Doctor of Philosophy in Development Studies (Rural Development)

Addis Ababa University

Addis Ababa, Ethiopia

September 2021

Addis Ababa University
School of Graduate Studies
College of Development Studies

**Crop Diversification, Food and Nutrition Security among wheat
producers in Sinana District, Bale zone, Oromia Regional State,
Ethiopia**

Dereje Derso

**A Dissertation Submitted to Center for Rural Development, College
of Development studies**

**Presented in Fulfillment of Requirements for the Degree of Doctor
of Philosophy in Development Studies (Rural Development)**

Major Advisor: Degefa Tolossa (PhD, Professor)

Co-advisor: Abrham Seyoum (PhD, Associate Professor)

Addis Ababa University

Addis Ababa, Ethiopia

September 2021

DISSERTATION APPROVAL

ADDIS ABABA UNIVERSITY

SCHOOL OF GRADUATE STUDIES

This is to certify that a thesis prepared by Dereje Derso entitled: Crop Diversification, Food and Nutrition Security among wheat producers in Sinana District Bale Zone, Ethiopia, submitted in fulfillment for the requirements for the Degree of Doctor of Philosophy (Rural Development) complies with the regulations of the University and meets the accepted standards with respect to originality and quality.

Signed by Examining Committee:

_____	_____	_____
Chair person, Examining Committee	Signature	Date
_____	_____	_____
External Examiner	Signature	Date
_____	_____	_____
Internal Examiner	Signature	Date
_____	_____	_____
Advisor	Signature	Date
_____	_____	_____
Advisor	Signature	Date

Chair of Department or Graduate program Coordinator

Declaration

I, the undersigned, declare that this is my original work, has never been presented in this or any other University, and that all the resources and materials used for the dissertation, have been fully acknowledged.

Name: _____

Signature: _____

Date: _____

This dissertation has been submitted for examination with my approval as university supervisor.

Supervisor Name: _____

Signature: _____

Date: _____

Supervisor Name: _____

Signature: _____

Date: _____

ABSTRACT

Crop diversification has several economic, social and environmental benefits for smallholder farmers. It increases farm household income and employment opportunities for farmworkers, improve conservation of natural resources, soil fertility, improve food and nutrition security, and reduces output production shortages. While productivity is constrained by many factors such as technology, resources, environment, socio-economic, infrastructure, and crop pests and insects, food insecurity and malnutrition were Ethiopia's main development challenges. In Sinana District, agriculture is traditional malnutrition is devastating problems, particularly for the poor and unprivileged households. The study builds on the basic assumption that crop diversification plays essential roles in improving household food and nutrition security in rural Ethiopia. The overall objective of the study was to analyze crop diversification, food and nutrition security among wheat dominant producer rural households in Sinana District Bale Zone, Ethiopia. The study is positioned in the pragmatism philosophical assumption that applies to mixed methods research. It focused on primary data that was generated through cross-sectional survey. The cross-sectional survey was conducted using semi-structured questionnaire, Household food Insecurity Access Scale, household dietary diversity questionnaire, anthropometric data, key informant interviews, focus-group discussion and field observations. The study sample size was 384 households. Multistage sampling was employed to study subjects at different scale. STATA software version 14.2 was used to analyze data. Descriptive and inferential statistics and econometric models were used to analyze data. A Cragg's Double Hurdle model used for measuring the probability, extent and determinants of crop diversification practices of rural households. Ordinary least squares regression model used to analyze the effect of crop diversification on household food security while multinomial logistic and Zero-truncated Poisson regression model were used to analyze determinants of household food insecurity and the determinants of household dietary diversity respectively. Pearson correlation coefficients were calculated to see the correlation between the nutritional security status indicators and the crop diversification index. Univariate and multivariate logistic regression were performed to identify factors associated with infant nutrition. The result reveal that the average crop diversification index of sampled households was 41.3 percent. The probability of crop diversification was positively influenced by household size, access to fertile farm plots, and access to extension services and negatively influenced by age of household head, and participation in off/non-farm activities. The extent of crop diversification is positively affected by access to extension services, labor availability, membership to farmers cooperatives, and distance to market. The diversification of crops has had a positive and significant effect on household food security. Although crop diversification has been positively associated with household food security, several other factors have been shown to be equally or more important in increasing household food security. Household education, access to irrigation system, owned livestock, total income and remittances have had a positive impact on household food security. Analysis of household dietary diversity has shown that almost all respondents consumed food made from cereal, while only 20.1 percent, 10.2 percent and 7.3 percent of the household consumed egg, meat and fruits in the previous seven days of a survey, respectively. On average, household consumed 5.7 food groups. About 13.5 percent, 50.5 percent, and 35.9 percent of the participants consumed low, medium, and high dietary diversity level, respectively. Education level, participating in irrigation farming, membership to farmers' cooperatives, farm size and livestock holding positively affected household dietary diversity, while remoteness from the nearest market and remittances negatively impacted household dietary diversity. The prevalence of malnutrition

particularly stunting (23.8 percent), underweight (21.2 percent) and wasting (9.5 percent), respectively. Crop diversification is negatively correlated with stunting and wasting and positively with underweight and children's dietary diversity score. Child nutritional status is strongly associated with age of household head, maternal and parental education, farm land size, livestock owned, availability of drinking water, sex of children, and dietary diversity of children, family access to sanitation, total annual income and family access to health services. Any effort to increase household food and nutrition security should consider empowerment of farmers through adequate training and informal education, enhancing crop diversification. Policy and development interventions should target intensive agricultural production, rural infrastructure development, and education and awareness tools to be provided. Families update nutritional knowledge and agricultural technologies to increase production and income, and thus improve family nutritional security.

Keywords: *Food & Nutrition security; Undernutrition; Dietary Diversity; Crop Diversifications; Determinants*

ACKNOWLEDGEMENT

Thanks to my dear God to whom all the powers and knowledge belongs, who bestowed me with the strength and energy to finish this herculean task. I have been accompanied and braced by many people in last 5 years while working for my coursework then the Dissertation. Finally, I have this opportunity to express my gratitude to all of them for their support and encouragement

I would like to thank Professor Degefa Tolossa (PhD) for his wise supervision, comments and feedbacks, encouragements with fatherhood guidance from the start of course work, building the project proposal to the conclusion of the study. I have learned and benefited from his immense supervision and research experiences and knowledge of Development study. I am very grateful to Abrham Seyoum (PhD), co-supervisor, for his valuable and constructive comments, which apparently enabled me to produce this paper in its present shape and content. I am grateful to reviewers who read manuscripts that have been submitted published and submitted to journals for publication. Your feedbacks and suggestions were helpful to strengthen the manuscripts.

Doing fieldwork in rural areas is not simple. The fieldworks were demanding and compounded with challenges. However, I was open-minded and flexible to learn new about the study in question from the subjective reality of the participants. This method led to a wealth of information. My special thanks go to interviewed farmers for openly sharing both their local knowledge crop production and food security experiences, and for their respect in all my contacts and household visits. I extend my gratitude to key informants which include government and NGO officials, food security experts, Development Agents (DAs), Peasant Association officials, and health extension workers for their time and all-round guidance. I similarly appreciated the contribution of field assistants to the study.

I am grateful to Reta Hailu (PhD), my friend and role model who during the course work, preparation of manuscript came with insightful comments. This thesis is especially made possible with the generous help of my Wife and daughter: Meseret W/hanna, and Heran Dereje. Truly speaking, your unconditional love and care strengthen and supported me in many ways in the face of complex life-threatening problems in my journey to Ph.D.

The list would be endless if I mention all the names of those who directly or indirectly helped me through this journey from my teachers, friends, colleagues, all those who helped me to learn a word, I would like to thank them for their contribution.

Table of Contents

ABSTRACT.....	v
ACKNOWLEDGEMENT	vii
List of Tables	xiii
List of Figures	xiv
ACRONYMS AND ABBREVIATIONS	xv
CHAPTER ONE: INTRODUCTION	1
1.1. Background of the Study	1
1.2. Statement of the Problems	4
1.3. Objectives of the Study	7
1.4. Research Questions	7
1.5. Significance of the Study	8
1.6. Methodological Approach.....	9
1.6.1. Philosophical Underpinnings	9
1.6.3. Research Methods	12
1.6.4. Method of Data Analysis	18
1.6.5. Hypothesis and Variable Definitions	18
1.7. Crop Diversification: Theoretical Overview.....	28
1.7.1. Basic concepts of crop diversification	28
1.7.2 Agricultural Household Decision Models.....	29
1.7.3. Empirical Studies on Crop Diversification	31
1.8. Food and Nutrition security: Theoretical overview	33
1.8.1. Changing Approaches to Food Security	33
1.8.2. Food and Nutrition Security Indicators.....	37
1.8.3 Empirical Review.....	41
1.9. Crop Diversification and Household Food and Nutrition Nexus	44
1.9.1. Pathways to Crop Diversification, Food and Nutrition.....	44
1.9.2. Empirical Review.....	45
1.10. Analytical Framework	47
1.11. Thesis Structure	51
Chapter Two: A Double Hurdle Estimation of Crop Diversification Decisions by Smallholder wheat Farmers in Sinana District, Bale Zone, Ethiopia	52

1. Background	54
2. Theoretical Framework of the Study	57
3. Material and Methods	59
3.1. Description of the Study Area.....	59
3.2. Data Collection	60
3.3. Sampling Design.....	61
3.4. Data Analysis	61
4. Result and Discussions	66
4.1. Household Characteristics and Status of Crop Diversification.....	66
4.2. Factors influencing smallholder farmers decision to crop diversification	68
4.3. Factors influencing the extent of Crop Diversification.....	71
5. Conclusion and Recommendations	74
Chapter Three: The Contribution of Crop diversification Food Security among wheat producers in Sinana District, Bale Zone, Oromia Regional State, Ethiopia.	
	76
1. Background	78
2. Materials and Methods.....	80
2.1. Sinana District Setting	80
2.2. Study Design.....	81
2.3. Methods of Data Analysis.....	81
3. Results.....	87
3.1. Socio-Demographic and Socio-economic Characteristics	87
3.2. Household Food security Status.....	89
3.2.1. Household Food insecurity status measured by HFIAS.....	89
3.2.2. Food Security Status Measured by DDS.....	90
3.3. Effect of Crop Diversification on household Food Security.....	91
3.4. Determinants of Household Food insecurity	92
3.5. Discussion	95
4. Conclusion and Recommendation	99
Chapter Four: Household dietary diversity in rural households of Sinana District Bale Zone, Oromia Regional state, Ethiopia: A cross-sectional study.	
	101
1. INTRODUCTION	103
2. MATERILS AND METHODS.....	106

2.1.	Description of the Study	106
2.2.	Data Collection	106
2.3.	Population and Sampling Technique	107
2.4.	Data Analysis	107
3.	RESULTS AND DISCUSSIONS	110
3.1.	Household Characteristics.....	110
3.2.	Household Dietary Diversity	110
3.3.	Determinants of Household Dietary Diversity.....	112
4.	CONCLUSION AND RECOMMENDATIONS.....	116
Chapter Five: The contribution of Crop diversification to Nutrition Security among wheat producers in Sinana District, Bale Zone, Oromia Regional State, Ethiopia.		117
1.	Introduction.....	119
2.	Materials and Methods.....	122
2.1.	Sinana District Setting	122
2.2.	Study Design.....	122
2.3.	Data sources	122
2.4.	Sample Size Determination.....	122
2.5.	Data Collection Methods and Instruments.....	123
2.6.	Empirical Model and Data Analysis	123
3.	Result and Discussion	126
3.1.	Households and Children Characteristics	126
3.2.	Prevalence of Malnutrition.....	128
3.3.	Effect of Crop Diversification on household Nutrition.....	129
3.4.	Determinants of Child Nutrition	130
3.4.1.	Univariate analysis	130
3.4.2.	Multivariate logistic regression analysis.....	131
4.	Conclusions and Recommendations	137
Chapter Six: Conclusions and Recommendations		139
6.1.	Re-capping the purpose of the study.....	139
6.2.	Conclusions.....	140
6.3.	Synthesis and Recommendations.....	142
6.3.1	Synthesis	142

6.3.2 Recommendations.....	145
6.4. Suggested Future Research Area	146
References.....	148
Appendices.....	168

List of Tables

Table 1. 1: Comparison of Basic research Philosophies in Social Research	10
Table 2. 1: Summary of Explanatory variables used in Cragg's Double Hurdle Model	65
Table 2. 2: Descriptive result of factors affecting crop diversification	68
Table 2. 3: Probit regression estimates for determinants of crop Diversifications	71
Table 2. 4: Truncated regression estimates for determinants of level of crop diversification	72
Table 3. 1: Summary of Variables included to affect Household food security status	86
Table 3. 2: Household Socio-economic Characteristics for continuous variables (n=384)	87
Table 3. 3: Household characteristics for categorical variables (n=384)	88
Table 3. 4: Distribution of households by HFIAS condition	90
Table 3. 5: OLS regression of the effects of crop diversification on Household food security	92
Table 3. 6: Multinomial Logit Model	93
Table 4. 1: Summary of explanatory Variables influencing household dietary diversity	109
Table 4. 2: Household Dietary diversity frequency in previous seven days (n=384)	112
Table 4. 3: Determinants of HDD in study area (n=384)	115
Table 5. 1: Summary of Variables included to affect child nutrition status	125
Table 5. 2: Household characteristics for categorical variables (n=189)	127
Table 5. 3: Household characteristics for continuous Variables (n=189)	128
Table 5. 4: Prevalence of stunting, underweight and wasting	128
Table 5. 5: Pearson Correlation coefficients for the continuous variables	129
Table 5. 6: Bivariate logistic regression estimates for child malnutrition	130
Table 5. 7: Multivariate logistic regression estimates for child malnutrition	131
Table A 1. 1: Conversion factor for livestock unit	169
Table A 2. 1: Collinearity statistics for variables in the double hurdle model	170
Table A 2. 2: Collinearity statistics for variables in the multinomial analysis	171
Table A 2. 3: Collinearity statistics for variables in the Zero-truncated analysis	171
Table A 2. 4: Collinearity statistics for variables in the multivariate analysis	172
Table A 2. 5: Correlation matrix of residuals:	172

List of Figures

Figure 1. 1: Analytical Framework	50
Figure 2. 1: Map of Study area	60
Figure 2. 2: Kernel density estimate for crop diversification index	69
Figure 3. 1: Household Dietary Diversity of Study Site	91

ACRONYMS AND ABBREVIATIONS

ADLI	Agricultural Development Led Industrialization
BZADO	Bale Zone Agriculture Development Organization
BZFED	Bale Zone Finance and Economic Development
CDDS	Child Dietary Diversity Score
CDI	Crop Diversification Index
CDI	Crop Diversification Index
CSA	Central Statistical Agency
DA	Development Agents
DDI	Dietary Diversity Index
DDS	Dietary Diversity Score
EDHS	Ethiopian Demographic Health Survey
EIU	Economist Intelligence Unit
EPHI	Ethiopian Public Health Institute
FAO	Food and Agriculture Organization of the United Nations
FDRE	Federal Democratic Republic of Ethiopia
FGDs	Focus Group Discussions
GDP	Gross Domestic Product
GFSI	Global Food Security Index
GTPs	Growth and Transformation Plans
HAZ	Height for Age Z-score)
HFIAP	Household Food Insecurity Access Prevalence
HFIAS	Household Food Insecurity Access Scale
HHI	Herfindahl-Hirschman Index
HI	Herfindahl Index
IIA	Independence of Irrelevant Alternatives
IMR	Inverse Mill's Ratio
KIIs	Key Informant Interviews
OLS	Ordinary Least Square
TLU	Tropical Livestock Unit
UNICEF	United Nations Children's Fund

VIF	Variance inflation factors
WAZ	Weight for Age Z-score
WHO	World Health Organizations
WHZ	Weight for Height Z-score

CHAPTER ONE: INTRODUCTION

1.1. Background of the Study

Food security and famine are at opposite extremes of a spectrum (Timmer 2000). According to Majumder *et al.*, (2012) food security is ensured when people live without threat of starvation and hunger. Examining absence of food security is the simplest way to perceive it (Rooyen and Sigwele 1998). Food insecurity is a situation when the society unmet the basic needs and wellbeing for a continuous survival (Mazumdar, 2012). It is manifested through hunger, malnutrition, and undernourishment. As Sila (2007) noted to continue its development, a nation requires adequate food in terms of quantity and quality for all people. Lack of food, in the long term, leads to hunger and starvation that can cause death.

Fighting hunger and food insecurity is possible with economic growth which raises incomes of the population. However economic growth may not reach everyone unless pro poor policies, which specifically target the poor in the rural areas, are designed. In poor countries reduction of poverty and hunger is achieved not only with sustained but also with broadly distributed growth. Smallholder targeted policies such as increasing food availability and agricultural productivity can achieve hunger reduction even with the presence of widespread poverty (FAO, 2013).

Thus, efforts have been made by the globe to eradicate food insecurity, hunger and poverty. Among the principal goals of agricultural sector policies in sub-Saharan Africa are to increase the productivity and incomes of smallholder farmers (AfDB *et al.*, 2016); to enhance food and nutrition security (FAO, 2012; Mazunda *et al.*, 2018); to stabilize agricultural output through greater use of irrigation; and to promote commercialization and intensification of production, appropriate and participatory policy formulation and environmental sustainability (Asfaw *et al.*, 2018). In most sub-Saharan African countries, development of the agricultural sector continues to be constrained by weak integration, inadequate institutions and support services and the concentration of production in a narrow range of agricultural products for export or domestic consumption.

Agricultural diversification is a strategy for enhancing the welfare of low-income rural households (Asante *et al.*, 2017; Khanal and Mishra, 2017). Its positive effects include improvement of food security, mitigation of risk, employment generation and conservation of biodiversity (Ahmed and

Melesse, 2018). 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 diversification is among the adopted livelihood strategies (activities) which are adopted at the farm or household level as short- or long-term risk and vulnerability management strategies. It has several economics, social and environmental benefits for smallholder farmers. Increase farm household income and employment opportunities for farm workers, improve conservation of natural resources, soil fertility and food security, reduces output production shortages (Jones *et al.*, 2014; Pellegrini and Tasciotti, 2014; Islam *et al.*, 2018) and increases the technical efficiency and productivity of farms (Coelli and Fleming, 2004; Di Falco and Chavas, 2009; Rahman, 2009; Ahmed and Melesse, 2018).

In situations where farmers are faced with the prospect of a poor harvest, a crop or variety of diversity is one of the possible coping strategies (DiFalco and Chavas, 2009) through which the genetic diversity of each crop species can support productivity and risk management strategies (Smale *et al.*, 1998). It is considered as an important tool for acceleration of agricultural growth by promoting food and nutritional security, income and employment generation, poverty alleviation, cautious use of natural resources and ecological management (Jones *et al.*, 2014; Pellegrini and Tasciotti, 2014; Islam *et al.*, 2018).

Diversifying crops by favoring mixtures of species over monocultures is one of the most reasonable means of controlling pests and disease and has generated a lot of interest in the recent years (Shoffner & Tooker, 2013; Tooker & Frank, 2012). Crop mixtures likely work by increasing natural enemies of insect pests, breaking the disease cycles and overwintering, suppressing weeds and volunteer crop plants, creating a dilution effect by reducing resource concentration, modifying the microenvironment within the crop canopy, or making pest and disease pathogen penetration more difficult. It is being adopted by most smallholder farmers as a mechanism for achieving a household food security as it spread the risk of a particular crop failure (Asante *et al.*, 2017). It enabled farmers to spread production and income risk and therefore, reduced livelihood vulnerability to weather or market shocks (FAO, 2018, Mango *et al.*, 2018). Clements *et al.*, (2011) and Feliciano (2019) associate crop diversification with the replacement of low-value raw materials with high-value raw materials, generally fruits and vegetables intended for the export market. Weather conditions that are deemed unfavorable to a particular crop and affects the yield

of the said crop negatively may be favorable to other crops that will show good yield. Therefore, combining diverse crops on a particular piece of land secures smallholder farmers some yields that would ensure food availability among others.

In rural agricultural households that mainly consume self-produced food, it would seem logical that diversified farm production would contribute directly to food and nutrition; for this reason have tended to focus on the channel between diversity in crop production and in household diets (Jones *et al.*, 2014; Malapit, Kadiyala, Quisumbing, Cunningham, & Tyagi, 2015). On the other hand, since most agricultural households practice a mix of subsistence and market-oriented production (Jones *et al.*, 2014), revenue from market-oriented production can be used to purchase food that is not produced on the farmer's own land and can enhance dietary diversity for the household in that way. Thus, while market-oriented production might lead to specialization and reduce the diversity of food produced on the own farm, the net effect might nonetheless be to improve overall food and nutrition security.

Ethiopia is fundamentally an agricultural and pastoral country. Agriculture dominates Ethiopian life to the point that little progress can be made if the challenges of agriculture are not addressed directly. In large part, agriculture in Ethiopia is livelihood. The main food crops are produced in almost all regions of the country despite the variation in production volume between regions. The variation may be attributed to the extent of area devoted to each crop type, weather change and a shift in preference for the crops grown (CSA, 2014).

Crop production pattern of Bale vary across the Zone in accordance with the agro-climatic condition. Cereals, pulses, Oilseed, fruit, vegetables and spice are the known crop grown in the zone. Increasing crop diversification presents opportunity in reversing trends of productivity, poverty and food insecurity (MoA, 2010). Bale highland is considered as one of the favorable environments for crop diversification as its agro geographical factor is suitable for production (Asfaw *et al.*, 1994). It has two major cropping seasons namely Maher and Belg. Maher season is the main cropping season for zonal farmers and the production during this season takes a lion's share over the other season of production because of rain suitability. Although cultivation of diversified crops is concentrated in northern and central part of the country, Bale highland has a great potential offering for production of different crops. However, due to several shortcomings

such as social, economic, and environmental the production could not meet the expected outcome (Shiferaw, 2008).

Apart from the improvement of crop specific productivity enhancement, crop diversification is also used as one of the fundamental instrument for ensuring food security, poverty reduction, and source of overall agriculture development in most developing countries including Ethiopia. It also helps to minimize production and marketing risk, and uncertainty due to climatic and biological vagaries. The increasing risks of crop failure due to erratic rainfall and crop disease usually forces farmers to diversify their portfolio as a hedge against these risks (Poudel *et al.*, 2012). This, in fact, crop diversification helps for proper utilization of agricultural resources including land, water and other resources through providing farmers with viable options to grow different crops on their land (Fetien *et al.*, 2009; Wondimagegn *et al.*, 2011; Degye *et al.*, 2012; Rehima *et al.*, 2013).

There is, however, little knowledge about the contribution of crop diversification to household food and nutrition security, and the underlying factors affecting them in southeastern Ethiopia. Also the knowledge on the link between these variables is scanty. Therefore, a thorough study on these issues may help to identify the crop diversification constraints at farm level and thereby develop policy recommendations to increase agricultural production and productivity so that it will contribute to food security and poverty reduction efforts. This study, thus, aims to contribute towards a better understanding of crop diversification, food and nutrition security among wheat dominant producer rural households of in Bale zone of southeastern Ethiopia.

1.2. Statement of the Problems

The most recent edition of the report on the State of Food Security and Nutrition in the World (FAO *et al.*, 2020) contains very worrying statistics: nearly 690 million people are hungry, i.e. 8.9% of the world's population. In fact, in 2019, nearly 750 million people, or about one in ten people worldwide, were at risk of severe levels of food insecurity. Further, the incidence of malnutrition continues to rise (FAO *et al.*, 2020). Thus, the world is not on track to achieve Sustainable Development Goal (SDG) 2: Zero Hunger by 2030 (UN 2015). If recent trends continue, the number of hungry people will exceed 840 million by 2030. It is therefore essential to find effective and lasting solutions to fight hunger.

The challenges for global agriculture in the 21st century are to produce 70 percent more food by 2050 feed an expected growing population by implementing more sustainable methods and responding to climate change (FAO, 2009). From an environmental perspective, climate change and its impact on production clearly suggests the need to address issues such as variations in the availability of water (lacking or in excess), the reduction of agricultural productivity and the need for low impact technologies.

Ethiopia recognizes two dominant farming systems which are mixed farming the highlands, where crops and animal production are integrated, and lowland pastoralism. Mixed farming has several sub-systems. Most of the agricultural production takes place in the highlands of Ethiopia, where there are five main grains; teff (*Eragrostis tef*), wheat, maize, sorghum and barley and enset (*Ensete ventricosum*) are the main foods and play a dominant role in cropping systems in terms of altitude, rainfall and market access (IFPRI, 2011). According to CSA (2014), crops in Ethiopia are inevitably affected by many factors, including climate, input prices, changes in agricultural practices, quantity of fertilizers used, and quality of seed varieties and use of irrigation. Crop yield per area (amount of crop harvested per amount of cultivated land) is the most commonly used impact indicator for agricultural productivity activities.

Although Ethiopia's smallholder farmers are supposed to feed the country's growing population, they are limited by a series of challenges that hamper their ability to provide food security for most people. As a result, the country was considered one of the most food insecure countries in the world with around 10.2 million people suffer from food insecurity (FAO, 2016). Various factors have been responsible for the low productivity of the farming sector in Ethiopia including Sinana District. Among the major factors, land degradation coupled with traditional cultivation practices, erratic rainfall, diseases and pests, mismanagement of land resources and drought have posed a serious threat to households' food and nutrition security and agricultural productivity in the country. Moreover, smallholder farmers are constrained by low yields, low productivity and lack of access to markets including credit markets (Mersha & Ayenew, 2018).

Whether farmers are food and nutritionally secure from producing a diverse set of food crops or from specializing in crop production for sale and then purchasing food has been the subject of debate among researchers (Hirvonen and Hoddinott, 2016; Jones, 2017; Sibhatu and Qaim, 2018;

Gupta *et al.*, 2020). This debate has important implications for national and international development policies; also improves diet quality, then governments, donors, and international organizations can continue to focus their policies in this direction with the hope that they will bring higher incomes, more food, and better quality diets. However, if greater diversity in production translates into better quality diets, more nuanced policies may be needed to support these multiple goals.

Many of existing empirical evidence suggests a positive association between crop diversification and food security among smallholder farmers (Lovo & Veronesi, 2019; Sibhatu & Qaim, 2018; Chinnadurai *et al.*, 2016; Romeo, *et al.*, 2016; Saaka, *et al.*, 2017). For instance, Chinnadurai *et al.*, (2016), found that crop diversity positively affected the respective household's dietary diversity. Likewise, Sibhatu and Qaim (2018) showed that the diversity of agricultural production in terms of single species count was positively correlated with most food indicators. Parvathi (2018) found that, for farm production diversity, higher diversity led to a higher dietary diversity. FAO *et al.*, (2012) underlined that small holder agricultural growth was the key to the under nutrition problem as it could increase employment and improve access to food especially for women smallholders. Jones *et al.*, (2014) find that, controlling for the effects of several covariates on household dietary diversity, crop diversification is positively associated with dietary diversity among Malawi households. Harvonen and Hoddinott (2014) also find a similar positive association using data from Ethiopia. Bhagowalia *et al.*, (2012) evaluated the association between nutrition, household income and agricultural production using the 2004/05 India Human Development Survey. They explored that the impact of income, unless it is accompanied by better access to health and sanitation facilities and education, has minimal impact on nutritional status of children measured by anthropometric indicators.

In the study area, almost all farm household depend on the mono-cropping pattern on a given farming land for their food and nutrition security. Farmers are generally involved in a cereal production businesses. Despite agriculture is the main source of livelihood for most Ethiopian smallholder farmers, not much work has been done in Sinana District on what factors determine smallholder farmer's decision and extent to diversify their enterprise to maximize their profit, role of crop diversification to household food and nutrition security among wheat producer rural households.

1.3. Objectives of the Study

In the field of Development studies, the importance of measures of development like food and nutrition security, per capita income and happiness, is to judge the safety and development of the people. For a human being to keep safe, his needs, at least, for food must be satisfied. Hence, when we talk about development studies food and nutrition security comes at the forefront for safe survival.

This research is therefore aimed at empirically identifying and examining linkages of crop diversification, household food, and nutrition security in Sinana District Bale Zone, Ethiopia. Specifically, the study first aimed to analyze crop diversification among wheat producer households in Sinana District (paper I). It analyzed the status and extent of crop diversification among wheat producer households and factors that influence them.

Second, the research attempted to analyze the contribution of crop diversification to household food security among wheat producer households. It examined household food security status and its determinant among wheat producer households and effect of crop diversification on household food security among wheat producer households (Paper II). Third, in striving to identify predictors of household dietary diversity in Ethiopia, the study employed a case study from Sinana district. It assessed status and determinants of household dietary diversity (Paper III). The fourth specific objective was to analyze contribution of crop diversification to household nutrition security in rural areas (Paper IV). This aims to analyze household nutrition security status, effect of crop diversification on nutrition security and determinants of child nutrition among wheat producer households.

1.4. Research Questions

The study investigated how crop diversification determines food and nutrition security among rural households in Ethiopia. It builds on the basic assumption that crop diversification plays essential roles in improving household food and nutrition security in rural Ethiopia. It is hypothesized that a higher crop diversity would reflect a better food and nutrition security. At a glance, crop diversification, food and nutrition security were questioned in this context. Hence, the research on crop diversification, food and nutrition security in the Sinana District has centered on the following key questions:

1. What is the level of crop diversification among rural households? How farm and household characteristic affect crop diversification? (Paper I)
2. How rural households are benefiting from increased crop diversification from food security view point? What are the determinants of farm and non-farm characters to achieve food security? (Paper II)
3. What are the challenges for dietary diversity among rural households? (Paper III)
4. How rural households are benefiting from increased crop diversification from nutrition view point? What is the prevalence of stunting, wasting and underweight of children below age of five in the study area? What are the key predictors of malnutrition among children below age of five in the study area? (Paper IV)

1.5. Significance of the Study

The study is meant to build on existing knowledge on crop diversification, food and nutrition security in Ethiopia. Furthermore, its importance is demonstrated in a number of the ways:

Contribute to the existing body of knowledge in development theory and practice on the role of crop diversification on food and nutrition security. In many studies, greater emphasis has been on diversification patterns, causal factors and determinants. This study additionally analyzed the contribution of crop diversification to food and nutrition security. This will help in understanding the extent to which crop diversification has been effective, obstacles to food and nutrition security and ways in which development players and governments can further tap into its potential. Thus, clarity on the community perceptions and expectations will better inform development planners on how to ensure food and nutrition security through crop diversification.

Secondly, communities participating in the research were brought together to further explore the challenges confronting them in practicing crop diversification, addressing food and nutrition security, collectively reflect on practical steps and initiate action aimed at improving food and nutrition security through crop diversification. This also encouraged cross fertilization of ideas among community members making them better able to engage development organizations in their areas.

Therefore, the study is significant in that it generates findings, lessons and recommendations on how crop diversification can be effectively harnessed by government, researchers, and

development agencies to improve food and nutrition security among rural households. It is hoped that this may influence programmatic approaches and interventions aimed toward reducing poverty, improving incomes and ensuring greater access to food in rural areas. Further, local and regional governments use this research as a basis to improve better understand crop, food and nutrition security status. The findings can also assist policy makers in designing future policies and strategies for crop diversification and/or nutrition sensitive agriculture, food and nutrition security. NGOs may use the outcome of this research as feedback to design programs that can increase the food production potential of farmers of the study area.

1.6. Methodological Approach

1.6.1. Philosophical Underpinnings

There is a strong interrelationship between the theoretical stances adopted by the researcher, the methodology, and methods used (Saunders, Lewis and Thornhill 2009). This philosophical base helps us to understand and answer the question of what constitutes the social reality-ontological base, what it means know the social reality the epistemological basis and how to study the methodological basis of social reality (Corbetta, 2003; Gray, 2014). Grix (2002) argues that there are logical links between ontology, epistemology, methodology and methods. Research starts from what the researcher thinks can be researched, by relating it to what he knows and how to acquire it. In addition, Grix (2002) differentiates the methodology of methods that claim that the methodology is the science of the study of methods and hypotheses on the modes of production of knowledge. Method is techniques or procedures of selecting, collecting, organizing and analyzing data (Blaikie, 2010).

There are two main ontological positions depending on whether the reality exists external to or within the mind of the individual (Table 1.1). These are objectivism (also called realism) which asserts that social phenomena and their meanings exist independently of social actors, and constructivism (also called subjectivism) which states that social phenomena and their meanings are continually constructed by social actors and thus in a constant state of revision (Saunders, Lewis & Thornhill, 2009). Likewise, there are two opposing epistemological positions contained in the perspectives of the positivist and the constructivist/interpretivist. The first supports the application of natural science methods to the study of social reality and beyond and the second

point of view that a strategy is needed that respects the differences between people and objects in nature sciences and, therefore, requires a social scientist to grasp the subjective meaning of social action (Grix, 2002; Saunders, Lewis and Thornhill, 2009).

Charles Sanders Peirce, an American philosopher, introduced another knowledge that justifies pragmatism in philosophy in 1878 (Maxcy, 2003). Pragmatism stems from actions, situations, and consequences rather than prior conditions and concerns about applications and solutions to problems. It mainly deals with the problems rather than the methods used and, therefore, the researcher uses a pluralistic approach to understanding the problem (Neuman, 2007, Creswell, 2013). Pragmatists see reality in two ways: First, they consider that there is an outside world independent of our mind (which agree with the positivist view of reality) and, second, they "deny" that "truth" can be determined once and for all. Moreover, they are not sure of the concept that one explanation of reality is better than another (Cherryholmes, 1992).

Pragmatism maintains that the demand for research is the most important factor determining the ontology, epistemology and methodology of a research and that it is possible to work with both positivist and interpretivist positions (Saunders, Lewis and Thornhill, 2009), which is a mixed research method (Creswell, 2013). This particularity of the pragmatic philosophy of research opens the door to the use of multiple methods, to have different worldviews and different assumptions as well as different forms of data collection and analysis through the application of qualitative and quantitative techniques (Creswell, 2014).

Table 1. 1: Comparison of Basic research Philosophies in Social Research

	Objectivism	Constructivism	Pragmatism
<u>Ontology</u>	Knowledge exists	Knowledge is	Reality is constantly
What is Reality?	independent of social actors	constructed by social actors, not discovered	negotiated, debated and interpreted
	Objective	and may change	Reality is external and multiple
	Single reality	No single reality	Truth is what works at the time, not based on
			Strict dualism between the mind and

			Reality completely Independent of the mind
<u>Epistemology</u> What does it mean to know the reality?	Observable phenomena can provide credible data Reality can be measured	Subjective meaning of social phenomena and object of study are not separate but interdependent	The best method is one that solves problems Focus on practical applied research Integrating different perspectives for data analysis
<u>Theoretical perspectives</u> Which approach to use to know reality	Positivism	Interpretivism: Phenomenology Symbolic Interactionism Hermeneutic Feminism	Free to use methods, techniques and procedures that solve problems Problem is more important than the method
<u>Methodology</u> How to go to find out the knowledge?	Application of natural science methods to study social reality and beyond Quantitative strategy Experimental research Survey research	Application of social science methods to grasp the subjective meanings of social actions Qualitative strategy Phenomenological research Ethnography Hermeneutical	Application of mixed or multiple method design

<u>Method</u>	Quantitative:	Qualitative:	Combination of
What techniques to use to find out the knowledge?	Questionnaire Measurement and scaling Analysis variables'	Interview Observation Case study Analysis 'by cases'	qualitative and quantitative methods

Adapted from Saunders, Lewis & Thornhill (2009); Creswell (2013); Gray (2014)

This study is positioned in the pragmatism philosophical assumption that applies to mixed research methods in which researchers freely rely on quantitative and qualitative hypotheses. Pragmatism is results-oriented and is concerned with determining the meaning of things (Johnson and Onwuegbuzie, 2006) or focusing on the product of the research (Biesta, 2010). It is characterized by an emphasis on communication and shared meaning-making in order to create practical solutions to social problems. It places primary importance on the research question (Tashakkori and Teddlie, 2003). Pragmatism is predicted on the assumption that theories are often both contextual and generalizable by analyzing them for “transferability” to a different situation.

Mixed methods research is a type of inquiry that is philosophically grounded where an intentional a combination of qualitative and quantitative approaches is used in a single research study. This mixture, or the integration of these two approaches, can take place in the philosophical or theoretical frameworks, methods of data collection and analysis, overall research design, and/or discussion of research conclusions. The purpose of a mixed methods research is to provide a more complex understanding of a phenomenon that would otherwise not have been accessible by using one approach alone (Creswell and Plano Clark, 2011, Morse and Niehaus, 2009). Therefore, in this study mixed method (qualitative and quantitative research method) were employed to analyze crop diversification, food and nutritional security among rural households in Sinana District, Bale Zone of Oromia Region, Ethiopia.

1.6.3. Research Methods

This research focused on primary data that was generated through cross-sectional survey during 2017/18 crop production season. The research adopts a cross-sectional survey as opposed to longitudinal survey, since the latter requires taking a repeated measurement on continuous bases that have cost and time implications (Kothari, 2004). The cross-sectional survey was conducted

using semi-structured questionnaire, anthropometric data, key informant interviews and focus-group discussion.

1.6.3.1. Quantitative Data Collection Methods

Semi-structured questionnaire

The questionnaire has several sections to collect different kinds of data required for this study. In particular, it has separate component for the socio-economic related information, measurement of crop diversification, food security indicators (Household Food Insecurity Access Scale and Household Dietary Diversity) and anthropometric data for children below the age of five. Both closed and open-ended semi-structured questionnaire was prepared to generate the required information. The semi-structured questionnaire that was prepared in English was translated into Afan Oromo, which is the official language in the study areas. Prior to the actual data collection, semi-structured questionnaire was pre-tested to ensure clarity, validity, and sequence of the question. The questionnaire was pre-tested in *kebeles* different from sampled *kebeles* and revised according to the feedback obtained. Then, the final semi-structured questionnaire was employed to collect data from the sample farmers.

Household Food Insecurity Access Scale (HFIAS)

The HFIAS used to measure the degree of food insecurity (access) within the household within the past 30 days. It reflects three universal domains of household food insecurity that it is the concern about the food insecurity of families, the insufficient quality and insufficient quantity of food (Deitchler *et al.*, 2011). This indicator captures the household's perception about their diet regardless of its nutritional composition (Coates *et al.*, 2007 and Mango *et al.*, 2014). The idea is argued that experiences of household food insecurity (access) reasons predictable reactions and responses that may be captured and quantified via a survey summarized in a score. Responses can be transformed into a continuous or categorical indicator of food safety. When calculating the HFIAS as endless indicator, each of the nine questions is scored 0-3, with 3 being the very best frequency of occurrence, and therefore the score for every is added together. The HFIAS total can range from 0 to 27, indicating the degree of unsafe access to food. As a categorical variable, households are categorized as *food secure*, *mildly food insecure*, *moderately food insecure*, or *severely food insecure* (Coates *et al.*, 2007). An important strength of the HFIAS, and other

experience-based food insecurity scales, it used to detect aspects of food insecurity that involve reduced access to sufficient quantity or quality of food as well as psychosocial manifestations of hysteria and uncertainty around food access, which may also affect health and wellbeing (Ballard *et al.*, 2013) In addition, it has been found to be understandable and applicable in different contexts, including urban ones (Mohammadi *et al.*, 2012) and rural (Knueppel *et al.*, 2010) settings. It is also relatively short and can easily be added as a module to other home surveys.

Dietary Diversity Questionnaire

Our second food security measure is a Household Dietary Diversity Score (HDDS), “*the number of food groups consumed by household members*” during the seven-day recall period. Dietary diversity indicators tend to be strongly correlated with more complex measures of dietary and nutritional intake (Ruel, Harris & Cunningham, 2013). As Headey and Ecker (2013) note, there are two basic reasons that these indicators are effective measures of food and nutrition security. First, a diverse diet is one that is more likely to capture the consumption of both macro- and micronutrients (Ruel, 2003). Second, there is evidence that individuals will only diversify into higher-value micronutrient-rich foods (such as meats, fish, eggs, dairy products) when they have satisfied their basic caloric needs. Thus, as their incomes grow, poor households substitute out of monotonous energy-dense diets into more diversified nutrient-rich diets (Jensen and Miller, 2010). For our HDDS we follow Swindale and Bilinsky (2006) and categorize the 377 food items in the survey into twelve food groups: (1) cereals; (2) roots and tubers; (3) vegetables; (4) fruits; (5) meat and poultry; (6) eggs; (7) fish; (8) pulses, legumes, and nuts; (9) milk and milk products; (10) oils and fats; (11) sugar and honey; and (12) miscellaneous food. Thus, the HDDS ranges from 1 (all food consumption derives from one food group) to 12 (household consumed items from all 12 food groups), with higher values representing higher quality diets.

1.6.3.2. Qualitative Data Collection Methods

In order to capture better the socio-economic context and type of households in the area qualitative data was collected through FGD, key-informants, field visits, and observations.

Focus-Group Discussions (FGD)

Focus group discussions have been recognized to be a useful tool in research. Despite the existence of many definitions of a focus group in the literature, but features such as organized discussion (Kitzinger, 1994), collective activity (Powell *et al.*, 1996), social events (Goss and Leinbach, 1996) and interaction (Kitzinger, 1995) confirm the contribution that focus groups make to social research. A useful definition by Powell, *et al.* (1996) describes a focus group as “*a group of individuals selected and assembled by researchers to discuss and comment, based on personal experience, on the subject of the research.*”

FGDs are meant to generate qualitative information through an organized discussion with a selected group of individuals on a particular topic (Gibbs, 1997). Thus, as noted by Webb and Kevern (2001) all definitions place emphasis on interaction among participants as a means of accessing data that would not appear if other methods were used. Interaction gives the method a high level of validity because what participants say can be confirmed, reinforced or contradicted within the group discussion.

Some researchers suggest that FGDs can be comprised of up to fifteen people (Goss and Leinbach, 1996), however *the recommended number of people per group* is usually six to ten (MacIntosh, 1993). Focus group sessions typically last one to two hours. The meetings can be held in a variety of places ideally there should be conducted at an accessible place where the participants hold their regular meetings. As Powell and Single, (1996) noted neutral locations is helpful for avoiding either negative or positive associations with a particular site or building.

During the study, thirteen (13) FGDs (two to three FGDs) were held in each sampled kebeles. Each discussion group had between 7-9 randomly selected participants who were men, women and youths (mixed) of ages years. Four trained facilitators used about eight guiding questions to moderate the discussions with participants selected through random sampling taking into account gender, age, length of stay in the district and socio-economic category among other factors. Judgment or quota sampling was employed according to the researcher’s judgment to ensure participants with the sufficient demographic and socioeconomic representation (i.e. individuals involved in agricultural activities, and small business). In total, 104 participants comprising women, youths and men were separately engaged in discussions to ensure balanced representation and input. The sampling in this study was done with the research assistants who knew the area and the people very well.

To ensure balanced input, the approach used during focus group discussions entailed interviewing men, women and youths of various ages involved in agricultural activities. The selected participants had similar background and experiences to discuss the research questions (Patton 2002). The FGDs were intended to explore ideas and opinions from community members. This helps to take into account different points of views and helps to strengthen or argue against some answers of farmers based on the results obtained. These discussions provided further insight into community members' experiences and perceptions on crop diversification practices, food and nutrition security in line with the objectives of the study. Interacting with community members in their natural setting promoted openness and cross fertilization of ideas among participants. With the help of checklists/unstructured question discussions was held with selected farmers to get some general information about crop diversification practices, food and nutrition security in the selected *kebeles of Sinana District*.

Key informant interviews (KIIs)

This was used to collect more information from some key informants on pertinent issues. In line with this Patton (2002) notes, the fieldwork began by speaking with key informants, “who knows a lot about” the study topic in question. It entails getting information from an individual who is considered knowledgeable about a topic of interest. Semi-structured interviews are conducted in a face-to-face setting with a key informant enabling the researcher to seek new insights and ask questions in different perspectives. During KIIs, since one is looking for useful ideas and insights, not just for statistics, respondents are chosen based on their knowledge and expertise. In situations where written records or published documents are limited, KIIs facilitate information on different perspectives especially when key informants are accessible and have in depth knowledge about a topic (McKillip, 1987).

The USAID (2003) notes that KIIs are useful in the following situations: (i) when qualitative, descriptive information is sufficient for decision making. (ii) When there is a need to understand motivation, behaviors, and perspectives of our customers and partners. (iii) When a main purpose is to generate recommendations. Key informants can help make recommendations that can improve a program's performance. (iv) When quantitative data collected through other methods need to be interpreted, key informant interviews can provide the how and why of what happened.

(v) When preliminary information is needed to design a comprehensive quantitative study. Interviews with key informants can help define problems before the investigation is undertaken.

Therefore, KIIs have a very specific purpose which involves identifying different members of your community who are especially knowledgeable about a topic and asking them questions about their experiences working or living within a community. It provides a useful platform to gather detailed data in a relatively easy way, raise awareness, interest, and enthusiasm around an issue as well as providing an opportunity to build or strengthen relationships with important community informants and stakeholders.

In the study, structured interviews were held with key informants using an interview guide. Eighteen key informants were selected using purposive sampling because of the need to engage individuals and or institutions that are likely to provide meaningful input to the study. These comprised eight community members engaged in agriculture activities, five researchers, two NGO officials and three government officials. Care was also taken to ensure diversity among key informants. This was meant to enrich findings and allow multiple perspectives that will minimize bias.

Field observation and note

The study employed both direct and participant observation techniques (Strauss and Corbin, 1990; Leedy and Ormrod, 2005), so as to deepen understanding of issues and also observe the interaction of people in their natural setting. Informal observation and interaction with community members during the research period enabled researchers to establish a relationship of trust with research participants which facilitated greater access to “inside” knowledge, thereby enhancing the credibility of the findings (Stringer and Genat, 2004). As Yin (2009) noted one of the advantages of using a case study design is that the researcher can observe the subjects within their environment. The method is important in order to understand the points of the topic studied: farming systems, forms of transport and other social services like health center, potable water, and market places. Field observation made during land preparation to obtain an insight into the production of different crops and to identify the farmers ‘problems with low productivity. I also visited the health posts and markets.

1.6.4. Method of Data Analysis

In this study STATA software version 14.2 was used to analyze data. Further, descriptive and inferential statistics and econometric models was used to analyze data. Descriptive statistical tools such as average, ratios, percentages, frequencies, etc. were applied to describe demographic, socio-economic, farm, institutional and technological characteristics of the study areas while inferential statistical methods such as χ^2 , t and F-tests were used to compare households in the selected *Kebeles* in terms of identified characteristics.

The detailed econometric model specifications for various types of analyses are given in subsequent chapters. The specification is sub-divided into five major analytical categories. The first category in chapter three looks at econometric model for measuring the probability, extent and determinants of crop diversification practices of rural households. A Cragg's double hurdle model was used to analyze probability and extent of crop diversification in the study area. The second and third category in chapter four looks at models of effect of crop diversification on household food security and determinants of household food security respectively. Ordinary least square methods and multinomial regression model used to analyze contribution of crop diversification to household food security and determinants of household food security respectively. The fourth category in chapter four looks at model of determinants of dietary diversity among rural households. Zero truncated Poisson regression model was used to analyze determinants of household dietary diversity. Finally, econometric model for measuring effect of crop diversification on household nutrition and its determinants were specified.

1.6.5. Hypothesis and Variable Definitions

Definition of Variables for Crop Diversification

This study analyzes the probability and determinants of crop diversification among rural families in Sinana district. The dependent variable for this study is crop diversity indices. Hypothesized variables that determine crop diversification among rural households are age and sex of household head, family size, labour availability, education, farm size, distance to farm, number of farms, distance to the market, livestock holding, oxen ownership, non-farm income, slop of plot, availability of agricultural machinery, frequency of extension contact and member to farmers' cooperative. The expected influence of each of this variable are discussed as follows:

Gender of the Household Head: This is a dummy variable that takes a value of 1 if the household head is male and 0 if female. Male as well as female headed households can choose to diversify or not based on their choice, preferences, and access to resources. Study by Rehima *et al.*, (2013) indicate that female-headed households have a positive effect on crop diversification. Researchers argued that female-headed households are more likely to be concerned about securing food for the family and are more likely to be engaged in diversification than males.

Age of Household Head: is a continuous variable (a variable that takes on any value between its minimum value and its maximum value. In this study, it is expected that elderly farmers' level of diversification is less than that of younger farmers. Elderly farmers look at farming as just a way of life, whereas young farmers may be more inclined to see agriculture as a business opportunity to financially support their families (FAO, 2012). Therefore, it is expected that the variable was negatively associate with crop diversification. Studies by (Fetien *et al.*, 2009; Ibrahim *et al.*, 2009; and Aneani *et al.*, 2011) found that older farmers are less likely to diversify crop than younger farmers.

Household Size: is a continuous variable indicating the number of family members living in a household. Household size is expected to have a positive effect on crop diversification through its effects on preferences and overall labor capacity. The larger the household size, the more likely that it will be able to diversify so as to increase its food production levels. In line with this study by Benin *et al.*, (2004) concluded that availability of adequate labour force has a positive effect on crop diversification practices.

Education of Level Head of Household: Level of education of the household head is taken to be a continuous variable representing year of schooling. It is claimed that educated people can understand agriculture instructions easily and are better able to apply skills imparted to them, unlike the uneducated. This variable is therefore expected to positively affect crop diversification. Studies by Seid and Seebens, (2008), Rahman (2008), Ibrahim *et al.*, (2009) and Rehima *et al.*, (2013) found that educational level of the household head positively influence crop diversification.

Landholding size: This is a continuous variable (a variable that takes on any value between its minimum value and its maximum value) referring to the total area of arable farmland that a farmer owns. The amount of land a farmer has available plays a crucial role in determining how many

crops a farmer can produce. Larger farms will tend to increase diversity, by increasing the capacity of households to allocate land to try out other crops. Previous finding shows that crop diversification is positively associated with large farm size (Benin *et al.*, 2004; Fetien *et al.*, 2009; Kanyua *et al.*, 2013; Sichoongwe *et al.*, 2014). Therefore, the variable should be positively associated with crop diversification.

Distance to Farm: Distance between farmer's residence and farm is a continuous variable measured in walking hour was expected to be negatively related to crop diversification. Greater distances from the house to the farm may reduce the opportunities to grow more crops because of requirements in walking time. This hypothesis is supported by Benin *et al.* (2004).

Number of Fields or Farm: This refers to the total number of fields or farm plots that a farmer has. This variable is continuous and it is expected to influence crop diversification in a positive way. Evidence indicated that the number of fragmented land and fragmentation index positively affected crop diversification (Benin *et al.*, 2004; Gauchan *et al.*, 2005; Nagarajan *et al.*, 2007; Fetien *et al.*, 2009; Wondimagegn *et al.*, 2011).

Distance to the Market: is continues variable, was measured in walking hour from residence to nearest market. Distance to the market is an indicator of physical access to markets and organized trade, as well as proximity to economic resources. The closer to the marketplace the farmer is, the simpler it turns into for her or him to diversify and to take produce to marketplace. However, in a few instances, farmers placed farther far from markets or fundamental roads, have to diversify to fulfill their good sized subsistence and nutrition species. Hence, the character of the affiliation of this variable with crop diversification is indeterminate and can be negatively or positively associated.

Different studies show that the nearer to the market the farmer is, the easier it becomes for him or her to diversify and to take produce to market. Hence, proximity to market center is expected to have a negative effect on crop diversification (Benin *et al.*, 2004; Ashfaq *et al.*, 2008; Sichoongwe *et al.*, 2014). A observe through Ibrahim *et al.*, (2009) indicates that farming families which might be farther far from the main markets face excessive prices of transportation to get their produce to the marketplace and in such instances, they choose to develop plants best for subsistence purposes.

Livestock holding: Total livestock holding of the household is measured as a continuous variable in terms of the TLU (tropical livestock unit). Livestock, as a measure of wealth, may act as insurance against crop production risk, bearing a negative relationship with diversity. On the other hand, it may have a positive effect on diversity through additional income, enabling farmers to intensify production and engage in multiple activities.

Non-farm income: is a dummy variable given a value 1 if the household works off-farm and 0 otherwise. The effect of income that is exogenous to crop choice, such as remittances, gifts, aid, and pensions will affect crop diversification. Holden *et.al* (2004) found that, off-farm activity has positive welfare implications. Thus, it is expected that off-farm income to have a negative effect on crop diversification.

Extension Contact: The number of visits by extension agents per month is a continuous variable expected to be positively related to crop diversification. Frequency of extension contact with extension workers would provide the farmer with necessary information about the availability of needed resources, market and prices. The large the frequency of contacts a farmer had with extension workers, the greater probable to have interaction in the production of additional crops. Different studies found a positive relationship between extension contact and crop diversification. (Fetien et al., 2009; Ibrahim et al., 2009; Wondimagegn *et al.*, 2011; Rehima *et al.*, 2013).

Definition of Variables for determinants of household food security

This section deal with analysis of determinants to household food security among rural households in Sinana District. The dependent variables to analyze determinants to household food security was Household Food Insecurity Access Prevalence (HFIAP) status. The variables that determine household food security among rural households are discussed as follows.

Sex of household head (GENDER): This is sex of household head taking value of 1 if household head is male and 0 otherwise. Women farmers may need a long period of adjustment to fully diversify their sources of income and become food secure (Christina *et al.*, 2001).The labor factor plays an important role in the study area. Hence, male headed households are in a better position to pull labor force than the female headed ones. Therefore, it has been hypothesized that households headed by men are more likely to be healthy for food.

Age of the household head (AGE): rural households mostly devote their time or base their livelihoods on agriculture. The older the head of the household, the more experience he has in agriculture and weather forecasting. In addition, the elderly are more risk averse and, for the most part, intensify and diversify their productive activities. As a result, the chance for such household to be food secure is high. In this study, it was hypothesized that age of the household head and food security are positively correlated.

Education (EDUC): Education provides individuals with the knowledge necessary to earn a living. Agriculture being a dynamic profession, conservation practices and agricultural production technologies are better and better known. Thus, if the household head is literate, he/she will be very prone to accept extension services and any other income generating activities. It is perceived that households who have had at least primary education or informal education are the ones more likely to participate than the others and their chance to be food secured will be higher. As a result, it is expected that education have positive impact on food security.

Family size (FSIZE): this variable refers to the size of household members living in the households in the previous six months. The existence of large numbers of family members with limited resources could affect the family's food security status. Further, as the family size increases, the number of mouths to be fed obviously increases which shares the available food in the household. Therefore, the expectation was that family size and food security status are negatively related. Evidence in the literature indicates that larger family size has negative impact on food security (Mulugeta Tefera, 2002; Abebaw Shimeles, 2003 and Ayalew Yimer, 2003). In several developing regions, the numbers of hungry people have continued to increase despite the impressive gains in food production due to large family size (Stone, 1992).

Size of cultivated land (LSIZE): This variable represents the total cultivated land size of a household in hectare. As the size of cultivated land increases, provided the other associated inputs remain normal, the likelihood of the owner getting more production is high. It was hypothesized that farmers who've large cultivated land size have been much more likely to be food secure than those with smaller area.

Participation in Irrigation Farming (IUSE): this is a dummy variable taking a value of 1 if farmers participate in irrigation farming and 0 other wise. Availability and participation in

irrigation activities allow farmers to produce variety of product which will allow them to earn higher income. Hence, we hypothesis that irrigation increase household food security.

Access to credit (CUSE): is a dummy variable taking value of 1 if household receive credit in the last five years and 0 otherwise. Credit is an important source of income. Those households who received the credit they wanted have better possibility to spend on activities they want. Either they purchase agricultural input (improved seed, fertilizer, agro-chemicals, etc.) or they purchase livestock for resale after they fattened them. All of these activities increase the family's income. The possible explanation is that in the study area, families who were willing to participate in the credit program and managed to earn more amount became capable to improve their income position through performing different activities and succeeded to secure better access to food than those who were not. Hence it was expected that credit will have a positive impact on food security.

Distance from market center (DMARKT): is continues variable, was measured in walking hour from residence to nearest market. To marketplace facilities creates get right of entry to additional earnings with the aid of using presenting off-farm/ non-farm employment opportunities, smooth get right of entry to inputs and transport. It was, therefore, predicted that families closer to marketplace middle have better hazard to improve the food security status of families compared to those who do not have proximity to market centers.

Membership to Farmers Cooperatives (COOPS): is a dummy variable taking value of 1 if farm household is member to farmers' cooperatives and 0 otherwise. Membership to farmers' cooperatives can create direct and indirect effect on food security. It was hypothesized that Membership to farmers cooperatives has higher probability of being food secure.

Crop diversity indices (CDI): This is a measurement for effect of crop diversification on household food security measured in Household food security access scale. We hypothesis that crop diversification has a positive association with household food security.

Definition of Variables for HDD

In this part determinants of dietary diversity among rural households in Sinana District were examined. The dependent variables to analyze determinants to HDD is dietary diversity indices. The variables that determine dietary diversity among rural households are age, sex, participation

in irrigation farming, food expenditure, access to credit, family size, education, distance to the market, livestock holding, participation in non/off-farm income, annual gross income, crop diversity index and sanitation training. The expected influence of each of this variable are discussed as follows.

Family size (FSIZE): Household size is negatively correlated with dietary diversity since the additional budgetary constraints may force the household to renounce to more expensive food types and only focus on the basic ones.

Mothers' Education (MEDU): Mothers' education determines nutrition outcome as educated mothers can access information about health care facilities and food processing relatively easily. It is argued that educated people can have better nutrition knowledge and are better able to apply skills imparted to them, unlike the uneducated. It is therefore expected that this variable will positively influence dietary diversity. This hypothesis is supported by Minten and Stifel (2017) who found that nutrition knowledge leads to considerable improvements in children's dietary diversity in Ethiopia. Murendo *et al.*, (2018) also shows nutrition education have important effect on household and individual nutrition in Zimbabwe.

Crop diversity indices (CDI): Crop diversification index is a continuous variable and measurement for effect of crop diversification on individual dietary diversity. We hypothesis that crop diversification has a positive association with individual dietary diversity. Supporting this hypothesis, Sibhatu *et al.*, (2015) found the positive association between crop diversification and dietary diversity. Further, different studies for instance, Koppmair *et al.*, (2017) and Koppmair *et al.*, (2015) found positive association between crop diversification and dietary diversity. However, the finding of Saaka *et al.*, (2017) and Galbete *et al.*, (2017) contradict this hypothesis.

Credit use (CUSE): this is a dummy variable taking a value of 1 if farmers receive credit and 0 other wise. Use of cash credit is one of the important factors that influence household food and nonfood expenditure. The use of cash credit is expected to be positively related to household nutritional status.

Participation in Irrigation Farming (IUSE): this is a dummy variable taking a value of 1 if farmers participate in irrigation and 0 other wise. Availability and participation in irrigation activities allow farmers to produce variety of product which will allow them consumption of

different food group produced at home. Hence, we hypothesis that irrigation increase production of nutritious food and positively influence dietary diversity. Supporting this Rajendran, et al., (2014) found that farmers who cultivate their crop under irrigation are more likely to have positive relationship with dietary diversity. Their finding indicates that cultivated area under irrigated has positive relationship with dietary diversity.

Total annual income (NINCOME): Annual income is total income that household will gain from crop production and sale of livestock and livestock products, and income obtained from non/off-farm income. Income determine access to health services and conditions of sanitation. A higher income allows households to pay for health services when they face sudden health shocks or to fulfil basic health care requirements.

Distance to the market (DMARKET): is a continuous variable and is an indicator of physical access to markets and proximity to economic resources. The nearer to the market the farmer is, the easier it becomes for him or her to diversify and to take produce to market. Access to market allow small holder for purchase of more nutritious food not produced at home. Therefore, access to market is positively related with individual dietary diversity. Previous study confirms that better market access through reduced distances could contribute to higher dietary diversity. This implies that farm households located nearer to the markets enjoy greater dietary diversity (Sibhatu *et al.*, 2017 and Koppmair *et al.*, 2017).

Livestock holding: Livestock, on one hand is a measure of wealth, may act as insurance against crop production risk. On the other hand, livestock holding contributes for household nutrition as individual may have access to animal source food. Therefore, we hypothesis that livestock ownership is positively associated with individual dietary diversity. Supporting this hypothesis other studies found similar results indicating livestock improves nutrition (Hirvonen and Hoddinott, 2017 and Rawlins *et al.*, 2014).

Participation on Non/off-farm income (NOFFINCOME): The effect of income that is exogenous to crop choice, such as remittances, gifts, aid, and pensions can affect small holder nutrition as it can contributes through distribution of income on food from market, health services and conditions of sanitation. Moreover, cash earnings from off-farm activities can increase the households' ability to buy diverse foods from the market. Therefore, it is hypothesized that

non/off-farm income will positively affect individual dietary diversity. Previous study by Linderhof *et al.*, (2016) and Sibhatu *et al.*, (2017) showed that smallholder access to off-farm employment have positive effects on household dietary diversity. However, other finding indicates the interaction term between off-farm income and production diversity shows mixed results. The negative coefficients in some of the models imply that the availability of off-farm income reduces the role of farm production diversity for household nutritional quality.

Definition of Variables for child malnutrition

This section deal with analysis of child malnutrition among rural households in Sinana District. The dependent variables to analyze determinants to child malnutrition were stunting (HAZ), wasting (WAZ) and underweight (WHZ). The variables that determine child malnutrition among rural households are discussed as follows.

Sex of household head (GENDER): Sex refers to the sex of the household head and also provides indications of what resource is available for improved nutrition in the household. Very young, less educated and female-headed households are more likely to have malnourished children than others.

Age of household Head (AGE): - was defined as the period from his/her birth to the time of his/her interview and was measured in years. It was hypothesized to positively influence Child Nutrition

Household Size (FSIZE): is the total family members of the household in terms of persons per household. The larger the family members, the more the labour force available for production purpose, the less the probability to default. However, we expect that the household with large number of children or economically dependent family members will face child malnutrition because of high dependency burden.

Education level of household head: (EDU): the number of years of schooling attained by the respondents up to the time of the survey. The impact of education on child nutrition might be (ii) through promoting awareness on the feasible benefits of modernizing agriculture via technological inputs and the diversification of family incomes, which in turn improve family supply. Household led by illiterate heads are much less probable to apprehend cutting-edge farming technology furnished to them via any media like extension workers, radio, and others than literate household

heads. Education level of household head was expected to have a negative influence on child malnutrition.

Education of mother (EDUMOTHER): the number of years of schooling attained by the Child mother up to the time of the survey. Higher level of mothers' educational attainment expected to negatively associate with child malnutrition. This is in line with previous related studies (Yimer, 2000; Wamani *et al.*, 2004).

Farm land size (FSIZE): Total cultivated land owned by household is important resource for food production. Hence, it is expected to be associated with positively with child nutrition. It was hypothesized that child in household who have larger farm landholding would have less probability to be malnutrition. Child dietary diversity is a simple measure of a high-quality diet that is highly correlated with more complex measures of food and nutrient intake (Ruel, et al., 2013).

Source of water (WATER): is a dummy variable taking a value of 1 if the household's source of water is safe/protected, and 0 otherwise. Use of potable water is expected to have negative impact on child malnutrition because even if the water is obtained from an improved source, when the water must be drawn from a source that it is not immediately accessible to the family, it can be contaminated during transport or storage (EDHS, Hence, drinking contaminated water causes for different infectious diseases for children.

Access to Toilet (TOILET): Availability of toilet is related to sanitation of an environment and reduces the probability of infectious diseases and indirectly causes certain types of malnutrition and expected to have negative effect on the child malnutrition. For the purpose of this study, dummy specification is adopted coding yes latrine availability in the household as 1 and No available of latrine 0.

Child morbidity (MORBIDITY): is a dummy, variable indicating morbidity status of the child taking 1 if the child was suffering from diseases in the last two weeks, 0 otherwise

Age of child (CAGE): is continuous variable indicating age of child in months. It is hypothesized that older children are more malnourished, and hence as age of children increase the probability of malnutrition increases.

Child sex (CSEX): is a dummy variable taking value of 1 if child sex is male and 0 otherwise. Different studies shows that malnutrition among boys is consistently higher than malnutrition girls (Christiaensen and alderman, 2004, Glewwe *et al.*, 2002).hence it is expected positive relationship with malnutrition.

1.7. Crop Diversification: Theoretical Overview

1.7.1. Basic concepts of crop diversification

From a broader point of view, agricultural diversification is a process accompanying economic growth, characterized by a gradual movement of resources out of subsistence of food crops to a diversified market-oriented production system, triggered by improved rural infrastructure and rapid technological change in agricultural production- particularly staple food production (Rosegrant and Hazell, 1999). Thus, agricultural diversification involves the entire rural economy and entails broadening the income sources of rural households. It is linked to increasing commercialization and to the structural transformation of the economy where the agricultural share of Gross Domestic Product (GDP) contracts. The process involves not only cropping, but also new marketing and agro-food based industrial activities that affect the overall rural economy (Goletti *et al.*, 1998; Francesco, 1999). Effective diversification will require key investments in infrastructure and institutional changes to promote farm sector competitiveness, particularly in agriculture production system. However, agricultural diversification implies increasing the variety of agricultural commodities produced at the farm level. From this point of view, diversification of agriculture means developing a large number of crops or enterprises-mix. It may be the response of subsistence farmers to reduce risks arising from climatic, biotic, or seasonal factors (Francesco, 1999).

The concepts of diversification can hence be applied to crop level in a given farm. Crop diversification is regarded as the re-allocation of some of a farm's productive resources, such as land, capital, labour, and farm equipment, into new farm activities. In other words, crop diversification helps for proper utilization of agricultural resources through providing the farmers with viable options to grow different crops on their land. Therefore, farmer's decision to diversify is considered a major economic decision that has a strong bearing on the farmer's income level and food security (Ashfaq *et al.*, 2008; Poudel *et al.*, 2012; Sichoongwe *et al.*, 2014).

The application of concept of diversification in empirical studies, therefore, requires making distinction between broader and narrower definition of agricultural diversification. Therefore, crop diversification can be defined in this study within the narrower definition of agricultural diversification, defined in terms of growing many crops at the same time on the same plot for home consumption, to minimize risk and uncertainty due to market fluctuations, climatic and biological vagaries.

1.7.2 Agricultural Household Decision Models

According to the framework of the agricultural household (Singh, Squire, and Strauss 1986; de Janvry *et al.*, 1991), the household combines farm resources and family labor to maximize utility over consumption goods produced on the farm or purchased on the market, and leisure. Decisions are constrained by a production technology, farm physical environment and land area; family working time, intended for work and leisure; and a full income bond.

The agricultural household requires a unique theoretical model because it combines producer and consumer theory. The farm simultaneously behaves both as a profit maximizing firm and a utility maximizing household. Farm profits include explicit profits from selling products in the market and implicit profits of consuming some of those products, while consumption includes that of both purchased and self-produced goods (Taylor and Adelman 2003). Singh *et al.*, (1986) formalized the agricultural household model. They noted that any exogenous shock such as a price policy or change in the market would simultaneously affect production, consumption, and labor supply, and therefore any attempt to estimate the impact of such a shock must recognize the interdependence of these components.

One component of the agricultural household model that is crucial to the discussion of crop diversification is uncertainty and risk aversion. For instance, Ellis (1993) explained “risk-averse theory of farmers” and generalized the use of it in her book entitled “Peasant economics”, farmers always operate under risk and uncertainty induced by natural hazards (pests, diseases and natural disasters), production and market fluctuations and social uncertainty. Accordingly, a farm household’s expected utility is dependent on its attitude toward risk. Even in a one-season model, a farm household’s utility is subject to uncertainty in, levels of rainfall, output prices, and consumption prices. A farmer’s production decisions including optimal crop allocation are

therefore dependent on that farmer's attitude toward risk (Fafchamps 1992) as well as the presence of markets for risk (de Janvry *et al.*, 1991). For example, markets for price information or crop insurance would decrease a farmer's perceived level of risk, affecting crop allocation decisions. The literature suggests that farmers in developing countries tend to be risk averse and crop diversification can be a strategy to guard against production and price risks.

These conditions pose risks to farm production and make farmer cautions in their farming decision. Hence, farmers are assumed to use risk aversion strategy and maximize utility in their decision-making process. As a mechanism for incorporating risk aversion into a farmer's decision-making process, crop diversification played a vital role (Davis *et al.*, 1987)

High relative price and productivity of any crop at the existing state of technology, given other conditions of agricultural production (in other words, high relative profitability) may create an affinity of the farmers towards that crop and vice-versa. These factors may be designated in view of their provocative and attractive forces, as the *forward stimulating factors* or *pull factors*. They are so christened because though the farmers at the existing state of technology and other production conditions, can avail themselves of alternative available opportunities, their choice for some particular crops is dictated by the *relative pull* factors (Barrett, Reardon and Webb, 2001; Ellis, 2000).

Other factors like rainfall, irrigation, improvement and availability of technology etc. at relatively cheaper cost which generate conditions congenial for the farmers to produce some crops which, without the aforesaid facilities could hardly be feasible. Therefore, a change in these factors may be associated with a change in the cropping pattern. These factors may be identified as the *enabling factors* or *push factors*. The specific crop has specific times and amounts of need for these factors, due to the special biological nature of the production process of different crops. Adequate and timely appearance of these factors in different seasons push forward the farmers to allocate land or expand production of crops specifically, sensitive to those specific factors (Ruben and Van den Berg, 2001; Davis *et al.*, 2014).

There are many factors that may lead a farm household to diversify its cropping enterprises. These include reducing production and market risk, changing consumer demands or changes in government policy, responding to external shocks, and coping strategy to the challenges arising

from climate change (Ashfaq *et al.*, 2008). It also provides a broader choice in the production of a variety of crops in a given area and hence lessens the risk of crop failure (Francesco, 1999). The analytical framework used for this study draws upon from both risk-averse and utility maximizing theories of farm household production behavior. The fundamental assumption is that farmer's decision on whether to minimize risks (diversify crops) or not is based upon utility maximization theory (Rahm and Huffman, 1984; Ellis, 1993).

1.7.3. Empirical Studies on Crop Diversification

There are a number of studies that identify level and determinants of crop diversification at different level. Reviewed literature indicates that there is a divergence in methodology in identifying level and determinants of crop diversification among small holder farmers at international and national level. For example, using instrumental variable regression model Weiss and Briglauer (2000) found that farm size, part-time farming, education, family size and district location are important determinants of farm diversification in Australia. Kimhi and Chiwele (2000), also used Heckman-Two-Stage model and their finding indicates that household demographics, the status of rural road construction, market access and the size of yield of maize are influenced Zambian maize diversification.

Joshi *et al.* (2004) applied the Generalized Least Square (GLS) technique and found that relative profitability, irrigation, road, markets, rural literacy, the proportion of small holders, income from crop, urbanization, rainfall and production year affected crop diversification in South Asia. Further, to find the determinants of agricultural diversification in Central Queensland of Australia, Windle and Rolfe (2005) used the Nested Multinomial Logit model and observed that debt, age, education, number of children, off-farm income, farm size, start-up cost, net income, other crops grown and risk time are the most determinant factors. Kumari *et al.* (2010) try to analyze crop diversification and income inequality in irrigation systems in Minipe and the logit analysis showed that the probability of the diversification was determined by family labor, farmers organizations' collective action including irrigation management and market arrangement. Ibrahim *et al.* (2009) on the other hand, by using Simpson index of diversity and ordinary least square regression analysis look at income and crop diversification amongst farming families in a rural location of north central Nigeria. Accordingly, crop diversification were determined by, age and level of

education of the household head, number of extension visits, availability of tractor rental services and income from agricultural production.

A recent study by Gabriel and Lota (2019) used three indices namely the weighted count index, Herfindahl index and Shannon index to analysis determinants of crop diversification in Burkina Faso. Their finding indicates that risk-averse producers focus more on the production of traditional, less risky and low market value crops. Further, education level, distance to market, farm area and land fragmentation are associated with greater crop diversification. Dembele *et al.*, (2018) also used multinomial logistics regression model to analyze factors influencing crop diversification strategies among smallholder farmers in cotton production zone in Mali. Their findings indicate that age of family head, education level, family size, oxen ownership, farm per capita income and crop pests significantly influenced household participation in the four diversification strategies.

Empirical study on level and determinants of crop diversification in Ethiopia is shallow. If there is, most of the study focus on macro level than identifying micro level crop diversification among smallholder farmers in specific locality. For instance, to examine factors explaining the inter-specific diversity and intra-specific diversity of cereal crops grown in communities and household farms in the highlands of Amhara and Tigray regions of Ethiopia, Benin *et al.* (2004) used combination of Margalef Index, Shannon Index and Berger-Parker Index. They conclude that land size, the proportion of male, ownership of livestock and oxen, farm fragmentation, number of fragmented plots, farm distance and regional location, agro-ecology of a community, access to markets, and the characteristics of households and farms were significantly affected both the inter- and infra-specific diversity of cereal crops in Ethiopia. Similarly, to identify significant factors affecting crop choices in Northern Ethiopia, Seid and Seebens, (2008) used Generalized Linear Model (GLM) and OLS model. Accordingly crop choices in Northern Ethiopia were significantly affected by proximity to town, access to road, education, liquid wealth, and irrigation access.

By using tobit model, Fetien *et al.* (2009) try to identify barley variety diversity in Tigray, Ethiopia. The result shows that barley variety diversity in Tigray was influenced by age, age square, male headed household, number of children, livestock, fragmentation index, farm size, altitude, rainfall, extension and temperature. Further, Wondimagegn *et al.* (2011) used Entropy Index and Tobit model to measure the level of crop diversification and its determinant in Eastern Ethiopia. They

conclude that access to extension, livestock holding, market information, access to irrigation, number of farm plots and ownership of farm machinery were significantly affected crop diversification in Eastern Ethiopia. Degye *et al.* (2012) also used Entropy Index and multivariate probit models to measure the status of crop diversification and its interaction with food security and dietary diversity status in the rural part of Ethiopia. Their finding reveals that cultivated land, land allocated to staples, gross annual income, distance to research institution, the farming system and other exogenous shocks were factors influencing crop diversification in rural part of Ethiopia.

To measure the level of crop diversification and identify the factors affecting farmers' crop diversification in SNNPR of Ethiopia Rehima *et al.* (2013) used Heckman's selection model and Margalef Index. Their finding indicates that crop diversification was affected by sex, education, trade experience, membership in cooperatives, resource ownership, features of the land owned, access to extension services and transaction cost. By using same model and index Rehima *et al.* (2015) identify determinants of crop diversification in Oromia Regional State Ethiopia. The finding indicates that Asset ownership, soil quality, agricultural extension, and level of infrastructural development were important factors affecting crop diversification in Oromia Regional State Ethiopia. Further, Sisay *et al.* (2016) also used Heckman two stage model and HI to identify factors influencing crop diversification in Ethiopia. Their finding reveals that sex, extension services, cooperative membership, livestock holding, land fragmentation, farm size, and distance to development and market centers were factors that influence crop diversification in study area.

Dessie *et al.* (2019) employed Tobit model and used to investigate the socioeconomic factors underlying the decision to adopt a diversified cropping system and extent of crop diversification in Gonder Ethiopia. The study revealed that the status and intensity of crop diversification were significantly influenced by farmland, sex, age, land fragmentation, distance to development center, market distance, and non/off-farm income participation.

1.8. Food and Nutrition security: Theoretical overview

1.8.1. Changing Approaches to Food Security

This section deals the changing food security analysis from a modernist perspective which often focus on the “macro, uniform and growth-oriented” approach to the post-modernist understanding

of the “complex, diverse realities and development at the micro level” (Maxwell 1996). Food security is a multi-faceted concept. It is defined in various ways over time depending on the approach chosen to address food insecurity (Frankenberger and Maxwell 1992). Following the 1974 World Food Conference, a number of definitions of food security have emerged. In the 1970s the food security definition focused on the long-term physical availability of food at the global level through increasing production and storage (Saga, 2012). This implies that achieving food security is a function of the aggregate amount of food produced. Thus, food insecurity problems can be solved by increasing total food production through the application of modern scientific techniques. FAO (2003) thus adopted a prices and supply-based food security definition: “Availability at all times of adequate food supplies of foodstuffs to sustain a steady expansion of consumption and to counter balance production and prices variations.” Moreover, the most commonly used definition of food security is given by FAO at the Rome Declaration on World Food Security that shows the multidimensional nature of the concept (Pangaribowo *et al.*, 2013). “Food security exists when all people, at all times, have physical and economic access to sufficient, safe and secure resources nutritious foods to meet their dietary needs and food preferences for an active and healthy life ”(FAO, 1996).

In the 1980s, the macro or global-level approach to ensure food security was revised by focusing on "national food supplies" which includes food reserves and aid, intensification of agriculture by increasing farm input application and irrigation and exports and imports from surplus to deficit regions (Bals *et al.*, 2008; Sage 2012; Westengen 2012). The national level food security analysis primarily aims to increase the food available at national markets by increasing production. Despite its positive effect on food supply, the food production and exchange-oriented approach to achieve food security pays little attention to the complex and dynamic nature of food insecurity, to local differences and to different socio-economic groups.

Shortfalls in production could be adjusted through imports. However, it is difficult to address the national food supply deficits through imports. Number of barriers, for instance, looking at the diverse agro-ecological conditions of Ethiopia prevent the movement of food products. According to FTF (2011) some regions produce food surpluses each year, while others face chronic food insecurity. Further, the number of people who are chronically food insecure remains high even though food production and availability have increased for the last two decades in Ethiopia

(ACAPS 2016; IFRC 2016; UNICEF 2017). An argument on this is that, policies should go beyond concerns about food availability at national level and focus at the problems of access to sufficient food throughout the year for poor people. As Bals *et al.*, (2008) noted key reason for this is that the impact on hunger and malnutrition can only be well estimated, if the effects on the household level are taken into consideration. FAO (2016) similarly indicates:

“What is needed is not only enough food being produced globally; enough food is produced globally now but there are still almost 800 million hungry people but that everybody has access to it, in the right quantity and quality, all the time.”

Sen (1981) changed the discourse about food security by bringing attention to the question of individual access and entitlement. His argument about food security is relevant in order to understand the multidimensionality of food insecurity, which differs over space and time. Sen revealed that famines are not always a result of food shortage. Rather, households ‘or individuals ‘food security status can be determined by the distributional effect of food supply and the differences in physical, social, and economic access to food rather than national food availability. However, Sen’s entitlement analysis was criticized because of its emphasis on “access to food as defining characteristics of food security” (Maxwell 1996). In line with this Deverux (2001) notes *“individuals as socially embedded members of households, community and states” [and the international ...] that famines are political crises as much as they are economic shocks or natural disasters.*” In this regard, what happened in the 1984/85 Ethiopian famine is an example. Studies for instance, Edkins (2000) and Graham *et al.* (2012) indicate aggravating factors of the famine which includes war and conflict, land reform policies favoring state farms, a government failure not only to reveal the famine to the public but also to provide urgent response to the situation. Graham *et al.* (2012) further notes that market restrictions in terms of grain movements between regions were another contributing factor of the famine.

Based on the criticisms on entitlement theory, Swift (2006) conceptualizes a model that includes three assets (investment, stores, and social claims) in determining household food insecurity. Swift maintains that when a household is able to produce more than their basic need requirements, then they use the surplus to invest in assets in the three forms. The assets are a safeguard in time of food shortages. The model shows that the role of social claims is important, mainly for resource poor

farmers in times of entitlement failure. In recognizing the complex social reality and the multifaceted and dynamic causes of food insecurity, poststructuralists and post-modernists similarly criticize the food production-oriented approach to food security in favor of complexity and diversity of perceptions of the food insecure themselves. The positivist universalism assumption to the problem of food security has been criticized by political economists. Their argument were that hunger and food insecurity continue in an alarming rate in many developing countries when food is adequate at the national level (Maxwell 1996; Westengen 2012).

FAO (2007) puts forward a comprehensive and widely accepted definition:

Food security exists when all people at all times have physical or economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life. To achieve food security, all four of its components namely availability, stability, accessibility and utilization must be adequate.

The above quotation reflects four keys, albeit interrelated concepts. First, sufficient food is sufficient calorie intake for a healthy life; second, access is the ability of a household or an individual to acquire sufficient food from production and purchase as well as gifts, loans, and transfers from governments; third, security refers to secure access to sufficient food; and the utilization dimension of food security includes the nutritional value, and food value.

The multidimensionality of the concept of food insecurity has been increasingly emphasized as it is experienced differently by different people. Chikhuri (2013) defines food security in terms of *self-sufficiency and food-self-reliance*. The former concept is the production of food for home consumption while the latter is implying food availability for consumption from either production and/or imports. These concepts and approaches have been used in this study. These multiple dimensions, causes and consequences of food insecurity differ from country to country, region to region, and even within the same locality (Waal, 1989). That is food security has spatial and temporal dimensions. It affects households, communities and nations in a definite space over a certain period of time (Degefa, 2005).

Although food security is still defined in different ways, most of the definitions accept the 1996 World Food Summit definition: “secure access at all times to sufficient food” (Franken and

Maxwell 1992,) at all geographical levels. In this definition, four dimensions of food security are embedded: availability, accessibility, utilization and stability of food (FAO *et al.*, 2014). The first dimension, availability of food, captures both the physical availability as well as quality of food and it is a prerequisite for other dimensions of food security (Pieters *et al.*, 2013). Accessibility of food captures the physical and economic accessibility of food. Food price and household resources mainly determine access to food at household level (Kalkuhl *et al.*, 2013; Pieters *et al.*, 2013). Utilization of food is the third dimension, which includes the ability of utilizing the available food, which is determined by the quantity and quality of food, access to clean water and sanitation (FAO *et al.*, 2014; Pieters *et al.*, 2013). The stability dimension deals with the permanency of the other three dimensions of food security and it reflects the resilience of individual to various shocks (FAO *et al.*, 2013; Pangaribowo *et al.*, 2013).

The food security concept recently includes “the biological utilization of food consumed” and a “balanced nutritious diet” in ensuring overall food security (WFP and FAO 2008). The notion of nutritional diet “suggests that it is not just the quantity of food entitlement that matters, but also the quality of entitlement” (Maxwell 1996). Nutrition security as a concept evolved in the mid-1990s as a result of efforts to add nutritional features into the food security concept (CFS, 2012; Pangaribowo *et al.*, 2013). Nutrition security goes beyond the availability and consumption of food and includes health services, healthy environment and caring practices that can supplement the proper utilization of available food. FAO has formulated that “nutrition security exists when all people at all times consume food of sufficient quantity and quality in terms of variety, diversity, nutrient content and safety to meet their dietary needs and food preferences for an active and healthy life, coupled with a sanitary environment, adequate health, education and care.” (CFS, 2012). Nutrition security deals with the health status of individuals in addition to food intake (Gross *et al.*, 2000).

1.8.2. Food and Nutrition Security Indicators

Measuring food security and nutrition security is challenging as the concepts have multidimensional features. It is impossible to get a single comprehensive indicator for both of the terms (FAO *et al.*, 2013; Pinstруп-Andersen, 2009). Consequently, the measures (indicators) of food security and nutrition security depend on the definition, the time (short term and long term) and the scale (individual, household or national) of analysis (Pangaribowo *et al.*, 2013).

As it has been discussed, it is also problematic to make a clear demarcation between food security and nutrition security due to their overlapping natures. Keeping that in mind, in the upcoming sections we present various indicators of food security and nutrition security used in them literature. An indicator is used to reflect an aspect of a given characteristic (in this case some dimension or component of food and Nutrition security). Based on degree or specific meaning an index or scale can be calculated from multiple measures which will help to construct indicators through classification of values of a single measure. As Habicht and Pelletier (1990) noted there's no exceptional indicator, or exceptional evaluation of a trademark in a usual sense. As Barrett (2010) mentioned the FNS concept is elusive. That is a single indicator cannot summarize the complexity of FNS. Set of indicators must be built in order to capture all the dimensions of FNS. Different indicators of food and nutrition security exists at global, national, household and individual level. Each indicator shows a specific aspect of FNS and is only relevant for certain situations. Thus, the next section documents the list of indicators which have been mostly used in the literature of various disciplines.

Dietary energy

This indicator also called the FAO method, and widely used to assess undernourishment of individuals and countries (Kalkuhl *et al.*, 2013). At individual level, the indicator measures if an individual consumed enough food compared to a daily recommended amount of calorie (usually macronutrients, i.e. carbohydrates, fats and protein). The indicator uses a recommended calorie cut-off point and considers individuals as food insecure if a daily calorie consumption of the individuals is less than the threshold (FAO *et al.*, 2014).

Nationally, it measures the average energy intake from food. But this measure does not capture micronutrient consumptions which also determine food security status. Moreover, the indicator uses a cut-off point that does not consider gender and age difference; and when measured at national level, it does not show the geographical distribution of the undernourishment problem (Pangaribowo *et al.*, 2013; Pinstруп-Andersen, 2009). It is also complicated to record all consumed food and calculate its calorie equivalence that might result in misleading results (De Haen *et al.*, 2011; Pinstруп-Andersen, 2009).

The Diet Diversity Scores (DDS)

Dietary diversity represents the number of different foods or food groups consumed over a given reference period (Hoddinott and Yohannes 2002). There are many diet diversities scores in the literature, with different purpose (for instance, measuring individual diet quality versus household food access), with different number and definition of food groups, unit of study (individual or household), reference periods, etc. Hoddinott and Yohannes (2002) embraced that diet diversity scores are meaningful indicators of FNS for four reasons. First, dietary diversity scores correlate with measures of food consumption and are a good measure of household food access and caloric availability. Second, a different diet is a worthy outcome in itself. Third, more dietary diversity is associated with a number of improved outcomes (Rao *et al.*, 2001), child anthropometric status (Hatloy *et al.*, 2000), improved hemoglobin concentration (Bhargava *et al.*, 2001), reduced risk of mortality from cardiovascular disease (Kant *et al.*, 1995) and incidence of hypertension (Miller *et al.*, 1992). Fourth, dietary diversity scores can be collected through household surveys and can be used to examine FNS at individual and intrahousehold levels.

Food gap

Food gap can be used to measure food security both at household and national level. The number of months that a household faces food shortage is mostly considered to assess household food security status (Berhane *et al.*, 2011). This indicator also uses the recall method, which might lead to biased results due to possible failure to recall properly. At national level, food gap measures the amount of food needed to raise consumption in each income.

The review of HFIAS identified four domains and several subdomains of food insecurity that appear to be universal across different countries and cultures (Coates *et al.*, 2006; Carletto *et al.*, 2013). The four domains (and subdomains) were: uncertainty (in the long term) and worry (in the short term) about food; inadequate quality (unhealthy foods and diets, limited variety); insufficient quantity (running out of food, not consuming enough, eating less, disrupted eating patterns); and social unacceptability (unacceptable means of acquiring food, eating foods that cause shame or embarrassment). The review recommended that elements reflecting these areas be used in the future for the construction and adaptation of food insecure access ladders. The HFIAS consists of nine items that measure both occurrence and frequency and represent universal domains associated with household food insecurity access, using a recall period of 30 days (Coates *et al.*, 2007)

Subjective (Perception based) measures

Subjective measures are also used to assess food security at individual or household level by asking their personal perception directly about their food security status (Kalkuhl *et al.*, 2013; Headey, 2013). This indicator might lead to a biased result due to its subjectivity nature and it is also difficult to make comparisons between different groups (Kalkuhl *et al.*, 2013).

Anthropometric indicators (AI)

Anthropometric indicators such as stunting (low height-for-age), underweight (low weight-for-age), and wasting (low weight-for-height) measure nutritional outcomes at the individual level. Unlike generic indices, anthropometric indicators measure directly the point of policy interest as they reflect undernutrition and how it might affect health and well-being (de Haen *et al.*, 2011). Poor anthropometric outcomes are associated with higher morbidity and mortality (Deaton and Dreze, 2009). Even though anthropometric indicators measure nutritional outcomes, they are doing not cover specific nutrients which may be deficient.

Height-for-age

This indicator reflects not only the nutritional status of children, but also long term and cumulative problems of nutrition and health in a population (Arndt *et al.*, 2012; Pangaribowo *et al.*, 2013). Stunting (low height forage) shows brevity and is generally used to represent chronic malnutrition (Kalkuhl *et al.*, 2013; Setboonsarng, 2005). It also reflects inadequate basic needs and indicates the extent of poverty (Gross *et al.*, 2000).

Weight-for-height

This indicator measures the weight of children, usually less than 60 months, compared to their height. We call it waste when the weight of children is low for their height. It shows acute malnutrition reflecting short-term deprivation and the effects of unhealthy and poor environmental conditions (Arndt *et al.*, 2012; Kalkuhl *et al.*, 2013; Setboonsarng, 2005).

Weight-for-age

This third indicator, weight-for-age, is a commonly used indicator of undernutrition. Underweight (low weight-for age) is considered as a composite index of stunting and wasting, i.e. chronic and acute undernutrition problems (Hasan *et al.*, 2013; Kalkuhl *et al.*, 2013).

1.8.3 Empirical Review

With the foregoing theoretical and conceptual approaches on food security, this section provides an empirical literature review on the determinants of food security in households.

Over the years, scholars have remained committed to measuring food security in Africa and any salient factor affecting it. Calorie intake (Mesay, 2009; Arega, 2012; Zerihun and Getachew, 2013; Mesfin, 2014), dietary diversity index, coping strategy index, food consumption score, household food balance model (Degefa, 1996; 2002;2008; Meskerem & Degefa, 2015; Feleke *et al.*, 2003; Anyaeji 2010; FAO and WFP, 2009; Aidoo *et al.*, 2013; Jones *et al.*, 2014; Assefa and Singh 2018), HFIAS (Omotesho *et al.*, 2006; Babatunde *et al.*, 2007; Coates *et al.*, 2007; Bashir *et al.*, 2010; Getachew *et al.*, 2018) anthropometric tools (Amare *et al.*, 2019) among others. Various determinants that have been investigated using different model/s can be summarized under economic, social and institutional factors. Findings from selected studies have been reviewed below.

Various studies have looked at the determinants of household food security. Food price, income diversification, households' socio-economic conditions, and availability of support programs are among the factors that determine food security. Households in the rural setting of developing countries are yet to secure agricultural produce from uncertain adverse conditions and affliction. Sindhu *et al.*, (2008) emphasized on the impact income plays in eradicating food insecurity at the household level. From the study they concluded that an increase in monthly income reduces exposure to food insecurity. Using a binary logistic regression, the authors noted that an increase in monthly income reduced food insecurity by 30 percent. Authors further, asserts that family size is a crucial determinant to food security. Using a similar approach in Nigeria, Babatunde *et al.*, (2007) also found that an increase in the household's annual income reduced food insecurity by 63 percent. In a similar study in Nigeria, Amaza *et al.*, (2006) affirmed that every additional family member reduces the household's food security by 1.5 percent. Given that every household member consumes a significant portion of the family basket, size is a key determinant to food security. In a similar study, Bashir *et al.*, (2010) through a Multinomial Logistic Regression concluded that households having 4-6 and 7-9 members were 97 percent food insecure.

In a descriptive study, Omonona and Adetokundo (2007) indicated that an increase in the age of the household head subsequently increases the incidence to food insecurity. In their study on food security in Nigeria, the researchers found that food insecurity escalated at the age between 21-70 years. Contrary to these assertions, Onianwa and Wheelock (2006) concluded that an increase in the age of households reduced their food insecurity by 2 percent. Further, Bashir *et al.*, (2010) noted that from 35 years onward, every additional year reduces food security by 83 percent. Although this is a complex analogy, household age affects exposure to food security.

Using a binary logistic regression model, Ojogho (2009) noted that having a household head with both primary and secondary education reduced the probability of food insecurity by 78 percent while with a tertiary level of education, food insecurity reduced by 92 percent. Similar study in Kenya, Mariara *et al.*, (2006) indicated that high education levels among mothers improve food security significantly. Given that education empowers household members and avails amicable resolutions to fighting food shortage, the higher the education level, the lower the exposure to food insecurity. However, Arene and Anyaeji (2010) and Aidoo *et al.*, (2013) found that education level of household head was insignificant in determining the food security status of households in Enugu state of Nigeria and Sekyere-Afram plains in Ghana respectively.

Empirical study on food security and determinants to food security in Ethiopia is over studied. However, little has been said about food security and crop diversification nexus in Ethiopia. The price of food affects food security because it determines the purchasing power of families, especially with a given level of income. Kumar and Quisumbing (2013) studied the impact of the 2007-2008 price increases on domestic food security using “Ethiopian Rural Household Survey”, which contains information before and after the food price rise. Their results implied that households with a female head of household were much more affected than households with a male head, and that households consumed less. Preferred foods and cutting the number of meals as coping strategies, which have implications to nutrition outcome of households. Akter and Basher (2014) also studied the impacts of the 2007-2008 food price hikes in Bangladesh, and documented that rising food prices have exacerbated food insecurity in rural Bangladesh.

Using binary logit Getachew *et al.*, (2018) found that access to irrigation, noticed frequent drought, distance from input/output market and distance to road transport has negative influence while

educational status, farm land size, total annual income, distance from health services and availability of other support organizations positively influenced household food insecurity in rural Ethiopia. By applying same model Assefa and Singh (2018) also found that shortage of farmland, poverty, recurrent drought and climate change, shortage of rainfall, and land degradation are determining factors of food insecurity. Abegaz (2017) applied the same model to analyze determinants of food security in rural Ethiopia. His finding indicates that food security was significantly determined by rain shock, lack of off-farm income, and region of the households. Hence, to assure food security, the farmers should have to consider every rain season in agricultural activity and the availability of off-farm income-generating activities should be improved.

Based on binary logistic regression model Motbainor *et al.*, (2016) analyzed degree and determinants of food insecurity in East and West Gojjam zones of Amhara Region, Ethiopia. Their finding indicates that Family size, education level, household monthly income quartiles, rural residential area, highland agro-ecology and livestock were significant factors affecting household food security in Ethiopia. Mebratu (2018) also applied binary logit to analyze determinants of food insecurity among rural households of South Western Ethiopia.

Another study conducted in Ethiopia by Fekadu (2012) using multivariate logistic regression analysis indicated that dependency ratio, household family size and market accessibility have showed significant and negative effect on food security; whereas cultivable land size, access to irrigation, number of livestock showed positive role for food security. On the other hands, Ejigayhu and Abdi-Khalil (2012) used Tobit model to identify factor influencing household food security in Addis Ababa City. The model output revealed that household size, household income, household head age, household head education, ownership of bank account and income from remittance and gift were found to be significant determinants of food insecurity in Addis Ababa.

Given that income either alleviates or inhibits the purchasing power, it immensely alters food security. According to Bashir *et al.*, (2010), households earning high income rarely experience food insecurity. Through the Pakistan based study, the authors unveiled that the population in higher income group of experience food security 15 times more compared to households with no income. With a stable source of income, households manage to offset the impending consumption balance. Given the scarce availability of land, finance, and capital resources, households without

income rarely secure their status. This is because the difference between production and consumption cannot finance non-food commodities in a consistent manner.

Livestock assets help rural households in undertaking some strenuous agricultural activities. For instance, a horse or ox assists farmers to cultivate large chunks of land faster and better. In Ethiopia, Haile *et al.*, (2005) found out that households that used an ox were 5 percent more profitable compared to those that solely relied on human labor. Although on a different perspective, Bashir *et al.*, (2010) also found out that households owning a milking cow were 32 times more food secure compared to families with no milking cow. Animals that aid in undertaking agricultural endeavors foster profitable production as they ease labor requirements. On the other hand, animals that produce substitute food products like eggs, milk, and meat significantly expand the production threshold. In both situations, livestock assets aid in negating food insecurity. Feleke *et al.*, (2003) however found out that the number of livestock (which was a proxy for wealth) was statistically insignificant in determining food security.

1.9. Crop Diversification and Household Food and Nutrition Nexus

1.9.1. Pathways to Crop Diversification, Food and Nutrition

The main theoretical pathways through which crop diversification affect smallholder nutrition can be used to hypothesize the effects of crop diversification on the diets of household members. They correspond directly with the causal pathways from agriculture to nutrition (FAO, 2010). This can be: (i) crop diversification can directly alter the food a family consumes if they eat what they produce, as most farm families in developing countries do. A farm family produces a more diverse set of foods, then they have access to consuming a more diverse set of foods. Additionally, if some of these foods are sold, others that depend on markets to meet some of their dietary needs will also have access to a more diverse set of foods. (ii) Crop diversification can increase income for farm families with which they can buy more diverse and more nutritious foods. This can be achieved through the production of marketable, higher value crops if local markets are able to offer producers good prices for those crops.

1.9.2. Empirical Review

There is an increasing support in literature for crop diversification playing an important role in improving nutrition (Masset *et al.*, 2012). In Mali, Torheim *et al.*, (2004) have found that the number of crops cultivated by a household was positively associated with adult nutrient adequacy. A study by Remans *et al.*, (2011) has revealed that the diversity of plant species on farms positively associated with the diversity of nutrients provided by farms in rural areas of Malawi, Mali, and Uganda. Herforth (2010) examined relationship between farm diversity and dietary diversity on his study of promotion of traditional African vegetables in Tanzania and Kenya. The finding indicates that crop diversity was significantly related to dietary diversity and was also more closely related to consumption of household from own produced food than consumption of market purchased food. In the rural highlands of Ecuador, on-farm species variety and family-level dietary diversity were also positively correlated (Oyarzun *et al.*, 2013). At the household level crop diversification improve household food security and nutrition through incomes realized from the sale of agricultural produce. Lorenzo and Luca (2013) on their part tried to see the causal linkages between crop diversification, dietary diversity and Agricultural income based on data from Eight Developing Countries. Their finding indicates that there is positive link between the number of crops produced and the dietary diversity indicator.

Ame *et al.*, (2016) assessed the linkages of household food security and crop diversification and their finding indicates that household food security status measured as HFIAS score is negatively correlated with HDDS and crop diversification. It also indicates that better food security is associated with crop diversification in the study area. On the other hand, Rajendran *et al.*, (2014) analyzed whether crop diversity contribute to dietary diversity in Tanzania. Their finding show that farm diversity does not have a positive and significant effect on dietary diversity after controlling for other covariates.

FAO *et al.*, (2012) and Headey *et al.*, (2012) assessed the position of agriculture in reaching nutrients status. Agriculture directly contributes to food security by making more food available or by enabling farm households to access micronutrient food by using their farm income. In addition to reaching vitamins security, income from farm would possibly enhance get admission to fitness facilities and wholesome environment, which might be significant components to attain vitamins security. This courting works the alternative manner spherical as well (FAO *et al.*, 2012).

Nutritionally secured families carry out higher of their farm that will increase their return from agriculture. FAO *et al.*, (2012) underlined that small holder agricultural growth is the key to the undernutrition problem as it can increase employment and improve access to food especially for women smallholders.

Kabubo-Mariara *et al.* (2009) also used the 1998 and 2003 Demographic and Health Survey data sets for Kenya and indicated that household and community characteristics determine nutrition status of children. In addition, their results showed that the prevalence of malnutrition was higher in boys than in girls and multiple births were found to be with high probability of undernourishment compared to singletons. Another study conducted in five villages sampled from two states of Nigeria also showed that mothers' age and status in the household, dependency ratio and composition of food consumption affected nutrition security of children which was classified as moderate or severe (Ojiako *et al.*, 2009).

Jones *et al.*, (2014) tested the association between farm diversity and nutritional variety among households in African nations and their finding suggest that there's a strong association among nutritional and farm diversity. Moreover, Srinivasulu, *et al.*, (2014) identified the causal linkages between crop diversification and dietary diversity. Contrary to other finding they conclude that crop diversity does not influences dietary diversity. Vincent *et al.*, (2016) analyzed the influence of household farming systems on dietary diversity and caloric intake in Uganda. With their analyses they found a positive relationship between production diversity and nutrition diversity for different combinations. Further they conclude that an increase in production diversity increases consumption diversity and thereby, likely, household nutritional levels.

Using multiple linear regression analysis Sibhatu *et al.*, (2015) analyzed farm production diversity and dietary diversity in Developing Countries. Their finding concludes that the link between farm production diversity and dietary diversity does not universally exist and dietary diversification through farm diversification does not necessarily require the production system to be subsistence. Through Hierarchical regression analysis Saaka *et al.*, (2017) analyzed the relationship between agricultural biodiversity and dietary diversity of children aged 6-36 months in rural areas of Northern Ghana. Spearman correlation analysis showed that agricultural biodiversity was positively associated with individual dietary diversity of the child. Their finding conclude that

improvement of agricultural biodiversity could be one of the best approaches for ensuring diverse diets.

1.10. Analytical Framework

This research studies crop diversification, households food and nutrition security in livelihood perspectives and amalgamates the SLF (DFID, 1999) with DFID (2011). Household endowments determine agriculture production. The sustainable livelihood framework (SLF) was followed to conceptualize household endowments. By making people as Centre of analysis, SLF conceptualized components of livelihoods as vulnerability context, livelihood assets, structures and processes, livelihood strategies and livelihood outcomes. SLF identifies five types of assets in the “livelihood assets” component. These assets are human capital, financial capital, physical capital, natural capital and social capital. The framework considers the assets as interlinked and one has to have enough access to these assets in order to achieve sustainable livelihood (DFID, 1999). In our study, all livelihood assets, will be considered to analyze crop diversification and household nutritional status among smallholder farmers in study area. The conceptual framework constitutes the main components (boxes) and variables that affect crop diversification and then rural households to food and nutrition security. Yet, complete analysis of all components and variables of the framework at a time is practically impossible and beyond the scope of this study. This study, instead, focuses on selective components (and variables) such as assets, institutions, and organization (access to basic services and infrastructures) which intrinsically affect the crop diversification and household food and nutrition security.

As figure 1.1 summarizes, the livelihood assets determine crop diversification and decision of households to diversify income sources. The value of major agriculture sale will be used as indicator of household food and nutrition security. Off-farm income will be calculated by including incomes from casual farm and off-farm works, and from own business activities. Education, Skills, household size, ability and health represent human capital of households’, which show the quality of labour in a household (DFID, 1999). In the models, household heads’ literacy, age, sex of household head, and household size were considered as human capital indicators.

Financial capital captures households’ access to finance which determines both consumption and production. Two different types of financial capital are usually used. The first is available stock,

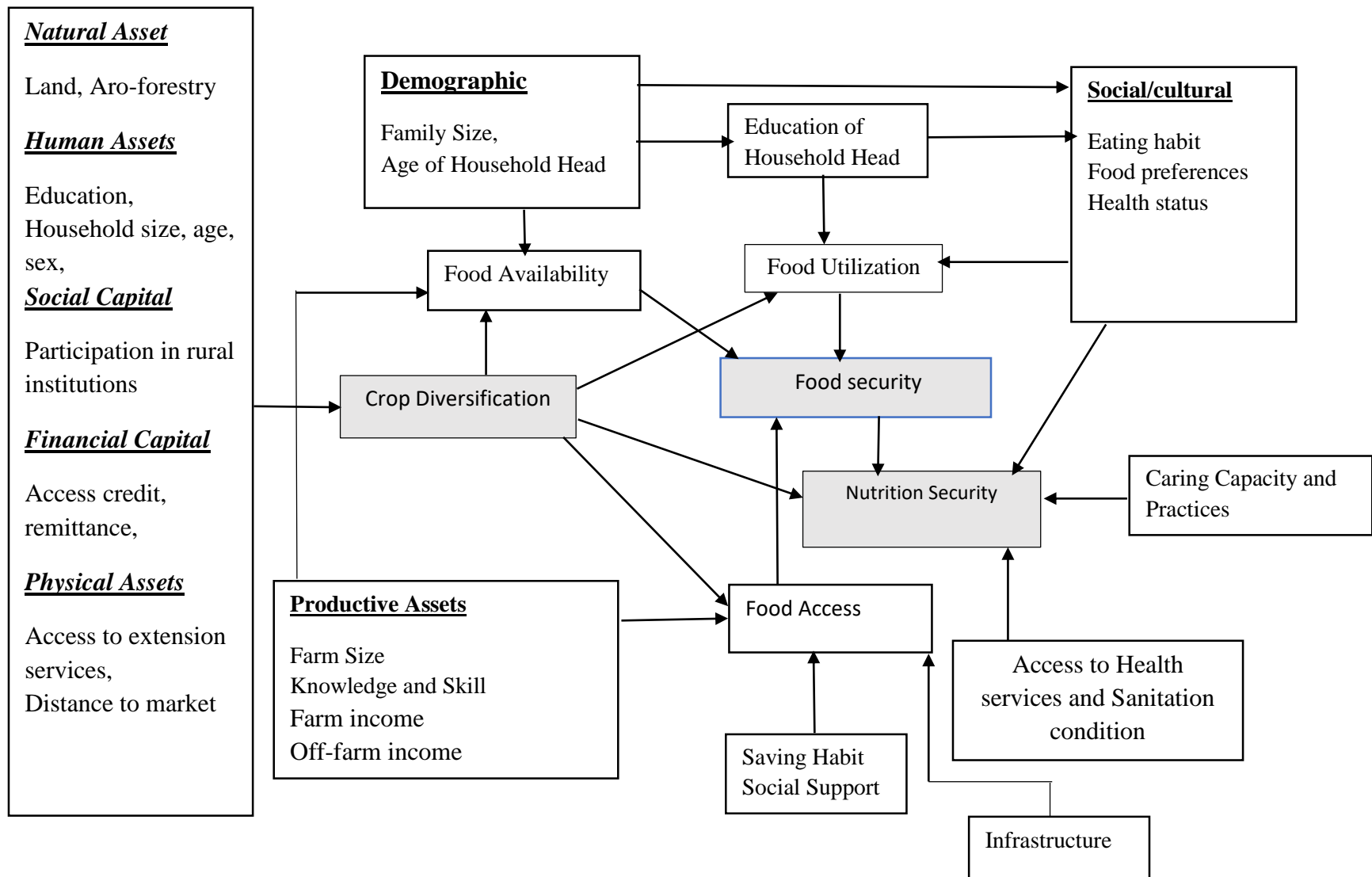
which is mainly savings in the form of cash, bank deposits and liquid assets, for example livestock and jewellery. The second form is regular inflow of money including pensions, remittances and other transfers. Financial capital helps households to access the other livelihood assets and used directly, for example to purchase food, which food access (Devereux, 1993; Degefa, 2002; 2008; Aidoo *et al.*, 2013). A farm income and income from various off-farm activities were considered as proxy for financial capital of households.

Physical capital, which shows access to infrastructures and producer goods, also determine the utilization of other livelihood assets and thereby livelihood outcomes. Infrastructure in the form of transport, shelter, water supply and sanitation facility, and access to clean and affordable energy are significant for sustainable livelihoods. It determine food utilization which is the way in which people consume their food (Degefa, 2002; 2005; Aidoo *et al.*, 2013.) Producer goods including livestock and other equipment (such as irrigation schemes) which are useful in production processes are also among physical capital (DFID, 1999; Farrington *et al.*, 2002).

Natural capital comprises both tangible and intangible natural resource stocks. Tangible natural capitals include land, water, trees, etc., whereas atmosphere and biodiversity represent intangible natural resources. Natural capital is crucial especially for those households whose livelihood is highly dependent on resource- based activities (DFID, 1999; Scoones, 2009). We used land size of households measured in hectares as proxy for natural capital.

Health status is a result of the interplay of access to health services (which is a function of physical infrastructure and income) and sanitation conditions of households. To capture sanitation, the type of kitchen and toilet that households use, and availability of tap water were used.

Figure 1. 1: Analytical Framework



Sources: Adapted from: Meskerem & Degefa 2015; Stuart *et al.*, 2012, with modification

1.11. Thesis Structure

The thesis comprises six chapters: Chapter One discusses the general background of the problem under investigation. It provides an overall introduction and background to the study by providing an overview how crop diversification has contributed to food and nutrition security in Ethiopia. The chapter further provides a theoretical and empirical review on crop diversification, food and nutrition security as concept.

Chapters Two through five are empirical papers organized into chapters to form a coherent piece of academic research. These chapters provide a summary of the research findings and discuss key issues emanating from the findings.

The last chapter, Chapter Six, concludes the thesis. The chapter climaxes the research through an enumeration and elaboration of recommendations for communities, policy makers and developmental organizations on the way to effectively strengthen crop diversification strategies in an effort to reduce food and nutrition insecurity.

**Chapter Two: A Double Hurdle Estimation of Crop Diversification Decisions
by Smallholder wheat Farmers in Sinana District, Bale Zone, Ethiopia**

Abstract

In Ethiopia with heterogeneity in agro-ecological, social, and economic conditions, crop production needs to be diversified to meet household consumption and market needs. This study analyzed determinants of crop diversification in wheat dominant producer rural households in the Sinana District of the Oromia Regional State. The study used a multi-stage sampling procedure to select 384 sample households. Data was collected through a structured survey, focus group discussions and interviews with key informants. Inferential and descriptive statistics were used to analyze the data. Cragg's double hurdle model was applied to identify factors influencing decision and extent of crop diversification. We found that decision to crop diversification was positively associated with access to fertile farm plots, and access to extension services and negatively associated with age of household head, farm land size, and participation in off/non-farm activities. The extent of crop diversification is positively associated with farm land size, access to extension services, distance to market, and total annual income. The result entails the, need to strengthen available extension packages, support existing farmers' cooperatives, and develop rural infrastructures in order to improve the smallholder farmers' extent of crop diversifications.

Keywords: Crop Diversification, double hurdle, Determinants, Bale Zone

1. Background

Agriculture plays an important role in economic growth, enhancing food security, poverty reduction, and rural development of the developing world. In sub-Saharan Africa, the agricultural sector is key for spurring growth, overcoming poverty, and enhancing food security. However, in this region, agriculture is often characterized by low productivity (Kassie, Shiferaw, & Geoffrey, 2011). Enhancing the productivity, profitability and sustainability of smallholder agriculture is the main direction out of poverty in in developing countries in general and sub-Saharan Africa in particular.

Block and Timmer (1994) and Pellegrini and Tasciotti (2014) noted that crop-diversification increases farm income, creates employment opportunities, reduces poverty, and enhances soil and water conservation. Through crop diversification, farm families can unfold manufacturing and monetary threat over a wider variety of crops, thereby lowering economic risks related to negative climate situations or marketplace shocks. Growing various merchandise can also assist financially through increasing marketplace potential. Further, various cropping structures commonly offer more numerous and more healthy meals for people and livestock.. As noted by Acharya *et al.* (2011) crop diversification is used as one of the fundamental instruments for ensuring food security, poverty reduction (FAO, 2017), and nutritional adequacy and is a source of overall agricultural development in most developing countries. The inclusion of a variety of crops, in some regions, may lead to development of new agricultural industries, improving the economic potential of a rural community.

Theoretically, there are two main pathways through which crop diversification affects farm household poverty. (i) It can enhance access to a wide variety of food products necessary for a balanced diet for the households. As diversified production improves dietary diversity or introduces new processed food products, it can improve nutritional value balance of people's diet and, in doing so, help improve their health and earning capacity, (ii) Farming diversified crops including marketable higher-value crops can lead to increased income for farm families (Mazunda *et al.*, 2018).

The increasing risks of crop failure due to erratic rainfall and crop disease usually force farmers to diversify their portfolio as a hedge against these risks (Asante *et al.*, 2017; Khanal and Mishra,

2017). Concurrently, Winters, Cavatassi, and Lipper (2006) have identified three key factors that derive farmers' 'demand' for crop diversity: managing risk, adapting to heterogeneous agro-ecological production conditions, and meeting market demands and food and nutritional security. Likewise, studies (FAO, 2012; Feliciano, 2019) argued that crop diversification has beneficial effects for the soil, guaranteeing environmental protection. It also potentially reduces pests and diseases as well as increases food security by offering farmers access to sufficient, nutritious, and diversified food in areas where markets are not available (Mukherjee, 2015; Van den Broeck, & Maertens, 2016). Other study (Habte, & Krawinkel, 2012) confirms that there is substantial economic loss of major cereals as compared to other crops such as pulses. For example, the economic benefit of faba bean production is 70 percent greater than that of wheat (FAO, 2016). It is also argued that diversifying by growing more enterprises may lead to farm income stability (Mazunda *et al.*, 2018).

In Ethiopia, agriculture continues to be the dominant economic sector in terms of share in the gross domestic product (GDP) (34.9 percent), employment generation (80 percent), and share of export (70 percent), and it provide about 70 percent of raw material for the industries in the country in the 2015/16 fiscal year (UNDP, 2016). Major policy documents of Ethiopia, for instance, economic growth and poverty reduction strategies, place emphasis on the importance of agricultural diversification. Specifically, the Agricultural Development Led Industrialization (ADLI) and the Growth and Transformation Plans (GTPs) I and II embodied all aspects of diversification (Ministry of Finance and Economic Development (MoFED) (2015).

Even though it has been emphasized on the policy documents, crop diversification in Ethiopia is not well practiced (Mesfin, Fufa & Haji, 2011; Sibhatu, Krishina & Qaim, 2015; Mussema *et al.*, 2015; Martin *et al.*, 2016). In the Bale Zone, agricultural productivity is unstable. Crop production in the study area is characterized by cereal-based production system. In this cropping system, the majority of farmers cultivate a single crop particularly cereal production. Such a mono-cropping system was striking farmers to be vulnerable to marketing risks, income instability, and hidden hunger. In the Sinana District of study site, agriculture is traditional, and dominated by monoculture cropping system. Its productivity is constrained by several factors such as technology, resources, environment, socio-economic, infrastructure, low soil fertility, and crop pests and insects (Bale Zone Finance and Economic Development (BZFED) (2018).

Different studies (for instance, Fetien *et al.*, 2009; Wondimagegn *et al.*, 2011; Degye, Belay, & Mengistu, 2012; Mandal & Bezbaruah, 2013; Kanyua *et al.*, 2013; Veljanoska 2014; Ainembabazi & Mugisha, 2014; Rehima *et al.*, 2013; 2015; Hitayezu, Zegeye & Ortmann, 2016; Eisenhauer, 2016; World Bank, 2018) confirmed that crop diversification is shaped by various factors within the farming households. These include available inputs such as labor, farm experience, availability of seed, prices, government policy, land availability, market access, extension service, household characteristics as well as environmental factors such as climatic and soil conditions. Other than the above cited studies, there has been confined studies to examine determinants of crop diversification at household level in study area. Hence, based on the above argument, the study was intended to identify and analyze the factors affecting the decision and extent of crop diversification by rural households. The findings of this study contribute to the growing body of crop diversification literature. It can also be used as an input to improve production income, food and nutrition security, and poverty reduction for most rural households.

2. Theoretical Framework of the Study

Agricultural production is subject to complex socioeconomic and environmental constraints. As stated by Singh, Squire, and Strauss, (1986) households' decision is to ensure a balance between production, consumption and labor input. Farmers' production decision objectives go beyond profit maximization, comprising multiple objectives, namely profit, risk and crop complexity (Van Dusen and Taylor, 2005). The objective of smallholder agriculture households is to maximize utility as consumers, unlike the traditional theory of profit maximization (Singh, Squire, & Strauss, (1986).

The analytical model used for this study was drawn from the theory of the farm household model (De Janvry, Fafchamps, & Sadoulet, 1991). The household¹ combines farm resources and family labor to maximize utility over consumption goods produced on the farm or purchased on the market. Household decisions are constrained by a production technology, farm physical environment and land area, family labor time allocated to labor and leisure and income constraint.

A farm household's expected utility is dependent on its attitude toward risk. Even in a one-season model, a farm household's utility is subject to uncertainty in, levels of rainfall, output prices, and consumption prices. A farmer's production decisions, including optimal crop allocation, are therefore dependent on that farmer's attitude toward risk (Fafchamps, 1992; Van Dusen and Taylor, 2005) as well as the presence of markets problems (De Janvry, Fafchamps, & Sadoulet, 1991; Hitayezu Hitayezu *et al.* (2016). For example, markets for price information or crop insurance would decrease a farmer's perceived level of risk, affecting crop allocation decisions. The literature (Hitayezu *et al.* 2016) suggests that farmers in developing countries tend to be risk averse and crop diversification may be a strategy to insure against production and price risk.

These conditions pose risks to farm production and make farmers cautious in their farming decisions. Hence, farmers are assumed to use the risk-aversion strategy and maximize utility in their decision-making process. As a mechanism for incorporating risk aversion into a farmer's decision-making process, crop diversification played a vital role (Davis *et al.*, 1987).

¹ A small group of persons who share the same living accommodation, who pool some, or all, of their income and wealth and who consume certain types of goods and services collectively, mainly housing and food.

The analytical framework used for this study was drawn from both risk-averse and utility-maximizing theories of farm household production behavior. The fundamental assumption is that the farmer's decision on whether to minimize risks (diversify crops) or not is based upon the utility-maximization theory (Ellis, 1993; Rahm & Huffman, 1984).

The expression $U(CD_{ji}^* P_{ji})$ is a non-observable underlying utility function, which ranks the preference of the i^{th} farmer for the j^{th} diversification process or status of diversification ($j = 0, 1$; where $0 = \text{no diversification}$ and $1 = \text{diversification}$). Thus, the utility derived from crop diversification depends on CD, which is a vector of demographic, socio-economic, farm specific, marketing and institutional attributes of the diversifier and P, which is a vector of the attributes associated with crop diversification. Although the utility function is unobserved, the relation between the utility derivable from the j^{th} diversification process is postulated to be a function of the vector of explanatory variables and a disturbance term having a zero mean:

$$U_{ji} = \alpha_j F(CD_i P_i + \varepsilon_{ji}) \quad (1)$$

Since the utilities U_{ji} are random, the i^{th} farmer will select the alternative $j = 1$ if $U_{1i} > U_{0i}$ or if the non-observable (latent) random variable $Y_i^* = U_{1i} - U_{0i} > 0$. The probability that Y_i equals one (i.e., that the farmer practices crop diversification) is a function of the explanatory variables:

$$\begin{aligned} P_i &= Pr(p_i = 1) = Pr(U_{1i} > U_{0i}) \\ &= Pr(\alpha_1 F_1(CD_i^* P_i) + \varepsilon_{1i}) > Pr(\alpha_0 F_1(CD_i^* P_i) + \varepsilon_{0i}) \\ &= Pr[(\varepsilon_{1i} - \varepsilon_{0i}) > F_i(CD_i^* P_i)(\alpha_1 - \alpha_0)] \\ &= Pr(v_i > -F_i(CD_i^* P_i)\beta) \\ &= F_i(X_i, \beta) \end{aligned} \quad (2)$$

Where X is the $n \times k$ matrix of the explanatory variables and β is a $k \times 1$ vector of parameters to be estimated, $Pr(\cdot)$ is the probability function, v_i is the random error term, and $F_i(X_i \beta)$ is the cumulative distribution function for v_i evaluated at $X_i \beta$. The probability that a farmer will diversify in crop production is a function of the vector of explanatory variables and of the unknown parameters and error term. Equation 2 cannot be estimated directly without knowing the form of

F . It is the distribution of v_i that determines the distribution of F . The functional form of F is specified with double hurdle model. It is used to assess the determinants of crop diversification as well as the factors influencing the extent of crop diversification by rural households.

3. Material and Methods

3.1. Description of the Study Area

The study was conducted in Sinana District, Bale Zone, Oromia Regional State of Ethiopia. The District is located in the southwest of Ethiopia and 412 km from Addis Ababa, capital city of the country. Robe Town is the major town of the District and of the center of the Zone. In the District, agriculture is dominant livelihood strategies of rural households. The major crops produced in the District are cereals (wheat, barley, maize, and teff), pulses (bean, field pea), and oil crops (Bale Zone Agriculture Development Organization (BZADO) 2017). In addition to farming activities, off-farm and non-farm activities were also practiced in small scale. Off-farm activities such as wage employment, participation in crop production on one else's land for harvest share (especially very small land size holders) were commonly practiced. In the study site, two *Kebeles* out of 6 were labeled food insecure. In response to this, in the District, Productive Safety Net Program was the major food insecurity interventions (BZADO, 2017).

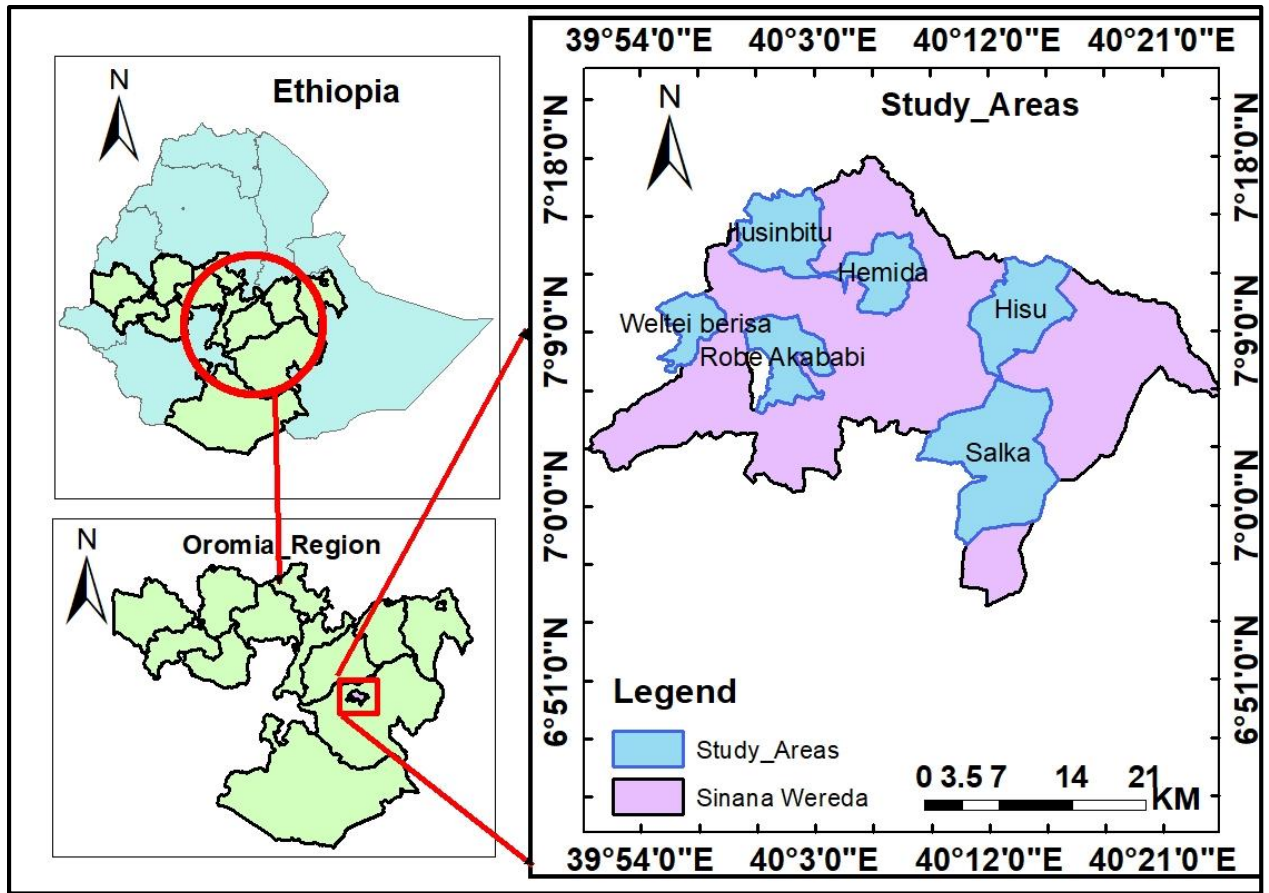


Figure 2. 1: Map of Study area

3.2. Data Collection

A combination of quantitative and qualitative data was collected from primary and secondary sources. Primary data was collected from rural households through semi-structured interviews, focus group discussions, and key informant interviews. To complement the primary data, secondary data was collected from records of government officials, published and unpublished reports, journals, books, and websites. The interview program, consisting of semi-structured questions, was prepared in English and translated into the local language (Afan Oromo) to collect information on socio-economic, demographic, and institutional characteristics of households. Furthermore, it was pretested in *Kebele*, different from sampled *Kebeles*, and necessary adjustments were made before the actual survey.

3.3. Sampling Design

In order to select the sampled respondents, a multistage sampling procedure was employed. In the first stage, *Sinana District* was purposely selected from ten districts of the Bale Zone due to dominance of wheat production. In the second stage, six *kebeles*, namely *Ilu-sanbitu*, *Hamida*, *Hisu*, *Salka*, *Robe-Akababi* and *Weltei-berisa* were selected based on a simple random sampling method. In the third stage, 384 sampled households were selected by using a simple random sampling technique following a scientific sample size determination formula developed by Yamane (1967).

$$n = N/1 + N(e^2) = 9768/1 + 9768(0.05^2) = 384 \quad (3)$$

Where **n** is sample size to be included in this study, **N** is population size and **e** level of precision.

3.4. Data Analysis

In this study STATA software version 14.2 was used to analyze data. In order to efficiently handle and analyze the diverse data collected from the households, a combination of descriptive statistics, inferential statistics, and econometric models were used. The t test was used to assess mean differences between crop diversifier and non-diversifier and continues explanatory variables. Chi-square test was also used to assess the association of households and farm related characteristics between groups (diversifier vs. non-diversifier). Moreover, in order to investigate the determinants of rural household decisions and extent of crop diversification, Cragg's double hurdle model was used.

Empirical model Specification

There are various methods to measure crop diversification (Magurran, 1988; Malik et al., 2002). The current study used Herfindahl Index (HI²) as measures of crop diversification to represent

³ *Herfindahl Index (HI): As proposed by Orris C. Herfindahl and Albert O. Hirschman (1964) "to quantify the amount of competition in a given industry where the market shares are expressed as fractions between 0 and 1". The method was applied to measure the extent of crop diversification for those farmers who diversified their crops. i.e., a measure of the crop concentration of the farm.*

relative land sizes of farming activities operated by a given farm, widely used in crop diversification literature (Magurran, 1988; Malik *et al.*, 2002; Sichoongwe *et al.*, 2014). The CDI has a direct relationship with crop diversification, such that a zero value implies specialization and a value greater than zero means crop diversification. The CDI is obtained by subtracting the Herfindahl index (HI) from one (1-HI). Precisely, the CDI is calculated as follows:

$$p_i = \frac{A_i}{\sum_{i=1}^n A_i} \quad (4)$$

where, P_i =proportion of i^{th} crop, A_i =Area under i^{th} crop (ha), $\sum_{i=1}^n A_i$ total crop land (ha) and $i = 1, 2, 3 \dots, n$ (number of crop)

$$\text{Herfindahl Index} = \text{HI} = \sum_{i=1}^n p_i^2 \quad (5)$$

$$\text{Crop diversification index} = \text{CDI} = 1 - \text{HI} \quad (6)$$

The analysis of crop diversification entails a situation where at each observation the event may or may not occur. An occurrence (crop diversification) is associated with a continuous non-negative random variable, while a non-occurrence (not diversifying) yields a variable with zero value (Cragg, 1971). Such a scenario presents a limited dependent-variable (Engel *et al.*, 2014) modeling problem where the lower bound of the variable, zero value, occurs in a considerable number of observations. The occurrence of the event allows a continuous distribution over positive values, but an "accumulation" at zero exists (due to non-occurrence), which is a corner solution for the diversification problem (García, 2013). Such common cases in the social sciences invalidate the use of the usual regression model and require models capable of handling binary endogenous variables.

The common approaches of modeling such situations include the Tobit, Heckman and double-hurdle models (Komarek, 2010). Several studies have applied the Tobit model to address this kind of studies (Bellemare and Barrett, 2006; Gebremedhin and Jaleta, 2010; Martey *et al.*, 2012; Gani and Adeoti, 2014), but the major drawback of this approach is that it imposes a restriction that both diversification decisions are simultaneously influenced by the same set of explanatory variables (Ground and Koch, 2008). Since we assume, in this study, that the decisions on crop diversification and level of diversification are influenced by different sets of independent variables, the Tobit model is not recognized. It is also argued that the model yields biased parameter estimates

(Wanyoike *et al.*, 2015) and recent studies have stressed the inadequacy of the Tobit, proposing the use of less restrictive alternative approaches the Heckman model (Heckman 1979) and Cragg's double-hurdle model (Cragg 1971). These two-step alternative models are relevant for our study because separate vectors of independent variables influence the farmer's crop diversification decision.

The double hurdle is a less restrictive variant of the Heckman and is best suited for samples drawn through random probabilistic sampling procedures (Komarek, 2010). Therefore, the double hurdle was adopted for the analysis of our randomly selected sample data. The model is a generalization of the Tobit, where two separate stochastic processes determine the participation and quantity decisions. The remarkable difference between the two-step models is based on the contribution of the Heckman, which non-participants will not participate under any circumstance (Kiwanuka and Machethe, 2016). Contrary, the double hurdle assumes that the decision not to participate is a deliberate choice (Tura *et al.*, 2016), thus the zeros from non-participants are considered as corners solution in the utility maximizing model (Yami *et al.*, 2013). The model is also flexible, assuming that there are no restrictions on the components of the independent variables in each phase of estimation.

The double hurdle model is more flexible than the Tobit and allows the participation and extent of crop diversification to be determined separately (Burke, 2009). The model requires a joint application of the probit and truncated regression models, sequentially or simultaneously (Yami *et al.*, 2013). The theoretical basis of the double-hurdle estimation framework by Cragg (Cragg, 1971) is grounded on the probit model where the probability of crop diversification at observation t , $p(E_t)$, is given by:

$$P(E_t) = \int_{-\infty}^{x_t'\beta} (2\pi)^{-\frac{1}{2}} \exp\{-z^2/2\} dz \quad (7)$$

Where X_t is a $K \times 1$ vector of exogenous variables at observation t and β represents a vector of parameter estimates. Then the cumulative unit normal distribution is designated as

$$C(z) = \int_{-\infty}^z (2\pi)^{-\frac{1}{2}} \exp\{-t^2/2\} dt \quad (8)$$

The probit model estimates the probability of a farmer to participate in crop diversification (first diversification decision). The second quantity of diversification occurs when favorable circumstances (search, information and transaction costs) prevail to allow the diversification to be completed (Moffatt, 2005). This non-negative quantity decision can only be measured for non-zero values in the first decision, thus estimated by the truncated regression (Ground and Koch, 2008). Therefore, the double-hurdle two-equation framework (Mathshe and Young, 2004 ;) Kefyalew, 2012) is presented as:

$$CD_i^* = z_i^* \alpha + \varepsilon_i \text{ Diversification Decision } Q^{CD**} = X_i' \beta + \mu_i \text{ Quantity Diversified } \begin{pmatrix} \varepsilon_i \\ \mu_i \end{pmatrix} \sim N \left[\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} 1 & 0 \\ 0 & \partial^2 \end{pmatrix} \right] \quad (9)$$

Where CD_i^* is the latent variable for the binary dependent variable taking a value of one for crop diversification and zero indicates otherwise. Q^{CD**} is the latent variable reflecting the number of crop diversified. z_i^*, α and ε_i represent vectors of explanatory variables, parameter estimates and the error term for the crop diversification decision. Likewise, X_i', β and μ_i represent vectors of explanatory variables, parameter estimates and the error term for the level of crop diversification. Since an individual farmer is involved in both sales decisions, the error terms are assumed to be independently and normally distributed, thus the first hurdle corresponds to a probit model (Kefyalew, 2012).

The binary dependent variable of the diversification decision in Equation (9) is defined by

$$CD_i^* = 1 \text{ if } CD_i^* > 0, CD_i^* = 0 \text{ if } CD_i^* \leq 0 \quad (10)$$

and decisions on the level of crop diversification is defined by

$$Q^{CD*} = \max(Q^{**}, 0) \quad (11)$$

The observed variable, Q^{CD*} (normally presented as y_i in literature) is determined as

$$Q_i^{CD*} = CD_i Q_i^{CD*} \quad (12)$$

and log-likelihood function for the double hurdle is:

$$\text{Log}L = \sum_0 \ln \left[1 - \Phi(z_i') \Phi\left(\frac{X_i' \beta}{\sigma}\right) \right] + \sum_+ \ln \left[\Phi(z_i') \frac{1}{\sigma} \Phi\left(\frac{y_i - X_i' \beta}{\sigma}\right) \right] \quad (13)$$

Variables Definition and Hypotheses

The decision and extent of crop diversification practices depend on demographic, socioeconomic, farm attributes, and institutional factors. These factors include sex, age, family size, education level, size of livestock holding, amount of off/non-farm-income, farm experience, farm size, land fragmentation, plot fertility, access to credit, extension services, distance to nearest market and cooperative membership. The list of explanatory variables used in the Cragg's Double Hurdle model and their expected signs are summarized in Table 2.1.

Table 2. 1: Summary of Explanatory variables used in Cragg's Double Hurdle Model

Variables	Measurement	Expected sign
Dependent Variable		
Crop Diversification Indices	Index	
Explanatory Variables		
Gender	Sex of household head (Male= 1, female =0)	+-
Family size	Persons in the household(Number)	+
Access to Credit	Access to credit (Yes= 1, No=0)	+-
Extension visit	Frequency of Extension contact (Frequency per month)	+
Cooperative member	Membership to farmers' cooperative (Yes=1, No=0)	+-
Education	Education of household head(year of schooling)	+
Farming Experience	Year of farm experience (Year)	+
Livestock holding	Tropical Livestock Unit (TLU)	+-
Farm land size	Land operated for farming by the household(ha)	+
Plot fertility	Plot fertility (Yes =1, No=0)	+-
Number of plots	Number of plot operated for farming (number)	+
Age of household head	Age of household head (years)	+-
Distance to market	Distance from homestead to nearest market (km)	+-
Distance to FTC	Distance from homestead to FTC (km)	+-
Distance to Farm	Distance from homestead to farm (km)	-
Labor availability	Access to labor for farming (yes=1, No=0)	+
Income (annual income)	Total income (birr)	+
Number of oxen	Number of oxen used for farming (Number)	+
Participation on off/non-farm income	Participation on off/nonfarm activities (yes=1, No=0)	-/+

-+ indicates listed variables were expected to affect crop diversification negatively or positively

4. Result and Discussions

4.1. Household Characteristics and Status of Crop Diversification

The finding indicates that 58.72 percent of rural households in study area did not diversify cropping systems. Further, using the Hirschman and Albert (1964) formula, the study found that the average CDI of sampled households is 41.28 percent. This implies that the cropping system is less diverse. Table 2 shows descriptive analyses that aim to give a picture of demographic and socio-economic characteristics of the diversifier and non-diversifier farmers in the study area.

The survey result shows that two third of the respondents were male-headed households while the remaining one third were female-headed households. The average family size of household was 7.06 with standard deviation of 2.24.

Most of the crop diversifier and non-diversifier households in the study area (88.78 and 81.43 percent, respectively) had not received credit. Only 2.63 percent of crop diversifiers and 6.44 percent of non-diversifiers were visited by extension agents in the study area. The finding also indicates that most of rural households (66.67 percent of crop diversifiers and 74.29 percent of non-diversifier) were members of farmers' cooperatives.

The results of the survey showed that 82.77 percent of household heads have no education. The remaining 17.23 percent attend different educational levels, i.e. primary school at 15.44 percent, secondary school at 1.57 percent, and university or college at 0.52 percent. The average years of farm experience of household head is 24.74 years with standard deviation of 8.68. Education level and farm experience of household head determine crop diversification because educated and farmers with more farm experience easily understand agricultural instructions provided by the extension workers.

Findings of the study showed that almost all sampled households own livestock though the number of livestock varies. The mean livestock holding in Tropical Livestock Unit (TLU) for the sample households is 7.48. Non-diversifier households have a better livestock holding than the diversifier households. The mean livestock holding in TLU for crop diversifier households is 7.53 and 8.10 for non-diversifiers.

Regardless of the size, all respondents have ensured that they own land they operate. The landholding of the sample households ranges from 0.5 ha to 9 ha. The average land holding is 2.99 ha. The mean landholding for crop diversifiers is 2.77 ha, and the corresponding figure for non-diversifiers is 3.14 ha. The survey results indicate that the mean number of farm plots that farmers own is 3.13. The mean farm plots for crop diversifiers are 1.82; the corresponding figure for non-diversifiers is 3.27 farm plots. Findings of the survey results indicates that 49.87 percent of households have fertile plots. The comparison between crop diversifiers and non-diversifiers showed that 29.11 and 52.10 percent of the households perceived that they have infertile land. (Table 2).

Household labor is the availability of economically active age groups that are ranging between 15 and 64. Availability of this age group helps households to diversify their livelihoods into various cropping systems, and hence easily assure their food need. The availability of household active labor has important role in the crop diversification. Households who did not have sufficient labor, especially for agricultural purpose would be forced to hire labor.

Using the Hirschman and Albert (1964) formula, the study found that the average CDI of sampled households is 41.3 percent. This implies that the cropping system is less diverse. Table 2.2 shows descriptive analyses that aim to give a picture of demographic and socio-economic characteristics of the diversifier and non-diversifier farmers in the study area.

Table 2. 2: Descriptive result of factors affecting crop diversification

Characteristics	Non-Diversified % or mean (n ₁ =71)	Diversified % or mean (n ₂ =311)	Total	χ^2 or <i>t-test</i>
Sex of household head (% female)	12.86	14.57	11.54	0.006
Family size in number	6.69	7.13	7.06	0.010
Use of credit (% yes)	18.57	11.22	12.50	0.024
Extension Visit (% yes)	94.29	95.51	95.05	0.097**
Membership to Coops (% yes)	74.29	66.67	67.97	-0.016**
Education level of household head	0.34	.37	.362	0.002**
Farm Experience in year	35.61	24.72	24.74	0.011***
Livestock holding in Tropical livestock unit/TLU	7.24	7.57	7.48	-0.002
Farm land size	2.67	3.06	2.99	-0.007***
Plot Fertility/Average (% poor)	97.14	61.22	49.87	0.092*
Number of Plot	2.64	3.22	3.13	0.001**
Age of HH	44.47	44.23	44.33	-0.003**
Labor availability (%yes)	47.25	75.56	63.34	.0405**
Distance to Market	26.29	30.03	29.33	0.003
Distance to FTC	15.66	15.93	15.87	0.003
Distance to Farm	15.96	15.73	15.77	-0.004
Total Income/AE in birr	5214.29	7370.19	6943.18	2.76e-06
Number of Oxen	2.39	2.37	2.68	0.061

*, ** and *** significant at 1%, 5% and 10% significance, level respectively

Source: Own survey (2019)

4.2. Factors influencing smallholder farmers decision to crop diversification

This result presented in (Table 2.3) shows that overall, the model is statistically significant at the <0.1 with Wald test $Wald \chi^2 (18) = 231.19$, Pseudo $R^2 = 1.0294$ and log likelihood = 3.3021182, which indicates that the model fulfilled the condition of good fit. Multicollinearity was checked using variance inflation factor (VIF) and the calculated VIF values are all less than ten (the cut-off point), which indicated that multicollinearity is not a problem. A test for normality of CDI was made using Kernel density plot residuals. Was completed the usage of the kernel density plot of residuals. The kernel density plot supplied a reasonably clean curve that closely resembles a normally distributed curve, indicating that the normality assumption was not violated (Figure 2).

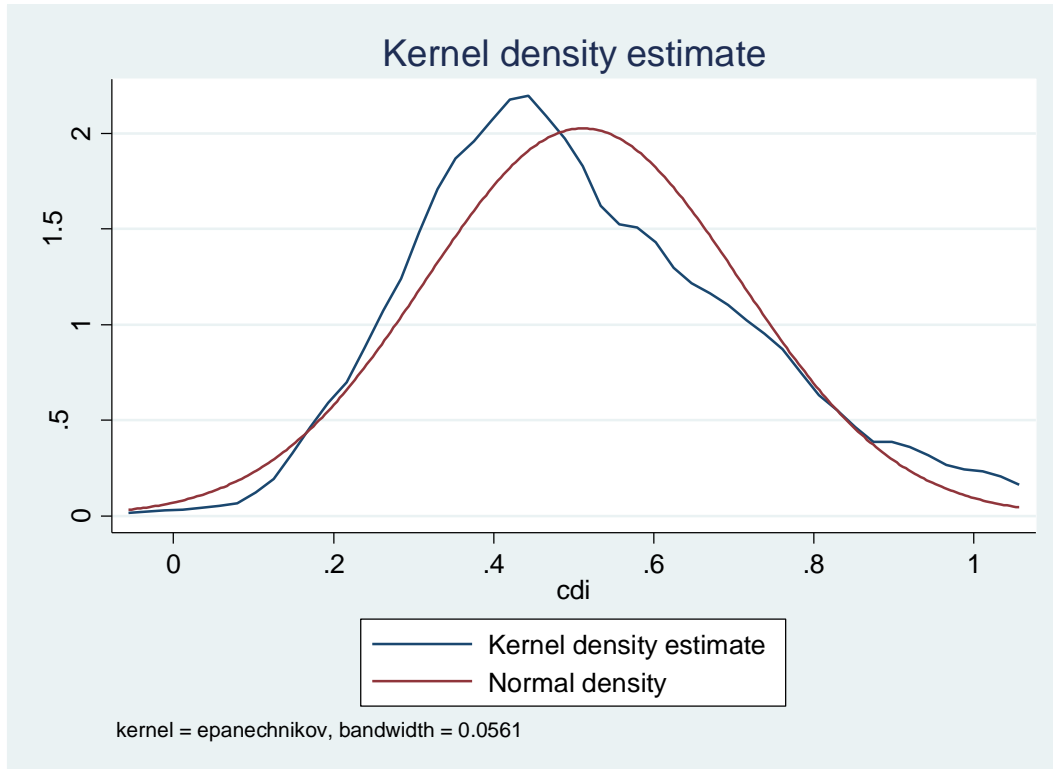


Figure 2. 2: Kernel density estimate for crop diversification index

The coefficient of age of household head is negative and significant at ten percent, indicating an inverse relationship between age of household head and decision to crop diversification. The result indicates that a one-year increase in age of household reduces the probability of crop diversification by 0.3 percent. Elderly farmers were less likely to participate in crop diversification and probably are engaging only in food crop production. The reason is that older farmers cannot manage the farm properly and usually rely on old farming systems. Further, it can also imply that households with more nonworking members are more prone to labor risk. This agrees with the findings of Ojo *et al.* (2014) and Lighton *et al.* (2016), who also found that a farmer’s risk-bearing ability reduces as his/her age increases.

Farm size has a negative significant effect on probability of crop diversification at one percent level of significance. The negative impact of farm size suggests that farmers with relatively small farm practice crop diversification than large farms. This is in agreement with our hypothesis formulated regarding the relationship between crop diversification and land holding size of the household. On average, each additional hectare of land decreases the probability of farmer crop

diversification by 25.4 percent. Similar to this, studies by Assefa and Gezahegn (2010) and Moti *et al.* (2013) found a similar result.

Plot fertility is significant at $p < 0.01$, reflecting that holding of infertile plot decrease probability of crop diversification. The study further revealed farmers with access to fertile farm plots are 4.33 percent less likely to diversify their crop production when compared to farmers with who has access to fertile farm plots. The negative coefficient for the number of fertile plots owned and operated by a household indicates that households with fertile farm plots are less likely to diversify by growing different crops. We surmise that if the soils are productive, the farmer will have more cropping options and is probably to participate in more than one crop enterprise on the farm. Farmers with low soil fertility farms are more likely to adopt diversified crop rotations as they have been shown to contribute to higher and more stable net farm income when compared to traditional monoculture, which over extended periods of time, has shown evidence of degradation of soil quality and reduced crop productivity (Clark, 2004).

It appears a positive and significant relationship between frequency of extension contacts per year and crop diversification and the coefficient is significant at <0.01 . This might be associated with the extension system, which is focused on enhancing farmers' productivity and profitability. Extension service providers favor crop diversification at the micro level and are generally aware of the role of crop diversification in risk minimization. We found that access to extension services increases the probability of a farmer's participation in crop diversification by 50.36 percent. The result is consistent with the findings of Mesfin, Fufa, and Haji, (2011); Rehima *et al.* (2013); Sisay, (2016), and Asante *et al.* (2017), where a positive relationship was found between probability of crop diversification of the household and their access to extension services.

Participation in off/non-farm activities negatively and significantly affects probability of crop diversification at five percent probability level. In those households that participated in off/non-farm activities, the likelihoods of farmers participating in crop diversification decreases by 20.70 percent. The plausible explanation is that if a household receives income from off-farm work, it is less likely to pursue crop diversification as a method of reducing financial risk associated with farming (Sandretto *et al.*, 2004). This finding is similar with findings of Lighton and Emmanuel (2016) and Dessie *et al.* (2019), who also found out that off-farm income had a significant and negative effect on crop diversification.

Table 2. 3: Probit regression estimates for determinants of crop Diversifications

Variables	Coeff.	Std. Err.	Marginal Effect
Gender	-0.022	0.026	0.002
Age of household head	-0.003***	0.001	-0.003
Household size	0.004	0.004	0.008
labor used	-0.003	0.017	0.050
Education level of household head	0.001	0.011	-0.007
TLU	-0.002	0.002	-0.005
Farm land size	-0.442*	0.104	0.254
Number of plots	-0.007	0.005	0.005
Plot fertility	0.119*	0.009	-0.046
Extension visit	0.086**	0.041	0.081
Remittance	0.011	0.018	0.089
Distance to nearest market	-0.001	0.001	0.006
Distance FTC	0.003	0.003	0.006
Distance to farm	0.002	0.003	-0.012
Number of oxen	0.012	0.008	0.002
Participation in off/non-farm activities	-0.037**	0.018	-2.070
_cons	0.856	0.137	-1.220
LR Chi (18)	=	231.19	
Number of Observations	=	383	
Prob > chi2	=	0.0000	
Pseudo R2	=	1.0294	

***, ** and *** significant at 1%, 5% and 10% significance level respectively**

4.3. Factors influencing the extent of Crop Diversification

Ceteris paribus, the statistically significant variables allude to an increase or decrease in the extent of crop diversification, subject to the sign of the relevant parameter estimate (see Table 2.4). The key factors affecting the level of crop diversification that reveal statistical significance at $p < 0.01$ include farm land size, plot fertility, extension visits, distance to nearest market, distance to farm, and total annual income.

Table 2. 4: Truncated regression estimates for determinants of level of crop diversification

Variables	Coeff.	Std. Err	Marginal Effect
Gender	0.009	0.256	-0.019
Age of household head	-0.011	0.009	-0.003
Household size	0.033	0.042	0.008
labor used	0.217	0.152	0.025
Education level of household head	-0.029	0.107	-0.004
TLU	-0.023*	0.024	-0.004
Farm land size	1.097***	0.637	0.209
Number of plots	0.022	0.050	-0.002
Plot fertility	-0.200**	0.102	0.073
Extension visit	0.385**	0.184	0.048
Remittance	0.349	0.365	0.115
Distance to nearest market	0.024*	0.009	0.002
Distance FTC	0.026	0.030	0.005
Distance to farm	-0.053**	0.028	-0.005
Total annual income	0.013*	0.07	0.010
Number of oxen	0.007	0.081	0.010
Access to Remittance	0.343***	.183	.048
_cons	-1.249	1.025	

Significance levels: * p < 0.01, ** p < 0.05, * p < 0.1.**

The amount of land owned by the farmer has a positive and significant effect on the extent of crop diversification at ten percent level of significance. This indicates that an addition of one hectare of land increases the extent of diversification by 20.9 percent. This implies that large farm size may enable households to allot their land for multiple crops, thereby, minimize income, production and price risks than small land holders. The result supports the finding of Benin et al. (2004), Fetien *et al.* (2009), Wondimagegn *et al.* (2011) and Rehima *et al.* (2013). They found a positive relationship between the level of crop diversification and total farm size in their respective studies.

The coefficient of fertile plot/plot fertility has significantly and negatively affected extent of crop diversification at five percent level of significance. Households that had access to fertile farm plots decreased their levels of diversification by 7.03 percent. This implies that fertile land is promising to increase production and yield, and the households might have motivated to produce a more profitable crop because they can easily increase production and yield levels. This is consistent with

the findings of Rehima (2013) and Lighton and Emmanuel (2016), who also found that a fertile plot had a significant and negative effect on crop diversification.

Extension service (frequency of contacts) has positively and significantly affected the extent of crop diversification practice at five percent level of significance. This implies that extension workers have an important role to play in creating awareness among farmers as well as educating them on the importance of diversification. A household who had more frequency of extension contact during the cropping period increased probability of being engaged in crop diversification practice by 4.8 percent. This finding is consistent with the research results of Ibrahim *et al.* (2009) and Rehima *et al.* (2013).

The coefficient of walking distance from residence to the nearest market significantly and positively affected extent of crop diversification at less than one percent significance level. An increase in one minute to walk to the nearest market increased the extent of crop diversification of households by 0.2 percent. The possible explanation is that the households that have poor market access are more likely to rely on diversification to meet their consumption needs and to avoid transaction costs. The finding concurs with Alpizar (2007), Rahima *et al.* (2013), and Dessie *et al.* (2019) indicating a household far from a market was positively related to crop and variety diversification.

Walking distance from residence to the farm plot significantly and negatively affected extent of crop diversification at less than ten percent level of significance. As walking to the farm plot increases by a minute, the extent of crop diversification of households decreased by 0.50 percent. This finding is similar with the finding of Benin *et al.* (2004) and Sichoongwe *et al.* (2014), who indicated households living farther from their farms manage fewer crop diversity.

The coefficient of total annual income positively and significantly affected extent of crop diversification at less than one percent level of significance. We found out that a one Birr increase in income increased the extent of crop diversification by 1.00 percent. This implies that higher incomes allow farmers to have access to critical productive resources such farm assets, inputs, and land, which increase the extent of crop diversification. The extra income earned by farmers from one crop is also important in providing financial resources that are used for diversification into other crops. Similar studies by Bonham *et al.* (2012), Rehima *et al.* (2015), and Basantaray and

Nancharaiah (2017) indicated that crop diversification is strongly associated with higher farm income.

5. Conclusion and Recommendations

The objective of this study was to analyze crop diversification among wheat-dominated rural households. Crop diversification was measured by Herfindahl-Hirschman Index, while Cragg's Double hurdle model was used to identify probability and extent of crop diversification in study area. The study found that the average CDI of sampled households was 41.28 percent. The results also revealed that age of household head and participation in off/non-farm activities negatively influence probability of crop diversification, while access to fertile plots of land, and access to extension services positively influence probability of crop diversification in study area. The results further showed that farm land size, extension visit, distance to nearest market, total annual income, and total annual income positively influence extent of crop diversification. In contrast, distance to farm plots, and access to fertile plots of land negatively affect extent of crop diversification in study area.

Access to extension services significantly and positively affect likelihoods of crop diversification practices. Given the positive effects of access to extension services on crop diversification, there is now a strong need to strengthening available extension packages to help smallholder farmers improve probability of crop diversifications. Hence, the local government should arrange experience-sharing and short-term training programs so as to share the rich knowledge to inexperienced farmers.

Membership to farmers' cooperatives significantly and positively affect extent of crop diversification practices. Thus, we recommend that efforts must be made to strengthen the role of farmers' cooperatives in information dissemination, farmer-to-farmer extension, and smallholder farmers' access to markets and their bargaining power for higher producer prices.

Household size positively and significantly affects likelihoods of crop diversification. The results also indicated that labor availability positively and significantly affects extent of crop diversification in study area. The results suggested that policy and strategy makers should consider availability of labor force before introducing labor-intensive technology in other similar agro-

ecology areas of the country. As the same time, regional and local governments should encourage the use of labor-saving technologies in diversified farming systems.

The study did not consider crop production efficiency. Future research should focus to conduct further analysis to understand the association that exists between crop diversification and household crop production 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 crop diversification, namely, risk and ecosystem/environmental management roles.

**Chapter Three: The Contribution of Crop diversification Food Security
among wheat producers in Sinana District, Bale Zone, Oromia Regional State,
Ethiopia.**

Abstract

Background: Agriculture is considered an important strategy for overcoming many of the emergencies faced by rural households in developing countries. In rural Ethiopia household access to food largely depends on what the household grows, either because they consume what they grow, or they purchase food with the income earned from what they grow. This study examines effect of crop diversification on food security and determinants of household food security among rural farm households of Sinana District, Oromia Regional state. The study uses a multi stage sampling procedure to select 384 sample households. Data were collected using a household survey, a focus group discussant (FGD), and key informant interviews. Ordinary least squares regression (OLS) and multinomial logistic regression model were used to analyze the data collected.

Results: we found that crop diversification had a positive and significant effect on household food security. The education of the household head, access to irrigation system, livestock owned, total income, and remittance positively affected household food security. Although crop diversification increased food security, age of household head and distance to nearest market were negatively associated with food security.

Conclusions: The study conclude that any effort to increase household food security should consider empowerment of farmers through adequate training and informal education, enhancing crop diversification, strengthening the rural infrastructural development (roads, market centers, and cooperatives).

Keywords: Food security, multinomial logistic model, Rural households, Bale zone

1. Background

In developing countries, agriculture contributes to the entire economy and a source of food. It directly contributes to food security by making more food available or by enabling farm households to access by using their farm income. Agriculture is also an important strategy to overcome many of the emergencies faced by rural in developing countries. (1, 2). In rural Ethiopia households' access to food largely depends on what the household grows, either because they consume what they grow, or they purchase food with the income earned from what they grow.

Food insecurity and undernutrition have been the major development challenges of developing countries (3, 4). Food security is achieved when all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life (5). Despite growing national and global commitment towards the food and nutrition problem, a significant proportion of the population is food insecure and suffers from micronutrient deficiencies (6).

A latest report by Food and Agriculture Organization (FAO) shows that 10.9 percent of the world, 20.4 percent of Africa and 31.4percent of Eastern Africa people were undernourished in 2017 (7). Likewise, study (8) shows that in many developing countries, the condition of household food security depends mainly on physical and economic means (accessibility). It stated that economic, social, and environmental sustainability are essential for the accessibility to food for all people. Hence, without integrating sustainability to food security, it is impossible for policymakers to mitigate food insecurity. In Ethiopia, about 80 percent of the society lives in rural areas under insufficient infrastructural facilities. The majority of the households are smallholders (9). They often face recurrent drought, weather variability, and food insecurity. Endalew *et al.* (10), for instance, came across that about 10 percent of Ethiopians were chronically food insecure throughout the normal year and this figure increased to 15percent during frequent drought periods. In connection with the situation of food insecurity, in 2018, the Global Food Security Index (GFSI) of the Economist Intelligence Unit (EIU) ranked Ethiopia as 100th among 113 countries based on food affordability, availability, quality, and safety. According to the EIU Index (11), Ethiopia is a state with 28.8 percent prevalence of undernourishment, and very low in diet diversification, sufficiency of food supply, micronutrient availability, and food consumption as a share of household expenditure.

Albeit, household food insecurity, hunger and undernutrition have major implications for smallholder farmers in Ethiopia. Undernutrition is an underlying cause of 53 percent of infant and child deaths. Over the past decade, rates of stunting and underweight have decreased gradually but it remains high with 44 percent of children under-five stunted and 29 percent underweight (12, 9).

Food insecurity in Ethiopia is derived primarily from dependence on undiversified livelihoods based on low output rain-fed agriculture (13). The challenges are traced back to poor infrastructure, declining soil fertility and climate change, among others. Like most part of Ethiopia, Sinana District, the focus of this study, has been stricken by poverty and experiencing household food insecurity (14). Consequently, smallholder farmers in the areas are forced or encouraged to diversify crop production in order to overcome twine-objective of stabilize their food stocks and incomes. Crop diversification, characterized by, cultivating more than one variety of crops belonging to the same or different species in a given area, is the mechanism to overcome household food insecurity problems (15). It is one way of developing a resilient agricultural system, especially where communities depend largely on agricultural products (food and fodder) for their livelihoods (15, 16). Pellegrini and Tasciotti (17) illustrated that the number of crops produced highly contributes to household food security and dietary diversity. They also argued that crop diversification has a double role: it has high impact on households' diets and, other things being equal, it increases agricultural revenues. A study (18) also suggested that families who grow a diverse set of crops are less likely to be poor as compared with households specializing in their crop production. According to (19), cultivating several crop species can also help smallholder farmers to manage price and production risks. Ultimately, crop diversification contributes to improved yield for the smallholder farmer, which in turn translated into more and a variety of food for consumption and marketable surpluses from production. Therefore, this study aimed at examining the effect of crop diversification on food security (access and utilization) and identifying determinants of household food security among rural households of the Sinana District, Ethiopia.

2. Materials and Methods

2.1. Sinana District Setting

The study was conducted in Sinana District which is located in Bale zone (Figure 1). It is bounded with Goro and Ginir in East, Dinsho in West, Agarfa and Gasera in North and Goba and Barbare Oreda in the south. The District lies between 6° 55' 00'' to 7° 18' 00 North and 39° 53' 00'' to 40° 26' 00'' East. The altitude of the District ranges from 1650 to 2950 m a.s.l.

The District has 20 rural kebeles. The total area of the District is about 1168 km². About 73.54 percent is plain land, 3.7 percent is hills, 9.6 percent is mountains, 12.3 percent is rugged and 0.86 percent is gorge. The annual average temperature is 16.5°C whereas the minimum and maximum temperature is 9°C and 23°C respectively. Rainfall pattern of the District is characterized by bimodal rain fall distribution. The annual average rainfall is 1105mm whereas the minimum and maximum rainfall is 1060 and 1150mm respectively (20).

With 99 percent of the population engaged in farming, agriculture is one of the economic activities of the District. Farmers in the District practice mixed farming that incorporates both crop and livestock. The major crops produced in the District are Cereals, pulses and oil crops. (14).

2.2. Study Design

The study employed a cross-sectional survey using a mixed methods research approach. The choice of mixed methods was dictated by the research problem under (21, 22). It involves a multi stage sampling technique to select sample kebeles and households surveyed. First, the District was selected purposively due to dominance and potential in wheat production. Second, representative Kebeles were selected using simple random sampling method. Third, respondent households were randomly selected from lists of names of household head in the Kebeles using computer-generated random number table.

The primary data were collected from the households, key informants such as, community elders, Development Agents (DAs), and Health Extensions and Researchers and different development experts in the District. Before starting the actual data collection, the questionnaire was pre-tested. Based on the pretest results, the necessary modifications were made to the questionnaire. Focus group discussions (FGDs) were also conducted with group of male and female on the issues related to economic activities, food security and home consumption behavior among rural households. Twelve FGDs, two in each selected kebeles were made to obtain important qualitative data.

In order to obtain a representative sample size, the study employed the sample size determination formula given by (23):

$$n = \frac{N}{1 + N(e^2)} = \frac{9768}{1 + 9768(0.05^2)} = \frac{9768}{1 + 24.42} = 384 \quad (1)$$

Where n is the sample size, N is the population size (total households in the six kebeles, which is 9768) and e is the level of precision.

2.3. Methods of Data Analysis

The survey data were coded, organized, summarized and analyzed using descriptive, and econometric model analysis. STATA version 14.2 was used to aid data analysis. While the qualitative data were analyzed using narration and conceptual explanation, quantitative data were analyzed using Ordinary least square (OLS) method and a multinomial logit model.

Crop Diversification Analysis

The study adopted one of the widely used in crop diversification analysis called Herfindahl-Hirschman Index (HHI) to measure crop diversification to represent relative land sizes of farming

activities undertaken by a given farm (24). The crop diversification index (CDI) is an index of concentration. It has a direct relationship with diversification such that a zero value indicates specialization and a value greater than zero signifies crop diversification. The CDI is obtained by subtracting the Herfindahl index (HI) from one (1-HI). Precisely, the CDI is calculated as follows:

$$p_i = \frac{A_i}{\sum_{i=1}^n A_i} \quad (2)$$

where, P_i =proportion of i^{th} crop, A_i =Area under i^{th} crop (ha), $\sum_{i=1}^n A_i$ total crop land (ha) and $i = 1, 2, 3 \dots, n$ (number of crop)

$$\text{Herfindahl Index} = \text{HI} = \sum_{i=1}^n p_i^2 \quad (3)$$

$$\text{Crop diversification index} = \text{CDI} = 1 - \text{HI} \quad (4)$$

Food Security Analysis

In this paper, we adopt Household Food Insecurity Access Score (HFIAS) and Dietary Diversity as a measure of household food security in the study sites.

Household Food Insecurity Access Score (HFIAS)

The HFIAS is a continuous measure of the degree of food insecurity (access) in the household in the past 30 days. Despite the limitations of all measures, the HFIAS has been found to be understandable and applicable across varying contexts (25). Additionally, it has been identified as it uniquely able to detect aspects of food insecurity involving decreased access to a sufficient quantity or quality of food (26).

According to (27), the HFIAS reflects the three universal domains of household food insecurity that is anxiety about household food insecurity, insufficient quality and insufficient quantity of food supplies. This indicator captures the household's perception about their diet regardless of its nutritional composition (28). It is based on the assumption that households' experiences of food insecurity cause predictable reactions and responses that can be captured and quantified through a survey and then summarized into a score. Following (29), the HFIAS is computed as follows:

HFIAS (0–27) = summation of the frequency of occurrence during the past 30 days for the nine-food insecurity-related conditions

$$\begin{aligned}
\text{HFIAS (0 - 27)} = & \quad Q1a * F1 + Q2a * F2 + Q3a * F3 + \\
& \quad Q4a * F4 + Q5a * F5 + Q6a * F6 + \\
& \quad Qa7 * F7 + Q8a * F8 + Q9a * F9
\end{aligned} \tag{5}$$

At a household level, a high HFIAS shows that a household is very food insecure, while a low score shows that a household is less food insecure.

Dietary Diversity Score

According to FAO's guidelines for assessing household dietary diversity, the population of interest should be chosen prior to the start of the data collection. Because, it helps to adapt the questionnaire to the local survey context (25). A dietary diversity questionnaire can be used to collect information at either household or individual level. The decision on how to collect information depends on the purpose and objective of the survey. If the purpose and objective of the survey are to determine nutrition, assessing household dietary diversity would be the best approach (30). The dietary diversity score (DDS), is calculated by summing the number of unique food groups consumed during the last seven days (31). The value ranges from 0 to 12, in which lowest DDS value signifies higher food insecurity status and vice versa. Even though there is no international consensus on which food groups to include in the scores (32), the DDS denotes 12 food groups. These are cereals; root and tubers; vegetables with tubers; leafy vegetables; fruits; meat, poultry; eggs; fish; pulses/legumes/nuts; milk and milk products; oil/fats; and sugar/honey. This study considered the 12 food groups in the analysis.

Effect of crop diversification on Household food security

In the analysis of the relation between crop diversification and food security, the study used an ordinary least squares (OLS) regression. Crop diversification index (a continuous variable and food security outcomes DDS and HFIAS are taken as dependent variables (all continuous variables) that, we decided to use OLS regression. According to (33), it is appropriate to use OLS to ascertain influence of a continuous variable on another continuous variable similar to the current study. The OLS model is specified as:

$$Y_i = \beta_0 + \beta_1 X_{i1} + \beta_2 X_{i2} \dots + \beta_n X_{in} + e \tag{6}$$

where, Y_i = household food security outcome (either DDS or HFIAS), X_{i1} = crop diversification index, X_{i2} = Sex of household head, X_{i3} = Age of household head (in year), X_{i4} = Education level of household head, X_{i5} = household size, X_{i6} = Farm land size, ..., β_0 = intercept, β_1 to β_n are coefficients, and e is the error term. Table 3.1 shows the description of variables used in our analysis.

Specification of multinomial logit model

We assessed the determinants of the levels of household food insecurity status using a multinomial logit model. The dependent variable is the discrete or categorical variable represented by Household Food Insecurity Access Prevalence (HFIAP) status. According to (34), the multinomial is a generalization of the familiar logistic regression, which is used when there are more than two discrete possibilities for the dependent variable. The multinomial logit model generally captures how households' socio-economic and demographic variables affect the probability that a household in the sample exhibit any of the identified possible levels of food insecurity in reference to base outcome. As noted by (35), the use of multinomial logit model is often an important econometric strategy when the choices are unordered. In this case, the test of independence of irrelevant alternatives (IIA) assumption of this model is required. Independence of irrelevant alternatives implies the marginal effect of choosing food secure households as reference households is not affected by the existence of other levels of food insecurity ($p = 1, 2, 3$). In other words, even if households in other levels of food insecurity are taken as a reference point, the outcomes or estimated parameters are expected to be the same. Subsequently, we tested the assumption of IIA and confirmed the suitability of multinomial logit model in the study.

Following (36) the multinomial logistic regression model is defined as follows:

$$p_{ji} = \frac{e^{x'_{ij}\beta_j}}{\sum_{j=1}^m e^{x'_{ij}\beta_j}} = 1, \dots, m \quad (8)$$

Where $p = 1$ food secure households; $p = 2$ Mildly food insecure households; $p = 3$ Moderately food insecure households and $p = 4$ Severely food insecure households; β_j is a vector of coefficients on each of the independent variables X . Equation (8) can be normalized to remove indeterminacy in the model by assuming that $\beta_0 = 0$, and the probabilities can be estimated.

The multinomial logistic coefficients are difficult to interpret, and associating the β_j with the j^{th} outcome is tempting and misleading. Thus, in order to interpret the effects of explanatory variables on the probabilities, marginal effects are usually derived (37):

$$\frac{\partial p_j}{\partial x_i} = p_j \left[\beta_j - \sum_{k=0}^j p_k \beta_k \right] = p_j (\beta_j - \bar{\beta}) \quad (9)$$

Where P is the probability, X is socioeconomic characteristics and other factors, and β is a vector of coefficients. The marginal effects measure the expected change in probability of a household fall into particular household food insecurity level with respect to a unit change in an explanatory variable (38). The signs of the marginal effects and respective coefficients may be different. The marginal effects depend on the sign and magnitude of all other coefficients.

Table 3. 1: Summary of Variables included to affect Household food security status

Variables	Variables unit and measurement	Variable class	Sign
Dependent Variables			
HFIAS	Household Food Insecurity Access Score	Continuous	
DDS	Score of food group consumed	Continuous	
Explanatory Variables			
CDI	Crop diversification index	Continuous	+/-
Gender	Household head, 1=male, 0=female	Discrete	+/-
Age	Age of household head in year	Continuous	+/-
Edu	Education in year of schooling	Continuous	+
Hsize	Size of household in number	Continuous	+/-
Lsize	Size of Farm in ha	Continuous	+
Iuse	Access to irrigation land, Yes=1, No=0	Continuous	+
Cuse	Access to credit, Yes=1, No=0	Discrete	+
Coops	Member to farmers cooperatives, Yes=1, No=0	Discrete	+
Market	Distance to local market in hour	Continuous	-
Nincome	Total annual income in birr	Continuous	+
TLU	Livestock holding in TLU	Continuous	+
Remit	Remittance, Yes=1, No=0	Discrete	+
Nonfarm	Participation on non-farm activities, Yes=1, No=0	Discrete	+
extenvisit	Extension contact in days per month	Continuous	+
Aginform	Access to agriculture information Yes=1, No=0	Discrete	+

Source: Own Hypothesis

3. Results

3.1. Socio-Demographic and Socio-economic Characteristics

The average age of household-head was 44 years old with standard deviation of 10.0. The age of sample household heads ranged from 25 to 68 years old. The study revealed that the majority of respondents were within the active labor force. The study also found that two to five persons participated in farming activities for most families.

The mean distance between the sample kebeles and the nearest market place in kilometer is 10.4 km with a minimum of 1.2 kms and a maximum of 15 kms (Table 3.2).

Table 3. 2: Household Socio-economic Characteristics for continuous variables (n=384)

Variables	Mean	St. Dev	Min	Max
Age of household head (in Year)	44.33	9.95	25	68
Education level of hh head (in year)	0.36	0.81	0	4
Household size (Number)	7.06	2.24	2	17
Farm/land size (in hectares)	2.99	1.59	0	9
Distance to nearest market (walking munit)	29.34	10.19	10	50
Total net income (birr)	6943.19	6899.99	1200	90000
Total non/off-farm income(birr)	1333.33	2139.50	0	9000
Livestock holding (TLU)	7.48	4.46	0	27.017
Length of food store after harvest (in month)	1.81	1.25	0	3

The study shows the average family size of household is 7.06 persons with standard deviation of 2.24. About 82.8 percent of household heads were unable to read and write. The remaining 17.2 percent had attended education level of (primary school 15.4 percent, secondary school 1.6 and university or college level 0.5 percent). The average farm experience of household heads is 24.7 years with standard deviation of 8.7.

Regardless of the size of landholding, all the respondents operate farm plots. The landholding size vary from 0.25 to 9 hectares (ha). The average landholding is about 2.99 ha with standard deviation of 1.59 ha. In the same token, almost all sample household's own livestock with the mean livestock ownership of 7.5 in Tropical Livestock Unit (TLU) with standard deviation of 4.5 (Table 3.2).

About 88.25 percent of studied households were male-headed while the remaining 11.75 percent were female-headed households. About 96.87 percent, 1.83 percent and 1.13 percent were married, divorced, and widow /widower, respectively.

In Sinana District, almost every one is a member of the traditional local institutions such as Idir/Afosha self-help group to cope with funerals, house construction and savings. The study result indicates that the majority (67.97 percent) were not members to farmers' cooperatives. Only 12.50 percent of the sample households received credit while 87.50 percent did not due to various reasons. Out of the non-users, 79.9 percent did not used credit due to their religion affiliations and 5.9 percent failed to use credit due to fear of repayment (Table 3.3).

Most respondents (72.66 percent) did not receive any remittance from anywhere while the remaining 27.34 percent received some remittances. The survey results also showed that 95.05 percent of the sample households obtained agricultural extension contact (Table 3.3).

Table 3. 3: Household characteristics for categorical variables (n=384)

Variables		Frequency	Percent
Sex of Household Head (Gender)	Male	46	11.75
	Female	338	88.25
Marital status (Mstatus)	Married	371	96.87
	Divorced	7	1.83
	Widowed	5	1.31
Participation on Irrigation farming (iuse)	Yes	354	92.19
	No	30	7.81
Use of credit (Cuse)	Yes	48	12.50
	No	336	87.50
Extension agent visit to farm (extenvisit)	Yes	365	95.05
	No	19	4.95
Members to famers cooperative (Coops)	Yes	261	32.03
	No	123	67.97
Remittance (remit)	Yes	105	27.34
	No	279	72.66
Participation on non/off-farm income (nonffarm)	Yes	132	34.62
	No	252	65.38

In order to triangulate the above results, focused group discussions were made. The discussants revealed that for rural farmers' food availability is highly determined by their own agricultural production and available assets mainly livestock. Moreover, landholding size is crucial for

farmers' food security situation. However, focus group participants argued that landholding size in the study area is diminishing mainly due to increasing population size and problem of engaging in the non-farm sector. Furthermore, participants also indicated that the increased variability of rain fall has triggered and escalated the vulnerability of food production. Consequently, the seasonal variability of rain-fall has pushed the farmers toward unforeseen margin of vulnerability due to low food production. In other words, unpredicted extreme weather events have impacted on the livelihood assets and threaten the stability of food supply system.

Similarly, findings from key informant explained that availability of inadequate infrastructures and social services development like road, transportation, communication, electrification, clean water, and agricultural services are the impediments for the sustainability of agricultural production and food security in the study area.

3.2. Household Food security Status

3.2.1. Household Food insecurity status measured by HFIAS

The result indicates that 55.73 percent (n = 213) of households were never worried about having no enough food. In contrast, the remaining 44.2 percent (n = 170) of surveyed households have experienced problems of both economic and physical access to food at various degree.

The severity level depicted that during the last 1-month period, about 44.56 percent of households encountered access problems “rarely”; about 24.87 percent “sometimes” and about 30.57 percent “often”. Furthermore, the finding shows the mean score of HFIAS for the respondents is 11.63 with a standard deviation of 5.16. The finding further showed that 55.87 percent (n = 214) were most food secure; 24.02 percent (n =92) were medium food insecure; and 20.10 percent (n = 77) were most food insecure. The result implies only 7.32 percent of the respondent's *food secure* i.e., such households never experience or worried about any form of the food insecurity conditions. In contrast, about 8.07 percent of the respondents were *severely food insecure* while about 49.96 percent and 34.64 percent of the respondents were *mildly food insecure* and *moderately food insecure* respectively.

Table 3. 4: Distribution of households by HFIAS condition

HFIAS condition	Rarely		Sometimes		Often	
	N	%	N	%	N	%
Worry about food	136	80.00	19	11.78	15	8.82
Unable to eat preferred foods	195	53.72	114	31.40	54	14.88
Eat just a few kinds of foods	92	30.46	84	27.81	126	41.72
Eat foods they really do not want eat	41	11.40	87	23.77	238	65.03
Eat a smaller meal	99	51.03	63	32.47	32	16.49
Eat fewer meals in a day	75	68.81	19	17.43	15	13.76
No food of any kind in the household	38	82.61	5	10.87	3	6.52
Go to sleep hungry	16	88.89	2	11.11	0	0
Go a whole day and night without eating	12	100	0	0	0	0

Clues to the severity status

- (1) Rarely (once or twice in the past 4 weeks)
- (2) Sometimes (three to ten times in the past 4 weeks)
- (3) Often (more than ten times in the past 4 weeks)

3.2.2. Food Security Status Measured by DDS

The results of the finding on the DDS show respondents were found to have consumed an average of 5.73 food groups with a standard deviation of 1.97. The minimum DDS value is 2 and the maximum DDS value is 11. The summary of the DDS in study area is presented in figure 2. Further, based on FAO (36) categorization about 13.54 percent of the respondents were found to consume less dietary diversity, implying they are more food insecure due to lack of the means to acquire and consume a variety of foods. Those who have medium level of DD account for 50.52 percent, and about 35.94 percent of the respondents have $DDS \geq 8$ that they were food secure and were able to acquire and consume a variety of foods.

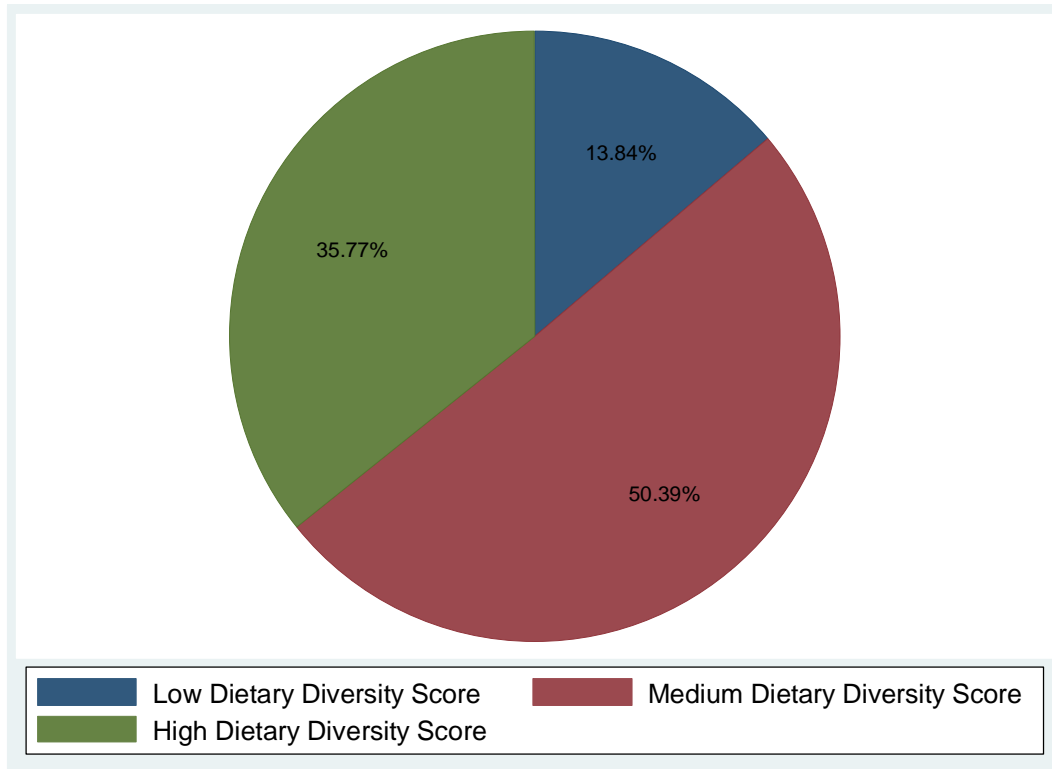


Figure 3. 1: Household Dietary Diversity of Study Site

Source: Field Survey 2019

3.3. Effect of Crop Diversification on household Food Security

We run F-statistics and found out that the variables included in the OLS models are significant in influencing the respective dependent variables DDS and HFIAS. The value of R^2 for the DDS and HFIAS model is 22 percent and 15 percent, respectively. This means that 22 percent of the variation in DDS and 15 percent of the variation in HFIAS are explained by the variables included in the two respective models. As such CDI, Farm land size, TLU, positively influence DDS, while distance to nearest market and access to remittance have a negative influence on DDS. While CDI, age and education have a negative influence on HFIAS, the distance to nearest market and access to remittance positively influence HFIAS (Table 3.5). Crop diversification as measured by the index has a positive influence on DDS and a negative influence on HFIAS. The coefficient of CDI is also significant at 1 percent and shows a positive influence on household DDS. Oppositely, the coefficient of CDI is significant at 1 percent and shows a negative influence on HFIAS.

Table 3. 5: OLS regression of the effects of crop diversification on Household food security

Variables	DDS		HFIAS	
	Coef.	P>t	Coef.	P>t
Crop Diversification Index (Number)	1.01	0.00*	-1.48	0.00*
Sex of household head (Male/Female)	-0.27	0.36	0.02	0.98
Age of household head (year)	0.01	0.32	-0.05	0.07***
Edu of household head (year of schooling)	0.14	0.25	-0.79	0.02**
Household Size (number)	-0.05	0.32	0.18	0.16
Farm land size (in hectares)	0.14	0.05**	-0.29	0.13
Irrigation farming (yes/no)	0.63	0.10	-0.35	0.74
Access to credit (yes/no)	0.00	0.99	-0.10	0.90
Membership to famers cooperatives (yes/no)	0.10	0.60	-0.25	0.67
Distance to the nearest Market (walking minute/hr)	-0.03	0.00*	0.06	0.02**
Total Annual net Income (birr)	0.18	0.18	0.83	0.12
Livestock Ownership in TLU	0.06	0.01**	0.03	0.64
Access to Remittance (birr)	-0.68	0.01**	2.82	0.00*
Participation on Off/non-farm activities (yes/no)	0.14	0.56	-0.21	0.74
_cons	4.99	0.00	7.11	0.00
R ²	22.0		15.0	
Adjusted R ²	19.01		11.7	
F	1.8		4.9	
N	383		383	

*, **, and *** indicate statistical significance at 1, 5, and 10% probability levels, respectively

3.4. Determinants of Household Food insecurity

We employed multinomial logistic analysis to determine factors affecting household food security phenomenon. We hypothesized independent variables were expected to affect the household food security. Before running the econometric model, the independent variables were tested for the presence of multicollinearity. The calculated VIF values are all less than 10 (the cut-off point) which indicated that multicollinearity is not a serious problem. The goodness of fit in multinomial logistic regression analysis was checked and the likelihood ratio test statistics indicated by the chi-square statistics is highly significant (significance = 0.0000) suggesting strong explanatory power of the model. The value of R^2 for the multinomial logistic regression analysis is 12 percent. The result of the multinomial logit analysis of the hypothesized independent variables which were expected to affect the household food security are provided in Table 3.6.

Table 3. 6: Multinomial Logit Model

Variables	Food Secure			Moderately Food Insecure			Severely Food Insecure		
	Coef.	Std.err	M.eff	Coef.	St.er	M.eff	Coef.	St.err	M.eff
Gender	0.645	0.523	0.079	0.281	0.465	0.008	0.271	0.509	0.002
Age	-0.029***	0.018	-0.005	0.007	0.017	0.002	0.020	0.020	0.003
Mstatus	1.332***	0.781	0.121	1.264	0.781	0.113	1.013	0.832	0.030
Edu	0.496**	0.225	0.079	0.079	0.179	0.034	0.003	0.222	0.011
Hsize	-0.011	0.075	-0.006	0.070	0.073	0.010	0.056	0.088	0.004
Lsize	0.068	0.116	0.011	0.047	0.111	0.008	-0.085	0.133	-0.013
Iuse	-0.512	0.546	-0.012	-1.469**	0.817	-0.217	-0.093	0.895	0.059
Cuse	0.886**	0.441	0.101	0.293	0.466	-0.020	0.787	0.543	0.054
Coops	0.226	0.380	0.059	-0.461	0.333	-0.079	-0.174	0.379	-0.008
Market	0.026	0.017	0.002	-0.003	0.016	-0.005	0.091*	0.021	0.010
Nincome	0.193	0.206	0.061	-0.219	0.213	-0.014	-0.800*	0.274	-0.088
TLU	0.013	0.036	0.005	-0.082**	0.039	-0.015	0.028	0.039	0.006
Remit	-0.338	0.449	-0.115	0.912**	0.394	0.131	0.897	0.459	0.076
Nonfarm	-0.367	0.402	-0.044	-0.464	0.373	-0.072	0.294	0.448	0.061
Prodpyear	0.663	0.542	0.072	0.697	0.488	0.087	-0.019	0.516	-0.047
agrinform	0.257	0.450	-0.015	-0.468	0.395	0.098	-0.850**	0.437	0.040
CDI	-0.472	0.312	-0.029	0.818*	0.304	-0.025	0.689**	0.355	-0.066
_cons	-2.620	1.627		-2.432	1.524		-5.551	1.708	
Log likelihood = -440.689			Number of Observation			=	384		
			LR chi2(51)			=	122.17		
			Prob > chi2			=	0.0000		
			Pseudo R2			=	0.1217		

*, **, and *** indicate statistical significance at 1, 5, and 10% probability levels, respectively

Age of Household head: The result of the model depicted that the age of the household head was negatively related to household food security compared to base category, which is mildly food insecure. Keeping other factors constant, food security condition decreases by 0.50 percent when age of the household head increases by one year.

Marital status: Marital status of the household head positively affected household food security when compared to base category. The model predicted that the likelihood of household being food secure increases by a factor of 0.121 when household is married.

Education level of Household Head: The result of this study indicates that when comparing with the base category, household head education level positively affected household food security. From the model result, the marginal effect reveals that the literacy level of household head increase likelihoods of household food security by 7.9 percent.

Access to Irrigation Farming: Participating in irrigation is another important factor in determining household food security. In study area merely about 21.7 percent of households participate in irrigation farming despite optimistic view of the focus group discussants and key informants who outlined the presence of some opportunities for irrigation-based farming. The model result indicated that there is a negative association between irrigation and moderately food insecurity status of the studied households. Irrigation negatively and significantly affected moderately food insecurity. All other things remain constant, the marginal effect of the model predicted that participation in irrigation farming decreases moderately food insecurity by a factor of 0.012.

Access to credit: Use of credit was also one of determinant factors that affect household food security. Credit utilization positively determines household food security. The marginal effect shows, other things being constant, the likelihood of household being food secure increase by 10.10 percent when household used credit.

Distance to the nearest market: In this study, distance to the nearest market was found to be the most important predictor variable affecting household food security. From the results we see that comparing with the base category, distance to the nearest market. The marginal effect indicates that, the likelihoods of the household being severely food insecure decreases by 1.00 percent as distance to the nearest market increases by one-minute walking.

Total the net Income: There is a negative relationship between total net income of the households and their food security conditions when comparing with the base category. The marginal effect shows other things being constant, the likelihood of household being severely food insecure decrease by 8.80 percent as income of household increase by one birr.

Livestock own in TLU: Livestock own in TLU is significant at five percent probability level and influences negatively the moderate food insecure category. Other things remain constant, the marginal effect of the model shows, with a one-unit increase in livestock holding in TLU decreases the household's tendency to fall in moderately food insecure by 1.50 percent.

Income received through gift (aid) and remittance: Income received through gift (aid) and remittance positively affected moderately and severely food insecurity categories. The marginal

effect of the model shows, with a one-birr increase in household remittance, the household's tendency to fall in moderately food insecure increases by 13.1 percent *ceteris paribus*.

Access to Agriculture Information: Access to agriculture information is significant at five percent probability level and influences negatively the severely food insecure category. Holding other variables in the model constant, the marginal effect of the model shows, access to agriculture information decreases the household's tendency to fall in severely food insecure by 4.00 percent.

Crop Diversification: Crop diversification index negatively affects moderately and severely food insecure categories in study area. The marginal effect shows, other things being constant, the likelihood of household being fall in the moderately and severely food insecure categories decreases by 2.50 percent and 6.60 percent, respectively as crop diversification index increases by one unit.

3.5. Discussion

This study assessed effect of crop diversification on household food security and determinants to household food security in Ethiopia. In this study, the average family size of 7.06 persons is by far larger than the national average of 4.6 persons per household (39, 40). The findings of this study revealed that households with higher crop diversification intensities are more likely to have diversity in terms of food crops that can be consumed within the household thus justifying the positive relationship. This implies crop diversification improves dietary diversification in Sinana District.

The result also showed crop diversification reduces the severity of food insecurity in Sinana District. It suggests that households with higher crop diversification intensities are more likely to diversity in terms of food crops. This indicates crop diversification improves dietary diversification in study area. The negative relationship between CDI and HFIAS implies that households with higher crop diversification intensities are more food secure as compared to those with relatively lower crop diversification intensities. Therefore, farmers who intensify crop diversification are better off than their counterparts because diversification is positively related to dietary diversification and negatively related to food insecurity. This is mainly attributed to the benefits of crop diversification to include, raising farm productivity, income, and reducing production and price risks. Our finding concurs with previous similar studies, which demonstrated positive

relationship between crop diversification and food security of the household (41-43). For example, Jones and others (44) found that farm production diversity was consistently and positively associated with household dietary diversity. More generally, Agriculture, crop diversification in particular can offer opportunities for soil and land use management, and biomass production (45). Others, for instance, (46, 47) found that crop diversification positively influence participation in insurance schemes that help reduce farmers' risk from weather and price shocks. Further, the merits of crop diversification in improving food security can be manifested through better management of price and production risks (48). This is probably due to growing more than one crop species in a single season gives the farmers more options. It in turn helps the farmers to manage price and production risks better as compared to less diversified farming enterprises.

The Age of household head negatively associated with household food security. However, this finding contradicts our expectation (Table 3.6). The possible reason could be as the age of the person increase, one may lose job and/or could not participate in other income generating activities. Furthermore, elderly farmers do not have the required labor force to produce more food crops compared to the young people. This is in line with findings from other studies (49). Previous studies argued that younger farmers are more likely to be food insecure than the older farmer due to better capital accumulation of the later (50).

Marital status affected household food security. However, being married in itself is not an assurance to escape from the risk of food insecurity. This might imply that a household headed by married parents support each other all their way to food sufficiency in contrast to a single or widow household who often lacks mutual support. It is related to factors such household size, level of income household, among others that affect food security status associate to marital status. Consonant with our study, (51) found that marital status has positive relation with household food security.

On average, large number of farmers did not attend the minimum required educational level. They may not understand adequately written agricultural instructions and information provided by the extension workers. The finding of the study indicates that education and farm experiences significantly affect household food security in study area. The possible reason is better educated household heads are more likely to secure food than uneducated (illiterate) household heads. This

is due to the fact that the contribution of education to work efficiency, competency, diversify income and becoming visionary in creating conducive environment is positive. It has had a spillover effect on the education of dependents and long-term target to ensure better living condition than illiterate ones. The result coincides with the theoretical evidences that educational improvement could lead to reducing the problem of food insecurity. Studies (51-53) in Dire Dawa, Addis Ababa and elsewhere supported our expectation that a household head with higher education level increases the chance of household achieving food security.

Participation in irrigation farming affected household food security. This implies that irrigation enables households to grow food crops more than once a year, hence increased production, income and food availability of the household. So, it overcomes of food insufficiency in dry or food shortage circumstance and normal seasons. This result is similar with the result of (54).

Credit is a source of capital that boosts the capacity of rural households to purchase yield enhancing agricultural inputs and has remained to be a shortcoming for poorer households in intensifying the farming sector. Thus, the influential association between use of credit and household food security may be due to the fact that households that use credit has opportunity to purchase agricultural input and allow households that cultivate larger land areas produce enough food to feed their household members and also produce surplus to sell and increase their household income. Similar study found out that credit is important to invest on activities that generate income for farm households. The households can purchase agricultural inputs such as improved seeds, fertilizer, and fattening and selling livestock to earn additional income. Farm households who have access to credit could increase their production and other possibilities and hence escape food shortage (55).

Market distance refers to the number of kilometers farmers have to travel to reach the next marketplace to sell their produce. Farmers who live near to the market places are more food secure than their counter part. Previous studies (56, 57) in Ethiopia revealed that market access has negative and significant effect on household food security.

The result shows that those households who possess large income are more likely classified as food secure. The result corresponds with the prior expectation and the possible explanation is that income determines purchasing power of the household with the prevailing price so that those households having higher income are less likely to become food insecure than low income

households. This finding is consistent with a study reported from Ethiopia, Ghana and South Africa (58-60).

The positive relationship between livestock owned and household food security is explained by the fact that livestock size being a proxy for rural household resource endowment and asset accumulation. As such, those sample respondents with large livestock size have better chance to earn more income. This demonstrated that as the livestock resources increases, the probability of the household to secure food increases. In support our finding, (61) found out that households with more livestock ownership were less likely to be food insecure in rural Ethiopia. Similarly, (62, 63) demonstrated that livestock ownership and sales contributed to the household food security through increasing in food consumption expenditure and dietary diversity.

The positive relationship between household food security and remittance is due to the fact that an increase in remittance and gifts income will have a positive effect because the change in income will lead to constant change in expenditure. Thus, the income received from remittance and gifts increases the income so that capacity of the households to consume more will increase. In support of this findings, (64, 65) revealed that households with remittances had better food consumption, minimized vulnerability, and better food security than the households that did not have remittances, but contended that the benefit to solve food insecurity was temporary. Further, the result is in line with the findings of (66). They argued that remittance contributes to economic development and protects basic human rights, where the aid fills a severe food gap. In contrast, a study conducted in Niger by (67) revealed that food aid influences negatively and significantly the household food security. Similarly, a study done by (50, 68) in Ethiopia suggests that food aid displaces domestic production and commercial trade by depressing prices in the recipient countries; it affects the labor supply negatively, enhances market imperfections and information asymmetries, and this, in turn, affects economic development.

Based on household food insecurity access prevalence, our study is in line with that of (44) who found out that more diverse production system can also lead to more diverse household diets in Malawi. Regarding the remoteness and the poor quality of infrastructure in our study areas, the household food access depends on what the household often produces. In other words, the households' food diet is closely linked to their experiences of crops production. Household may

choose to diversify crops because of poor infrastructure (69). This would help them to obtain the kind of food they need at the local level. Concurrent results were reported from Kenya and Tanzania by (70) who found that in, the number of crops grown by a household has associated with the dietary variety of the household.

4. Conclusion and Recommendation

The main aim of this study was to examine the effect of crop diversification on household food security and analyze socioeconomic factors affecting food security. Crop diversification was measured by Herfindahl-Hirschman Index while food security was measured by the household food insecurity access scale and household dietary diversity. Crop diversification index negatively influenced HFIAS and positively influenced DDS. Notwithstanding, the HFIAS multinomial regression model revealed that higher education levels of household head, age of household head, participating in irrigation farming, livestock holding in TLU, access to agriculture information and crop diversification index positively influenced household food security conditions. On the other hand, distance to the nearest market negatively affected household food security.

We tend to conclude that rural households with diversified cropping systems were more secure in terms of food supplies and income and hence they are able to meet for the food requirement of their households. This suggests that crop diversification potentially improves food security through improving food security stocks in terms of quantity and variety and also in improving income through sale of crop produced from a variety of crops grown. In turn, improve consumption patterns of the household. Therefore, District Agriculture office needs to intensify the promotion of crop diversification in rural farming with particular focus to less diversified households so as to improve the food security status of the rural people.

Considering the fact that a larger number of households kept livestock based as a tradition, increasing the number of livestock kept as a means of boosting income should be prioritized. To this end, provision of support towards training and animal husbandry and pastureland development may enhance the livestock production and productivity and hence increase food security.

In tandem, any efforts geared towards improving household food and nutritional security in the long run should be centered on the development of irrigation farming as one of the key

determinants of food security. Precisely to say irrigation farming tremendously increases household food security status. Thus, to increase food security, measures that would improve irrigation farming should be introduced.

In addition, household educational level immensely contributed to the status of food security. Therefore, any interventions meant to support rural households by governmental and non-governmental organizations need to emphasize capacity building through training and informal/alternative basic education. Informal education and training could create opportunities for gaining knowledge on nutritious food production and consumption and sharing of experiences among farmers. Thus, empowerment of farmers through adequate training and informal education has the potential to improve household food security condition.

Finally, households' distance to nearest market was significantly and negatively associated with food security. Thus, improving rural infrastructural development such roads and market center and market information contribute to enhance food security status of rural residents.

**Chapter Four: Household dietary diversity in rural households of Sinana
District Bale Zone, Oromia Regional state, Ethiopia: A cross-sectional study.**

Abstracts

Household Dietary Diversity (HDD) is an important nutritional discovery that measures the economic capacity of a household to access a variety of foods over a given time period. This paper examines the determinants of HDD among wheat dominant producer rural households of Sinana District, Oromia Regional state. Multi stage sampling procedure used to select 384 sample households. Data were collected using structured survey questionnaire, focus group discussions, and key informant interviews. Zero-truncated Poisson regression model was used to measure the determinants of HDD. The results show that almost all of respondents consumed food made from cereal and only 20.05 percent, 10.16 percent and 7.29 percent of the household consumed egg, meat and fruits in previous seven days respectively. In average household consumed 5.73 food groups. Further, the finding indicates that about 13.54 percent, 50.52 percent, and 35.94 percent of the participants had consumed low, medium and high dietary diversity level respectively. Marital status, education level, participating in irrigation farming, membership to farmers' cooperatives, farm size and livestock holding positively affected HDD while distance to nearest market and remittances negatively influenced HDD. Therefore, stakeholders in the agricultural sector should promote and encourage crop diversification strategies, expand access to irrigation, introduce agricultural technologies to boost income of rural households and thus diversify their diet.

Keywords: *Dietary diversity; Determinants; rural households; Poisson regression*

1. INTRODUCTION

The Household Dietary Diversity Score (HDDS) is a qualitative methodology that has been validated in several countries such as a rough measure of food availability and food accessibility aspects of food security (Cordero Ahiman *et al.*, 2017). It assesses the number of different food groups consumed in the household during a defined reference period, such as the last 24 or 48 hours or the last 7 or 14 days (Koppmair *et al.*, 2016; Cordero-Ahiman *et al.*, 2017). Therefore, a diversified diet is linked to the economic capacity of a family to access a variety of foods resulting in a number of different food groups consumed over a period of time. In other words, increased dietary diversity is associated with the socio-economic status and food security of families.

There is a positive association between higher diet diversity and reduced prevalence of stunting and underweight among children under five, and a positive association between diet diversity and mean micronutrient adequacy for women and children (UNICEF, 2009; Becquey *et al.*, 2010). Moreover, nutritional needs are more likely to be met where diverse diets are the norm. The diet is more likely to include the variety of nutrient-dense foods needed for good health than a monotonous diet. Two studies, Ruel, 2003 and Ruel *et al.*, 2013, noted that Diet Diversity Scores are important indicators of diet quality and nutritional status in developing countries.

Poor dietary diversity is a challenge for rural communities in developing countries. Their diets mainly starchy staples with inadequate animal products, fresh fruits and vegetables (Arimond and Ruel, 2002). As discussed by Kalkuhl *et al.*, (2013) adequate supply of all nutrients is of paramount importance to satisfy the nutritional requirements human beings for the maintenance of the body, growth, strength, physical labor, cognitive abilities, immunity and good health. World Health Organization (2010) also notes that during early life, the growth and development of the body as well as its maintenance are dependent on correct supply of all essential nutrients. In later life or during maturity, when development and growth are complete, the body requires food mainly for the aim of labor, body maintenance and repair. Nutrients are contained in foods in different contexts, structures and levels that form the organizational and functional components of edible plants (Von Braun and Tadesse, 2012). The findings of Ghandilyan, (2006) indicate that there is always a marked variability in the concentration of nutrients and biologically active ingredients in foodstuffs of plant origin. This indicates that only a mixed supply at recommended level can satisfy the nutrient requirements of all age and gender groups of human beings.

According to FAO (2010) hunger continues to be a dramatic problem in developing countries and that progress towards this goal is slow, with nearly a billion people starving. The document clearly notes that many have access to the minimum number of calories, but are deficient in one or more micronutrients. Adding to this Jones *et al.*, (2014) notes households in developing countries are often limited to one or two starchy staple foods and may be especially lacking in micronutrient-rich fruits, vegetables and animal-source foods and hence, it is necessary to have more diversified food basket to ensure balanced diets so as to enhance nutrition. Cognizant to this Alderman *et al.*, (2006) shows that unbalanced diets resulting from the consumption of predominantly carbohydrate-rich diets also contribute to productivity losses and to reduced levels of education and income. Consequently, low dietary diversity is the most critical for nutritional security problem (Horton and Ross, 2003) as most diets are often deficient in essential vitamins and minerals.

Household food insecurity, hunger and malnutrition remain critical issues; poor nutrients status of smallholder farmers has been a consistent problem in Ethiopia (CSA, 2011). Lack of dietary diversity and micronutrient-dense food consumption, and child feeding practices contribute to the high rates of child undernutrition. This and related factors leave children to low birth weight, short stature, lower resistance to infections, and higher risk of disease and death (Kalle *et al.*, 2015).

In the study area, most rural households consume mainly staples (Bealu, *et al.*, 2018), which are high in carbohydrates, but low in nutrients and vitamins. The consumption of micronutrient rich foods by smallholder farmer is insufficient. Traditional bread is the most common food item (Annet, 2016). However, cereal based diets are recognized as monotonous, lacking essential micronutrients and contributing to malnutrition and micronutrient deficiencies, especially in children, who need energy and nutrient-dense food to grow and develop both physically and mentally (Vakili *et al.*, 2013). This paper addresses a research question: What are the main determinants of household dietary diversity among wheat producer rural households in Sinana District of Oromia region?

The rest of the document proceeds as follows. Section two explains study site, descriptions of the nature of data, measurement of variables and analytical methods are explained. The third section presents the results and the discussion. Descriptive statistics are provided first, followed by the

results of rigorous econometric results with detailed discussion. The last section summarizes the document.

2. MATERILS AND METHODS

2.1. Description of the Study

The study area, *Sinana District*, is located in Bale zone about 412 km southwest of Addis Ababa, the capital city of Ethiopia. *Sinana* is located between 60 55' 00'' to 70 18' 00 N longitude and 390 53' 00'' to 400 26' 00'' East latitude. The total area of the District is about 1168km². The administrative center of the District is Robe town and District has 22 rural *Kebeles*. The total population of the District is 164,124 of which 86,324 are male and 77,800 are female. (CSA, 2015). Agriculture is the main source of livelihoods in *Sinana District*. The type of agriculture within the community includes animal rearing and production of different crops such wheat, barely, maize, bean, field pea, potato, teff. "Wheat" is the dominant crop and stable food of the community.

2.2.Data Collection

Both primary and secondary data of quantitative and qualitative nature was used for this study. Primary data was collected using household survey. Data on household dietary diversity was collected using a dietary diversity questionnaire developed by FAO. Respondents were visited at their homes during the survey and women/caregivers or people responsible for food preparation responded to the questionnaire. In addition, Focus Group Discussions (FGDs) and key informant interviews were used to generate qualitative nature of primary data. Secondary information from published and unpublished documents and reports from relevant organization were gathered and incorporated with the primary data.

According to FAO's guidelines for assessing household dietary diversity, the population of interest should be chosen prior to the start of the data collection. Even though there is no international consensus on which food groups to include in the scores (FAO, 2010), the DDS denotes 12 food groups in which the following are considered in this study: Cereals; White tuber and roots; Vegetables; Fruits; Meat; Eggs; Fish; Legumes, nuts and seeds; Milk and milk products; Oils/fats; Sweets; Spices, condiments and beverages. Respondents were asked to remember all foods and beverages consumed in the seven days prior to the interview. One point was assigned to each of the food groups consumed during the reference period, indicating a maximum total sum dietary diversity score of 12 points for each household, in which lowest DDS value signifies higher food insecurity status and vice versa. This score was then recoded into a three-level categorical variable

using some threshold values indicating low dietary diversity, medium dietary diversity and HDD categories. However, as there is no international consensus on the cutoff values to use (Cordero Ahiman *et al.*, 2017), we used an HDDS less than or equal to three as the low dietary diversity group and between four to six as medium category while HDDS greater than or equal to seven as high diversity score category.

2.3. Population and Sampling Technique

A community based cross sectional study was conducted in *Sinana District*. The *District* has about 34193 households. The population of the study included 9768 wheat producing household heads in the *District*.

Multi-stage sampling procedure was used in the selection of representative samples. In the first stage, *Sinana District* was purposively selected from ten *Districts* of Bale zone due to dominance of wheat production. In the second stage, six *kebeles* were selected based on simple random sampling method. Finally, sample households who participated in the study among the six *kebeles* were selected based on simple random sampling technique. The number of sampled households was determined following Yamane (1967).

$$n = \frac{N}{1 + N(e^2)} = \frac{9768}{1 + 9768(0.05^2)} = \frac{9768}{1 + 9768(0.05^2)} = 384$$

2.4. Data Analysis

STATA 14.2 was used to analyze the overall statistical data. Both descriptive and econometric analysis was employed to examine status and determinants of household dietary diversity experience of rural households.

Specification of zero-truncated Poisson regression model

Dietary Diversity (DD) has always been modeled in the literature with either Dietary Diversity Score (DDS), which represents count data, or Dietary Diversity Index (DDI) that represents indices. For instance, Woldehanna and Behrman (2013) and Ecker *et al.*, (2013) employed DDS, while Drescher *et al.*, (2007) and Gaiha *et al.*, (2012) utilized DDI in their respective studies. The current study used zero-truncated Poisson regression model to analyze determinants of dietary

diversity. Following Rashid *et al.*, (2011) we made use of zero-truncated Poisson regression model to estimate DDS as the dependent variable. In this regard, we assume DDS is random and, in a given time interval, has a Poisson distribution with probability density defined as:

$$pr(y_i = DDS_i) = \frac{e^{-\lambda_i} \lambda_i^{DDS_i}}{DDS_i!}, DDS_i = 1, 2, \dots, 12 \quad 1$$

Where DDS is the realized value of a random variable with mean and variance y_i and λ_i respectively. y_i is assumed to be strictly positive ($y > 0$). According to Cameron and Trivedi (1998), this is a case of truncation from below that is taken into account when specifying a zero-truncated Poisson model.

To incorporate the set of explanatory variables x and Y stated in into Eq. 1, and to ensure a non-negative mean y , the parameter λ is specified as:

$$E \{ y_i / Y_i, x_{ik} \} = \lambda_i = \exp(\phi Y_i + \beta_1 x_1 + \dots + \beta_k x_k) \quad 2$$

The implicit assumption in the Poisson model is that the variance λ_i is equal to its mean y_i or the data are equally dispersed. Any violation of this assumption has consequences similar to the failure of the assumption of homoscedasticity in the linear regression model (Cameron and Trivedi 1998).

As a second analytical model, we have also used ordered probit model. However, the result of this model is reported as annex as the result is not fundamentally different from Poisson regression model except some of those variables that were statistically significant with the former model turned out to be insignificant with probit model. We believe, such use of multiple measures allowed us to assess the robustness of the estimates and their consistency.

Table 4. 1: Summary of explanatory Variables influencing household dietary diversity

Dependent Variable: Household Dietary Diversity Score		
Explanatory Variables/Determinants	Measurement	Hypothesis
Sex of household head	Yes/No	-/+
Marital status	Yes/No	+
Participation on Off/non-farm activity	Yes/No	-/+
Participation on Irrigation farming	Yes/No	+
Access to credit	Yes/No	+
Remittances	Yes/No	-/+
Membership to farmers cooperatives	Yes/No	+
Age of household head	Year	-/+
Farm land size	In hectare	+
Education level of household head	In year of schooling	+
Livestock holding in TLU	Number	+
Distance to nearest Market	In walking hour	-/+
Household size	Number	-
Annual gross income (farm and off-farm)	Birr	+
Crop Diversification	Indices	-/+

Source: Own Hypothesis

3. RESULTS AND DISCUSSIONS

3.1. Household Characteristics

The sample respondents composed of both male and female household heads. The majority of households in the sample are headed by males. Out of 384 sampled household heads, female and male household heads take 11.75 percent and 88.25 percent respectively. The finding also indicates that out of the total household about 96.87 percent were married. The result revealed that the average age of the sampled household heads was 44.33 years while the average family size of sample respondents was 7.06 with the minimum and maximum size of 2 and 14, respectively. The survey result shows that about 82.77 percent of household-head were uneducated. The remaining 17.23 percent attend educational level of different grade level (primary school 15.44 percent, secondary school 1.57 and university or college level 0.52 percent).

Approximately only 12.50 percent of households received credit and only 7.81 percent of households have access to irrigation farm. The average total farm income of sample respondents was 2350.2 birr with the minimum and maximum size of 0 and 17,800 birr. The average household farm land size of sample respondents was 2.99. The average livestock holdings of sample respondents were 7.48 in TLU.

3.2. Household Dietary Diversity

Almost all (99.74 percent) of respondents consumed food made from cereal food groups and about 82.03 percent of household consumed food made from white tuber and roots such as potatoes. Consumption of milk and milk products shows that more than fifty percent (62.24 percent) of households consumed milk and milk products in the previous seven days. On the other hand, only 10.16 percent and 20.05 percent of the household consumed meat and egg in previous seven days respectively. Further, very few (7.29 percent) of households consumed fruits in the previous seven days in study area.

The finding on the DDS further show that respondents were found to have consumed an average of 5.73 food groups with a standard deviation of 1.97. Moreover, the minimum DDS value is 2 and the maximum DDS value is 11. The summary of the DDS in study area is presented in table below. Further, the finding indicates that about 13.54 percent of the participants consumed low

dietary diversity (with dietary diversity score of less than 3). Those who have medium level of DD account for 50.52 percent (with scores ranging between 4 and 6 points) while 35.94 percent falls within the range of higher dietary diversity category with the score above 7 points. This implies that about 14 percent of the households do not have adequate dietary diversification while the majority (about 86 percent) is enjoying good dietary diversification. However, it should be noted that the DDS value could be reduced if sugars and beverages are to be taken out, because they do not add to the nutritional quality of the diet (Faber and Drimie, 2009).

During one of the focus group discussions organized with women farmers, the participants reported that they were unable to diversify their diet. Some of the reasons mentioned by farmers for low dietary diversity were (i) low crop varieties in home, (ii) remoteness of market, (iii) lack of transportation facilities, and (iv) lack of money to purchase different food items in the study area. The discussion also revealed that the participants would improve their dietary diversity if they had off-farm income sources and had easy market access for exchanging foods. A similar study of rural households in South Gonder Zone, Amhara Regional state, Ethiopia, showed that 21.1 percent of the households reported a low-level dietary diversity, 62.7 percent of the households reported a medium-level dietary diversity, and 16.2 percent households reported high-level dietary diversity (Nega *et al.*, 2015). The difference might be due to variations like geographical location, seasonal variability, and other socio-demographic factors.

Table 4. 2: Household Dietary diversity frequency in previous seven days (n=384)

Food group consumption in previous seven days	Number (percent)
Cereals	383 /99.74
White tuber and roots	315/82.03
Vegetables	279/72.66
Fruits	28/7.29
Meat	39/10.16
Eggs	77/20.05
Fish	00/00
Legumes, nuts and seeds	252/65.63
Milk and milk products	239/62.24
Oils and fats	50.00
Sweets	190/49.48
Spices, condiments and beverages	207/53.91
Low dietary diversity	53/13.84
Medium dietary diversity	193/50.39
High dietary diversity	137/35.77

Source: Field Survey, 2019

3.3. Determinants of Household Dietary Diversity

The following Table (Table 4.3) presents the determinants of HDD. The finding shows, marital status positively and highly significantly affected HDD ($p < 0.000$). The Poisson regression coefficient estimates indicates that, holding other variables constant in the model, being married increased HDD by 0.197 compared to unmarried. The finding is similar with previous studies (Liu *et al.*, 2014; Fahima and Muntaha, 2019) indicating married people tend to consume a greater variety of food, perhaps because responsibility for other family members leads to a wider variety of dietary items in the household.

The estimation of Poisson model indicated that education level of household head positively and significantly affected HDD. Holding other variables in the model constant, HDD is expected to be 0.191 unit higher for literate household head compared to illiterate. This is due to the fact that the education of the household head can be taken as a proxy for consumer dietary knowledge and ability to process dietary information which has a significant positive relationship with the household dietary diversity. Comparable findings from other studies noted that educated household heads has higher dietary diversity than uneducated, because of a better understanding on their health benefits (Taruvunga *et al.*, 2013; Woldehanna and Behrman 2013; Workicho *et al.*,

2016; Melaku *et al.*, 2019). The result is also consistent with studies in other contexts (Gitagia *et al.*, 2019) who reported woman's education level positively affected dietary diversity in low agricultural potential areas.

The result of the Poisson regression model analysis shows that land size has positive and significantly relation with HDD at less than ten percent significance level. Land is an important factor for diet diversity and households holding larger areas of agricultural land had higher dietary diversity. Most of the households in study area derived more than 90 percent of their incomes from agriculture, thus land is important for food production and dietary diversity. The Poisson regression estimate indicates that, given the other variables are held constant in the model, as household land holding increases by one-hectare HDD would be expected to increase by 0.023 unit. Related study by Ochieng *et al.*, (2017) in Tanzania indicates that land is highly contributing factor for household dietary diversity and households owning larger areas of agricultural land had higher dietary diversity.

Model results indicate a positive association between being a participating in an irrigation farming and dietary diversity. Moreover, irrigation is positively and significantly affected HDD at less than ten percent significance level. These findings suggest that households who participate in irrigation have a higher likelihood of attaining a high dietary diversity. The implication is that irrigation provide an opportunity for participants to grow a variety of cash and domestic horticultural crops which may directly improve their household food groups. Indirectly, cash crops from irrigation can also improve households' food purchasing power. The finding indicates that holding the other variables constant in the model, participation in irrigation farming increased household dietary diversity by 0.090 points. Similar comparable findings were suggested by Taruvinga *et al.*, (2013) indicating households who participate in irrigation have a higher likelihood of attaining a high dietary diversity.

Regarding membership to farmers cooperatives the finding indicates that membership to a farmer's cooperatives had positive relation with HDD. The Poisson regression estimate revealed that, given the other variables are held constant in the model, membership to farmers cooperatives increased HDD by 0.174 unit. This finding is supported by Nugusse *et al.*, (2013), who examined the association of cooperative and food security in northern Ethiopia. Their finding indicates that study

households with cooperative membership were food-secure, while households without cooperative membership were food-insecure. Similarly, Wossen *et al.*, (2017) studied the effects of access to extension services and membership to cooperatives on household welfare in rural Nigeria. Their finding revealed that extension access and cooperative membership had a positive relationship with household food security.

As it was hypothesized, the model result indicates that the variable distance to market had negatively and significantly affected HDD at less than one percent significance level. This negative relationship indicates that the households who lived further away from the market are less likely to consume varieties of food. The possible justification could be that the household who are closer to the market centers incur fewer costs to access market incentive for market output for home consumption. Therefore, a long distance to the nearest market reduces the probability of household consumptions if the household will rely on market for their livelihoods. The Poisson regression estimate for a distance to the nearest market indicates that, given the other variables are held constant in the model, as distance to nearest market increase by one-kilometer HDD score would be expected to decrease by 0.006 unit. This agrees with (Geremew *et al.*, 2019) who reported strong link between remoteness from markets and HDD. Better market access through reduced distance could contribute to higher dietary diversity (Sibhatu *et al.*, 2015; Hirvonen *et al.*, 2017)

The model result reveals that, TLU is significant at less than ten percent probability level and positively affected HDD in study area. Holding other variables in the model constant, the likelihood of HDD increases by 0.011 unit for households with more livestock number in TLU. The positive relationship is explained by the fact that livestock size being a proxy for farmers resource endowment, those sample respondents with large livestock size have better chance to earn more income and also consume different livestock outputs. The significances of TLU on dietary diversity could be from a direct consumption of what they own or through increased purchasing ability of the households as they generate income from owning livestock. This finding is similar with Taruvinga *et al.*, 2013; Belachew *et al.*, 2013) indicating that livestock are sources for several food groups (eggs, meat, and goat milk) that may provide micro and macronutrients and largely contributes for household nutrition.

In contrast to what we were expecting remittance significantly and negatively related with HDD at less than one percent significance level. The Poisson regression estimate indicates that for a one-

birr increase in remittance, given the other variables are held constant in the model, HDD would be expected to decrease by 0.145 unit. One convincing explanation for this finding could be because the remitted households may not use financial resources obtained to purchase nutrient dense foods that diversify household diets. Further, remitted household may use obtained income to purchase agricultural input and other services.

Table 4. 3: Determinants of HDD in study area (n=384)

Dietary Diversity Score				
	Coef.	Std. Err.	Z	P>z
Sex of household head (Gender)	-0.001	0.055	-0.010	0.988
Age of household head (Age)	0.002	0.002	1.030	0.302
Marital status (Mstatus)	0.197	0.035	5.620	0.000*
Education level of household head (Edu)	0.191	.076	2.51	0.012**
Household size (Hsize)	-0.006	.008	-0.75	0.454
Farm size (Lsize)	0.023	0.013	1.760	0.078***
Participation in irrigation farming (Iuse)	0.090	0.055	1.650	0.099***
Use of credit (Cuse)	-0.003	0.046	-0.060	0.956
Extension visit (Extenvisit)	0.046	0.055	0.840	0.400
Membership to farmers cooperatives (Coops)	0.174	0.044	3.980	0.000*
Distance to the nearest market (Market)	-0.006	0.002	-2.970	0.003*
Total net income (Nincome)	0.030	0.022	1.350	0.177
Total livestock unit (TLU)	0.011	0.004	2.700	0.007*
Remittances (Remit)	-0.145	0.049	-2.950	0.003*
Non/off-farm income (nonfarm)	0.000	0.000	0.860	0.390
Crop Diversification Index (CDI)	.018	.033	0.54	0.589
_cons	1.125	0.170	6.610	0.000

*, **, and *** indicate statistical significance at 1, 5, and 10% probability levels, respectively

Source: Field Survey 2019

4. CONCLUSION AND RECOMMENDATIONS

Household food insecurity, hunger and undernutrition remain critical issues; the poor nutritional status of smallholder farmers has been a consistent problem in Ethiopia. The study demonstrated that the diet of all of the households was composed cereals, white tuber and roots, vegetables, legumes, nuts and seeds, and spices, condiments and beverages. Consumption of milk and milk products shows that more than fifty percent (62.24 percent) of households consumed milk and milk products in the previous seven days. On the other hand, other animal source food (meat and egg) was a rare component in the household's diets. The results of the finding on the HDDS showed that respondents have consumed an average 5.73 food groups. Further, based on FAO (2013) categorization about 13.54 percent, 50.52 percent and 35.94 percent of the respondents were found to consume low, medium and high level of DD. Analysis of zero-truncated Poisson regression model also indicates that marital status, education levels of household head, farm land size, participation on irrigation farming, membership to farmers cooperatives and TLU positively influenced household dietary diversity in study area. On other hand, distance to nearest market and remittances were negatively influencing individual dietary diversity.

In the light of these findings, we recommend that the regional and federal governments should provide educational empowerment through training for households to broaden their understanding of the nutritional health benefits of a diverse diet. Local government and stakeholders in the agricultural sector should promote and encourage crop diversification strategies, expand access to irrigation, introduce agricultural technologies to boost income of rural households and thus diversify their diet. Further, market infrastructure should be improved to enhance households' access to market that could contribute for improving household dietary diversity.

Chapter Five: The contribution of Crop diversification to Nutrition Security among wheat producers in Sinana District, Bale Zone, Oromia Regional State, Ethiopia.

Abstract

The long-term impact of malnutrition on the lives of populations, particularly in the areas of health, education, and productivity, strongly affects the human capital of a country. Agriculture directly contributes to nutritional security by enabling farm families to access micronutrients through farm income. This study aimed to assess the effect of crop diversification on the nutritional security of households and explores determinants of under-five child malnutrition among rural farm households of Sinana District, Oromia regional state. Multi-stage sampling followed by a systematic random sampling technique was used to include study subjects. A structured questionnaire, focus group discussions (FGD) and key informant interviews were used to collect the data. Anthropometric measurements were collected and converted into Z-scores by the WHO Anthro software version 3.2.2., 2011. Then exported to STATA and analyzed using descriptive statistics and inferential statistics. Pearson correlation coefficients were calculated to see the correlation between the nutritional security status indicators and the crop diversification index. Bivariate and multivariate logistic regression was performed to identify factors associated with infant nutrition. The result revealed that the prevalence of malnutrition particularly, stunting was (23.81 percent), underweight (21.16 percent) and wasting (9.52 percent), respectively. The correlation coefficient indicates that crop diversification is negatively correlated with stunting and wasting and positively with underweight and children's dietary diversity score. Multivariate logistic regression model indicate that child nutritional status is strongly associated with age of household head, parental education, farm land size, livestock holding in TLU, availability of potable water, child sex, child dietary diversity, household access to toilet, total annual income, and household access to health services. In conclusion, policy and development interventions should target intensive agricultural production, development of rural infrastructure, and education and awareness tools for providing families with up-to-date nutritional knowledge and agricultural technologies to increase production and income, and thereby improve family nutritional security.

Keywords: *Nutrition security, anthropometry, stunting, wasting, logit model*

1. Introduction

Early childhood nutritional status determines the cognitive development and physical capabilities of a population that threaten the productivity of future generations (Black *et al.*, 2013; Von Braun and Tadesse, 2012; Maluccio *et al.*, 2009). Anthropometric indicators of children are usually used to assess nutrition outcome at early age of life. These indicators include height-for-age indicating a long-term nutritional status; weight-for-height that capture short term nutritional outcome; and weight-for-age which is a mixed indicator short- and long-term nutrition outcome (Kalkuhl *et al.*, 2013; Pangaribowo *et al.*, 2013; Smith *et al.*, 2005).

Children are the most visible victims of malnutrition. Chronic global malnutrition in children is widespread and remains a major challenge. The Food and Agriculture Organization of the United Nations estimates that around 805 million out of 7.3 billion people in the world, or one in nine, were affected by chronic malnutrition in 2012-2014. Almost all of the hungry, 791 million, sleep in developing countries, or 13.5 percent, or one in eight, of the developing country's population. There are 11 million undernourished people in developed countries (FAO, 2014). According to this report 214 million (23.8 percent) of all the hungry people of the world are found in sub-Saharan African countries (www.worldhunger.org).

Hunger and malnutrition are devastating problems, particularly for the poor and unprivileged countries like Ethiopia. About 29.9 percent of the total populations of Ethiopia (30.4 percent in rural and 25.7 percent in urban areas) are found to be under the poverty line. The poor nutritional status of children continues to be a serious problem in Ethiopia. According to 2019 EDHS mini report nationally, about 37 percent, 21 percent, and 7 percent of all children under 5 in Ethiopia were stunted, underweight and wasted respectively. The problem is even more serious in rural areas. For instance, the prevalence of underweight and stunting among rural children was 23 percent and 41 percent compared with only 14 percent and 26 percent among urban children, respectively. In the Oromia region, the prevalence of child malnutrition indicated that 29.1 percent was underweight with 6.6 percent severe underweight, 14.1 percent of the children are wasted (3.5 percent severe wasting) and 53.6 percent of the children are stunted with 17.1 percent severe stunting (EDHS, 2016).

The long-term impact of malnutrition on the lives of individuals and individuals, particularly in the areas of health, education, and productivity, strongly affects human capital. For example, an estimated loss of 4.7 billion US\$ (equivalent to 16.5 percent of the national GDP) was recorded in 2009 due to child undernutrition in Ethiopia (EPHI, 2013). Therefore, the government of Ethiopia has been following different approaches to scale back maternal and childhood undernutrition significantly. The “*Seqota*” Declaration (2015-2030) was recently launched with the aim of eliminating all forms of malnutrition in children under 2 years of age by 2030 (FDRE, 2016). However, this cannot be achieved unless the production pattern, socio-cultural and religious issues related with feeding practices are deeply investigated and addressed in Ethiopia.

Headey *et al.*, (2012) assessed the role of agriculture in achieving nutrition status. Agriculture directly contributes to nutritional security by enabling farm families to access micronutrients through farm income. In addition to achieving food security, income from farm might improve access to health facilities and healthy environment, which are significant ingredients to achieve nutrition security. This relationship works the other way around as well (FAO *et al.*, 2012). Nutritionally secured households perform better in their farm that increases their return from agriculture. FAO *et al.* (2012) underlined that small holder agricultural growth is the key to the undernutrition problem as it can increase employment and improve access to food especially for women smallholders. However, the agricultural growth should be “nutrition sensitive” in the sense that it should improve access to health services, drinking water and sanitation. Headey *et al.* (2012) also implied that agriculture should be viewed as one of the multiple nutrition strategies as nutrition is the result of several dimensions, including education, health and the allocation of resources within families. Bhagowalia *et al.* (2012) evaluated the association between nutrition, household income and agricultural production using the 2004/05 India Human Development Survey. They explored that the impact of income, unless it is accompanied by better access to health and sanitation facilities and education, has minimal impact on nutritional status of children measured by anthropometric indicators.

Although the problem of child malnutrition in Ethiopia has been sufficiently documented, the reasons are still poorly understood. There is also inconsistency across studies regarding the determinant factors behind child nutrition. The researcher shares the idea and the main reason behind the need to study contribution of crop diversification on nutritional status in study area is,

so far, there are not detailed studies conducted to explore contribution of crop diversification on nutritional status in study area. While most studies on nutrition of both children and adults look into the effects of nutrient consumption and food availability, few studies focus on the relationship between nutritional status and non-nutritional factors, like production patterns, educational attainment, availability of water and sanitation, etc. The objective of this study therefore is to measure the effect of crop diversification on household nutrition security and identify determinant factors influencing child malnutrition among rural farm households of Sinana Woreda Bale Zone, Oromia Regional state, Ethiopia.

2. Materials and Methods

2.1. Sinana District Setting

The study was conducted in *Sinana District* which is located in the Bale zone (Figure 1). It is bounded with *Goro* and *Ginir* in East, *Dinsho* in West, *Agarfa* and *Gasera* in North and *Goba* and *Barbare District* in the south. Astronomically Sinana District lies between 6° 55' 00'' to 7° 18' 00' North and 39° 53' 00'' to 40° 26' 00'' East.

2.2. Study Design

Cross-sectional design was employed to gather relevant and sufficient information. The study design was used quantitative and qualitative research approach to assess the effect of crop diversification on household nutrition and determinants of child malnutrition in Sinana District of Bale Zone; from May 21 to June 21, 2019.

2.3. Data sources

Both primary and secondary data were collected for this study. The primary data was collected using structured questionnaire from eligible respondents (mother or caregiver of index child) and anthropometric measurement. Whereas, secondary data were collected from available document at Bale Zone and *Sinana District Health Office*, catchment Health Center and Health post.

2.4. Sample Size Determination

To determine the children to be included in the study different methods were employed in order to get representative sample size. A multi stage sampling technique was used to select sampled households. In the first stage, one *District* was selected randomly from nine highland *District* of Bale Zone. In the second stage based on simple random sampling technique six *Kebeles* from Sinana District were selected. To obtain a representative sample size, the study employed the sample size determination formula given by Yamane (1967):

$$n = \frac{N}{1 + N(e^2)} = \frac{9768}{1 + 9768(0.05^2)} = 384$$

Where n is the sample size, N is the population size (total households in the six *kebeles* which is 9768) and e is the level of precision. Finally, based on random sampling techniques all 6-59 months of children in selected household were included in this study.

2.5. Data Collection Methods and Instruments

Quantitative data was collected using a structured questionnaire. The questionnaire was translated and contextualized to the local situation. Data on socio-demographic factors were collected by interviewing mother or caregiver of index child. Anthropometric measurement was collected. A structured questionnaire was used to collect data on the child dietary diversity. Qualitative data were collected through focus group discussions (FGDs) to complement the quantitative data so as to identify factors affecting child nutrition. FGD participants were selected purposely among selected sample households in each selected *kebele*. Seven guiding questions were asked for each session. There were 7-9 women participants in each group; a total of 105 participants in 13 groups.

2.6. Empirical Model and Data Analysis

The quantitative data collected through structured questionnaire was entered in to STATA 14.2 for analysis. To convert the anthropometric data into Z-scores of the indices WHO Anthro version 3.2.2, 2011 software was used for stunting HAZ (Height for Age Z-score), underweight WAZ (Weight for Age Z-score) and wasting WHZ (Weight for Height Z-score) and exported to STATA 14.2 for further analysis. Descriptive statistics such as frequency, percentage, mean and standard deviation was used to organize distribution of child demographic, household's demographic and socioeconomic, maternal and caring behavior and environmental characteristics. Pearson's correlation coefficients were used first to analyze the role of crop diversification on household nutrition. Bivariate and multivariate logit regression model used to estimate the determinants that influence child malnutrition in study area.

Specification of logistic model

In this study, anthropometric data was converted into weight-for-age Z-scores (WAZ), height-for-age Z-scores (HAZ) and weight-for-height Z-scores (WHZ) in relation to the (WHO, 2006) reference population. More specifically, Z-score for an individual i will be calculated using the following equation:

$$\text{Z-Score} \frac{X_i - X_r}{\delta_r} \quad (1)$$

Where X_i = an observed value for i^{th} child in a target population

X_r = a median of the reference population; and

δ_r = a standard deviation (SD) of the reference population

A Z-score of -2 standard deviation is the most commonly adopted cut-off point for all nutrition indicators. Consequently, in this study, a child with Z-scores below -2 SD in respective nutrition status indicators will be considered to be malnourished. Clearly, stunted (-2 δ HAZ), underweight (-2 δ WAZ) or wasted (-2 δ WHZ).

Thus, the probability that a child's nutritional status is normal, which is indicated through HAZ, WAZ, WHZ, can be specified using the following equation (Gujarati, 1995):

$$P(M_i=1/k) = \frac{1}{1 + e^{-(a_0 + a_1 k_i)}} \quad (2)$$

Where, k is a vector of explanatory variables influencing nutritional outcomes; e is the base of natural logarithm; a_s are regression coefficients to be estimated; and i indexes individual children below the age of five.

Data Diagnostics and Estimation Procedure

Before estimating the econometric models, assessments were made on the data to make sure that the data meets some basic statistical assumptions. In particular, the study applied Variance Inflation Factor (VIF) procedure to test the presence of multicollinearity among the explanatory variables of models. The VIF test for each explanatory variable X_i is applied based on the following formula:

Tolerance = $1 - R^2$ where R^2 is the coefficient of determination for the regression of that variable on all remaining independent variables.

$$\text{VIF}(X_i) = \frac{1}{1 - R^2}$$

Where, R^2 is the coefficient of determination when X_i is regressed on the remaining explanatory variables of the model. A VIF value greater than 10 is used as a signal for existence of severe multicollinearity (Gujarati, 1995). To minimize potential heteroscedasticity due to interdependent

observations, the standard errors of the model coefficients were estimated using robust standard errors with clustering at household level.

Definition of Variables and Working Hypothesis

In Table 5.1, we identify the main explanatory variables along with their anticipated impact on the child nutrition status. Our hypotheses on the variables have been guided by economic theory, previous empirical studies and local knowledge on the problems being studied.

Table 5. 1: Summary of Variables included to affect child nutrition status

Variables	Variables unit and measurement		
Dependent Variables			
Stunting	HAZ (Height for Age Z-score)	Binary outcome	
Underweight	WAZ (Weight for Age Z-score)	Binary outcome	
Wasting	WHZ (Weight for Height Z-score)	Binary outcome	
Explanatory Variables			
Age	Age of household head in year	Continuous	+/-
Edu	Education level in year of schooling	Continuous	+
Hsize	Size of household in number	Continuous	+
Cfiveandb	Number of children less than five year	Continuous	+
Lsize	Size of farm land in ha	Continuous	+/-
Dhealth	Distance to health center in walking minute/hour	Continuous	-
Nincome	Total income in birr	Continuous	+
TLU	Livestock holding in TLU	Continuous	-
Nonfarm	Participation on non-farm activities, yes=1, No=0	Discrete	+/-
Edu moth	Education level of mother in year of schooling	Continuous	-
Csex	Sex of child, 1 =Male, 0=Female	Discrete	+/-
Cage	Age of child in year	Continuous	+/-
Electricity	Access to electricity, Yes=1, No=0	Discrete	-
cleanW	Access to clean water, Yes=1, No=0	Discrete	-
Toilet	Access to toilet, Yes=1, No=0	Discrete	-
Morbidity	Incidence of morbidity (like diarrhea, fever and cough) Yes=1, No=0		+
Healthacc	Access to health services, Yes=1, No=0	Discrete	-
CDI	Crop diversification index	Continuous	-
CDD	Child Dietary Diversity, count of consumed food	Continuous	-

3. Result and Discussion

3.1. Households and Children Characteristics

Descriptive analysis of data regarding age of the household head shows that sample household heads' age ranged from 25 to 67 years with mean of 40.9 years. About 90.5 percent of the sample households were male-headed and the remaining (9.5 percent) were female-headed. Out of the 189 children in the sample households, 52.9 percent were male, while 47.1 percent were female. About 77.3 percent and 55.0 percent of the fathers and mothers have never attended formal education, respectively. With regard to the marital status of the sample respondents, 92.6 percent were married, 5.29 percent were widowed and the remaining (2.12 percent) were divorced. The majority of the respondents (80.3 percent) were Muslims and 15.4 percent orthodox respectively and the rest were protestant.

Clean water and toilet facilities are indicators of healthy environment which may improve child health and nutrition. Hence, according to the survey, about 38.1 percent of the sample households were using clean water/ protected water. In response to the question regarding the use of latrine, the survey result indicates that about 43.4 percent of the sample households have latrine exposure.

Table 5. 2: Household characteristics for categorical variables (n=189)

Variables		Frequency	Percent
Gender	Male	171	90.48
	Female	18	9.52
Marital status	Married	175	92.59
	Widowed	10	5.29
	Divorced	4	2.12
Child sex	Male	100	52.91
	Female	89	47.09
Religion	Muslim	151	80.32
	Orthodox	29	15.43
	Protestant	8	4.26
Potable water	Yes	72	38.10
	No	117	61.90
Toilet	Yes	82	43.39
	No	107	56.61
Electricity	Yes	49	25.93
	No	140	74.07
Access to health services	Yes	134	70.90
	No	55	29.10
Morbidity	Yes	170	89.95
	No	10	10.05

The average family size of the sample households is found to be about 7.0 persons. The mean age of children was approximately 26 months and the minimum and maximum age of the sample children is 11 and 59 months. Concerning number of children less than five year in the household the average children less than five year was 1.2 and the maximum children less than five year in the household was 3.

In the study area, livestock are used for different purposes. Cattle are used especially for milk and meat, source of income and as drought power. Equines are used for transportation; sheep and goat are also source of income. The households also obtain income from the sale of animal products such as eggs, cheese, butter, and milk. In the study areas, the average total livestock unit (TLU) of the study households was 7.4 with 4.5 standard deviation. Concerning household annual income, the average household annual income was 5208.5. The average child dietary diversity was 3.6 with minimum and maximum of 2 and 6 food group consumed respectively.

Table 5. 3: Household characteristics for continuous Variables (n=189)

Variables	Mean	SD
Age of household head	40.90	10.44
Household size	7.01	2.56
Number of children less than five yea	1.20	0.47
Education level of household head	0.49	0.94
Education level of mother	1.40	1.83
Age of children	2.14	1.00
Total annual income	5208.47	2303.57
Livestock holding in TLU	7.38	4.46
Child dietary diversity	3.62	1.05

3.2. Prevalence of Malnutrition

Better nutritional status of children reflects a healthy and a productive generation in future. In particular for preschool children, it is a critical factor for optimum growth and it should be neither inadequate nor excessive manner. It is widely believed and scientifically proved that improved nutrition and health enhance the learning ability of the children. In the long run, it leads to an increase in the strength of the labour force and thereby it contributes positively for the economic growth.

In the present study, the results for the extent of child nutrition status are presented using three common anthropometric indicators: height-for-age (HAZ), weight-for-age (WAZ), and weight-for-height (WHZ) Z-scores. The Z-scores were derived using the reference standards. As noted earlier, standard cut-off points and definitions are used for malnutrition.

A summary statistic of nutritional status of children in the study area reveals that the prevalence of stunting ($< -2\text{HAZ}$), underweight ($< -2\text{WAZ}$) and wasting. Analysis of the results shows that the level of stunting, underweight and wasting in children in study area were 23.8 percent, 21.2 percent and 9.5 percent respectively. The prevalence of stunting in study area is found to be high for female children (60.0 percent) than male children. Further, the finding indicates that prevalence of underweight and wasting in study area is found to be high for male children (57.5 percent and 66.7 percent) respectively.

Table 5. 4: Prevalence of stunting, underweight and wasting

Gender Group	Stunted	Underweight	Wasted
Male	18 (40.00)	23 (57.5)	12 (66.67)
Female	27 (60.00)	17 (42.5)	6 (33.33)
Combined	45 (23.81)	40 (21.16)	18 (9.52)

3.3. Effect of Crop Diversification on household Nutrition

This sub-section presents the relationship among the household nutrition status and crop diversification with respect to the sample households. Pearson Correlation coefficients was calculated to see the correlation of the Nutrition security status indicators (HAZ, WAZ, WHZ and DDS) and crop diversification index (CDI). Table 5. 5 gives the overview of the Pearson's correlation coefficients for the continuous variables.

Table 5. 5: Pearson Correlation coefficients for the continuous variables

	CDI	HAZ	WAZ	WHZ	CDDS
CDI	1.00				
HAZ	-0.0055	1.00			
WAZ	0.0761	-0.1984	1.00		
WHZ	-0.0175	0.0725	-0.0357	1.00	
CDDS	0.0653	-0.1266	-0.1551	-0.2167	1.00

The finding indicates that, CDI score is negatively correlated with HAZ and WHZ and positively correlated with WAZ and CDDS. As the nutrition status increases, HAZ and WHZ decreases. Negative association between CDI and HAZ and WHZ means that Crop diversification increases household nutrition security. Further higher CDI means higher crop diversification and higher CDDS scores indicate better nutrition status of the households. However, the correlations between crop diversification index and nutrition indicators were not significant and the correlation between child dietary diversity and nutrition indicators were significant at less than 0.01. Using correlation analysis, it was examined that the DDS score is negatively correlated with nutrition indicators.

3.4. Determinants of Child Nutrition

3.4.1. Univariate analysis

Multivariate logistic regression analysis was performed to identify independent predictor variables influencing child malnutrition. The calculated VIF values are all less than 10 (the cut-off point) which indicated that multicollinearity is not a serious problem. Before running the econometric model, the dependent variables were tested for interdependence. From the analysis the Breusch-Pagan test is significant, so the residuals of these three space variables are not independent of each other.

The univariate analysis (crude analysis) was conducted to find out the independent effect of each explanatory variable on the binary outcome variables. It helps to identify potential variables for the multivariate analysis. The variables associated at 10 percent level of significance were taken into account in order to not exclude potential determinants from the analysis at early stage. Binary logistic regression indicates that education level of household head, distance to health center, total annual income, mother education, and access to electricity were found statistically significant predictors of stunting in the univariate analysis. Further, age of household head, education level of household head, number of children less than five-year, farm land size, TLU, access to potable water, availability of toilet and access to health service were significantly affecting underweight in the univariate analysis. On the other hand, age of household head, household size, number of children less than five years, participation on non-farm activities, mother education, child sex, access to health services and child dietary diversity were significantly affecting wasting in the univariate analysis (Table 5.6).

Table 5. 6: Univariate logistic regression estimates for child malnutrition

Explanatory variables	Stunting (HAZ)		Underweight (WAZ)		Wasting (WHZ)	
	M.eff	Std.err	M.eff	Std.err	M.eff	St.err
Age of household head	0.002	0.030	-0.011	0.063*	-0.007	0.054**
Education of household head	0.060	0.363**	-0.056	0.524***	0.022	0.396
Household size	0.014	0.140	-0.010	0.188	0.029	0.219**
Children less than five year	-0.036	0.726	0.093	0.919***	-0.131	0.966**
Farm land size	-0.017	0.227	0.051	0.287*	0.003	0.218
Distance to health	0.006	0.038***	-0.002	0.048	-0.003	0.044
Total annual income	-0.279	0.908	0.029	0.485	0.033	0.482
TLU	0.002	0.074	-0.020	0.138**	-0.002	0.078
Participating on non/off-farm	-0.047	0.701	-0.058	0.954	-0.102	0.889***
Education of mother	-0.244	1.016*	0.016	0.212	-0.028	0.233***
Child sex	-0.048	0.568	0.001	0.740	0.105	0.769**
Child age	-0.028	0.298	0.009	0.364	0.019	0.321
Access to Electricity	-0.088	0.684***	-0.051	0.865	-0.068	0.877
Access to potable water	0.052	0.792	-0.182	1.371**	-0.079	0.956
Availability of Toilet	0.032	0.762	0.101	1.047***	0.075	0.863
Morbidity	0.181	0.093**	-0.108	0.076	0.155	0.072**
Access to health services	0.003	0.628	-0.315	1.062*	0.216	1.377**
Crop diversification index	0.084	1.125	0.020	1.348	0.002	1.266
Child dietary diversity	-0.006	0.134	-0.003	0.152	-0.022	0.181**
_cons		2.249		3.510		2.787
Number of observations	188		188		188	
Correctly predict	58.99		64.14		34.94	
Model Chi-square $\chi^2(22)$	122.06		$\chi^2(18) = 124.82$		$\chi^2(18) = 41.47$	

*, **, and *** indicate statistical significance at 1, 5, and 10% probability levels, respectively: M.eff= marginal effect, St.er= standard error

3.4.2. Multivariate logistic regression analysis

Multivariate logistic regression analysis was performed to identify independent predictor variables influencing child malnutrition. All significant explanatory variables included in the univariate analysis were analyzed in the multivariate model to find out the imperative determinants of child malnutrition (Table 5.7).

Maternal and father educational status is one of the most determinants of child nutritional status (Turyashemerwa *et al.*, 2009). This might be due to educated mothers and fathers were more aware of their children nutritional consequence than illiterate parents. Illiterate parents may be less likely to introduce new dietary practices that help improve the nutritional status of their children. This study found that maternal and father education were found to be statistically significant factor that determines stunting and wasting. The negative value shows that a child whose mother had

formal education has less probability to be stunted and wasted compared to a child whose mother did not attend formal education. The marginal effect shows other things being constant, the likelihood of child being stunted and wasted decrease by 1.6 percent and 2.2 percent respectively as education level of mother increase by one year. Likewise, the probability of the child being WAZ and WHZ decreases by 0.9 percent and 0.4 percent, respectively, as education level of household head increases by year. The fact that the mother's level of education was significant is in agreement with several studies undertaken on the same problem. For instance, studies done in Ethiopia, Bangladesh, and Nigeria (Sebanjo *et al.*, 2009, Mengistu *et al.* 2013, Dasgupta *et al.*, 2014) confirm this finding. Indeed, educated mothers are more aware of the health of their children and tend to take better care of their children. Moreover, literate mothers can easily introduce new feeding practices scientifically, which help to improve their children nutritional status (Das *et al.*, 2008).

The coefficient associated with household income is found to be negative and significant determinant of child nutrition indicator HAZ. In short, children from high-income families are less puny than low-income children, *ceteris paribus*. Specifically, the marginal effect shows that, the probability of the child to be stunted will be decreased by 18.9 percent with one-birr increase in household income. This result is consistent with other studies (Girma and Genebo, 2002; Kandala *et al.*, 2010). The study indicated that richer households had better access to food and higher cash incomes than poor households, allowing them to quality food, better access to medical care and more money to spend on essential non-food items such as school, clothing and hygiene items.

The women discussants reached consensus with the idea, "As far as money is there, it is possible to buy everything and diversify our child diet even though the market is so far."
(FGD)

The coefficient associated with farm land size, could be worth mentioning; similar to our anticipation, this variable is a negative and significant determinant of the infant nutrition indicator, WAZ. In brief, children from household with large farm land size are less underweight than those with small farm land size, *ceteris paribus*. Specifically, the probability of the child to be normal in WAZ, will decrease by 5.9 percent, with one hectare increase in cultivated farmland. Similar study by Fentaw *et al.*, (2013), and Saaka and Osman, (2013) found that land size significantly and

positively associated with improved dietary diversity and food access, which is extremely important to improve the nutritional status of children.

Multivariate logit regression model result reveals that, TLU is significant at ($p < 0.1$) probability level and influences negatively underweight. The negative relationship is explained by the fact that livestock size being a proxy for rural household resource endowment, those sample respondents with large livestock size have better chance to earn more income. Other things remain constant; the marginal effect of the model shows, having large size of livestock decrease probability of underweight by 1.0 percent. The significances of TLU on underweight could be from a direct consumption of what they own or through increased purchasing ability of the households as they generate income from owning livestock. This finding is similar with Taruvunga *et al.*, (2013), Belachew *et al.* (2013) indicating that livestock are sources for several food groups (eggs, meat, and goat milk) that may provide micro and macronutrients and largely contributes for household nutrition.

The women discussants reached consensus with the idea, “Since we usually produce crops on our farm and we can’t produce all types of foods. Men farmers interested in producing wheat only. Sometimes we rely on market for child diet. Currently it’s very difficult to get livestock output like milk, meat and others in most households. Although that is possible to get milk and butter from the market distance of market makes food exchange very difficult, especially for elders, pregnant women, and mothers with children.” (FGD)

The findings of this study indicate that incidence of morbidity (like diarrhea, fever and cough) for the last two weeks before the survey is a contributing factor to the prevalence of malnutrition. The variables (WAZ and WHZ) are found to be negative and significant (< 0.05). The marginal effect of the variable indicates that the probability of the child to become stunting and wasting will increase by 10.5 percent and 14.9 percent respectively if he/she is morbid for the last two weeks. There may be two justifications for this effect. One is bearing in mind that wasting is a picture of current or acute malnutrition, morbidity can contribute to a failure to gain weight or actual weight loss. Another can be wasting from childhood diseases are more likely because of reduced appetite, less quantity of fluids and foods offered during their sickness. It is also known that malnourished

children will have frequent diarrheal episodes and lose weight and can quickly become malnourished (CSA *et al.*, 2011). This result was consistent with finding of other studies (Ajao *et al.*, 2010, Bealu *et al.*, 2017).

Another noteworthy finding of this study is the negative and significant relationship of the availability of electricity, clean water and toilet to child nutrition status measured by HAZ and WAZ respectively. The variable Electricity negatively and significantly affected HAZ at ten percent significant level. The marginal effect value depicted that, the probability of the child to be stunted will be decreased by about 9.6 percent if there is electricity in the household. Further, availability of clean water to household negatively and significantly affected child nutrition measured by WAZ at one percent significant level. From the model result, the marginal effect reveals that the likelihoods of underweight decreased by 17.9 percent if household has access to clean water in study area. This is corroborated by a study conducted in the Amhara region, northwestern Ethiopia and rural Ethiopia (Bantamen *et al.*, 2014; Alemu, 2013). In the rural population of Ethiopia, lack of access to safe drinking water is the main environmental problem for the transmission of common diseases. Lack of access to safe drinking water and unsafe drinking water is strictly related to the incidence or episode of water-borne illnesses such as diarrhea that contribute to malnutrition. The population does not have access to drinking water) is a direct cause of malnutrition (Kandala *et al.*, 2011). This is also consistent to the study done in Tigray, Ethiopia, which revealed, using unprotected sources of water in the household of children were 2 times more likely under nutrition as compared with those who consumed protected water (Alemayehu *et al.*, 2014).

FGDs held with women's group indicated that access to potable water and electricity was the main problem in their village. Despite the fact that the majority of respondents own the latrines, however, there was a problem with use. Bringing bad smell and, as a result, compelled members of households to excrete in unsafe places. A key informant interview held with the head of the District's health office also confirmed the scarcity of the use of latrines due to the scarcity of water that can be used for cleaning.

Among other important economic variables, access to health services is also found to be significant determinant of the child nutrition status. As expected, the coefficient of the variable is found to be

negative and statistically significant for underweight. In other words, a child in households who have better access to health services is relatively more wasted than a child in a household with no access to health services, *ceteris paribus*. The marginal effect of the variable indicates that the probability of the child to be underweighted will be decreased by about 54.5 percent if household have access to health services.

Sex of the children is important demographic variable. Male children were more likely to be wasted than girls. From the model result, the marginal effect reveals that the likelihoods of wasting increase by 8.0 percent, for male children comparing with their female counter parts. This study is consistent with the other similar study in Ethiopia; Amhara and Tigray regions (Teshome *et al.*, 2009; Alemayehu *et al.*, 2013) and Inconsistence with study in Oromia Region (Mengistu *et al.*, 2012). This discrepancy might be due to cultural and Environmental similarity and deference. The cause of this discrepancy in sex is not well established in the literature, but it might be due to boy were more exposed or influenced by environmental circumstance than girls.

The coefficient of child dietary diversity is significant at 10 and 5 percent and shows a negative and positive impact on child stunting and wasting respectively. The negative influence implies that child with higher child dietary diversity are less malnutrition than low dietary diversity. Marginal effect indicates that, holding other variables in the model constant, the probability of the child to be stunted will be decreased by about 2.2 percent as food group consumed by children increased by one. In contrast to priori hypothesis the coefficients of wasting are positive indicating that children with higher child dietary wasted than child with lower child dietary diversity, *ceteris paribus*. In particular, the marginal effect shows that, the probability of the child to be wasted, will increase by 1.9 percent, as food group consumed by children increased by one. These findings advance support to findings of previous studies (Taruvinga *et al.*, 2013; M’Kaibi *et al.*, 2016).

Table 5. 7: Multivariate logistic regression estimates for child malnutrition

Explanatory variables	Stunting (HAZ)		Underweight (WAZ)		Wasting (WHZ)	
	M.eff	Std.err	M.eff	St.er	M.eff	St.err
Age of household head	0.005	0.003***	-0.009	0.002*	-0.004	0.002***
Education of household head	0.055	0.032***	-0.021	0.026	0.026	0.025
Household size	0.014	0.014	-0.010	0.011	0.015	0.011
Children less than five year	-0.026	0.065	0.087	0.053	-0.083	0.051
Farm land size	-0.013	0.019	0.059	0.016*	0.008	0.015
Distance to health	0.006	0.004	-0.001	0.003	-0.001	0.003
Total annual income	-0.189	0.039*	-0.012	0.031	0.020	0.030
TLU	0.002	0.007	-0.010	0.006***	0.000	0.005
Participating on non/off-farm	0.014	0.062	-0.059	0.051	-0.077	0.049
Education of mother	-0.078	0.016*	0.021	0.013	-0.022	0.012***
Child sex	-0.060	0.056	-0.016	0.046	0.080	0.044***
Access to Electricity	-0.057	0.066	-0.096	0.054***	-0.012	0.052
Access to potable water	0.119	0.081	-0.179	0.066*	-0.132	0.064**
Availability of Toilet	0.007	0.075	0.155	0.061**	0.134	0.059**
Morbidity	-0.179	0.091**	0.105	0.075	-0.149	0.713**
Access to health services	0.082	0.060	-0.545	0.049*	0.129	0.047*
Child dietary diversity	-0.022	0.012***	0.008	0.010	0.019	0.009**
_cons		0.200		0.163		0.156

*, **, and *** indicate statistical significance at 1, 5, and 10% probability levels, respectively:
M.eff= marginal effect, St.er= standard error

4. Conclusions and Recommendations

In this study, we mainly investigated the relationship between crop diversification and nutrition security in sinana District using cross-sectional survey collected in 2019. In addition, we analyzed the determinants of child malnutrition level using bivariate and multivariate estimation techniques.

The study demonstrated that crop diversification enhances household nutrition security. Analysis of the results shows that the level of stunting, underweight and wasting of children in study area were 23.8 percent, 21.2 percent and 9.5 percent respectively. The prevalence of stunting in study area is found to be high for female children (60.0 percent) than male children.

The bivariate analysis indicates that child stunting was affected by education level of household head, distance to health center, total annual income, mother education, and access to electricity. Further, age of household head, education level of household head, number of children less than five-year, farm land size, TLU, access to potable water, availability of toilet and access to health service were significantly affecting underweight in the bivariate analysis. It is also indicated that age of household head, household size, number of children less than five years, participation on non/off-farm activities, mother education, child sex, access to health services and child dietary diversity were significantly affecting wasting in the bivariate analysis. On the other hand, multivariate analysis revealed that various intermediate factors like age of household head, education level of household head and mother, farm land size, total annual income, TLU, sex of children, access to electricity, potable water, toilet, health services, morbidity prior to data collections, and child dietary diversity were found to influence household nutrition security.

Based on the findings of the study, we recommend that the regional and federal governments should provide access to education for households to broaden their understanding of the nutritional health benefits of a diverse diet and Sinana Agricultural and Natural Resources Office and stakeholders in the agricultural sector should promote and encourage availability of intensive agricultural practices, introduce agricultural technologies to boost income of rural households and thus diversify their diet.

Sticking to the findings of this study, access to health services which implies the contribution made by income was found significant and substantial in achieving nutrition security. This implies that

efforts have to be made to improve income from crops production and non/off-farm activities to ensure nutrition security through promotion of input use and marketing facilities. Further, Market and health infrastructure should be improved to enhance households' access to market and health that could contribute for improving household nutrition.

Livestock sub sector plays a great role in the struggle to eliminate child malnutrition. Its contribution to the child dietary diversity is significant. Hence, necessary effort should be made to improve the production and productivity of the sector. This can be done through the supply of adequate veterinary services, improved water system points, introduction of timely and effective artificial insemination services to up-grade the already existing breeds, launching sustainable and effective forage development program, provision of coaching for the livestock holders on the way to improve their production and productivity and improving the marketing conditions.

Chapter Six: Conclusions and Recommendations

6.1. Re-capping the purpose of the study

Agricultural production in the country is mainly rain-fed. Having low access to government and market-based risk management options, rural farm households consider diversification activities and risk sharing as risk management strategies. Crop 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 unfavorable weather shocks and uncondusive policy. Considering the government's aspiration towards alleviating food insecurity and transformation objectives, analysis of crop diversification and the consequences on household food and nutrition is important. The aim of the study is, hence, to examine crop diversification and its effect on household food and nutrition security using cross-sectional data collected from high potential wheat 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. HFIAS and HDD, and anthropometric measurement were used to measure household food and nutrition security respectively. A Cragg's double hurdle model was applied to identify factors influencing the extent of crop diversification. The effects of crop diversification on household food security were examined using OLS regression model while multinomial regression model used to analyze determinants of household food security. Zero-truncated Poisson regression model was used to measure the determinants of HDD. Finally, Pearson Correlation coefficients was calculated to see the correlation of the nutrition security status indicators and CDI, while Bivariate and multivariate logit regression model used to estimate the determinants that influence child malnutrition in study area.

6.2. Conclusions

The purpose of this chapter is to summarize the results of the research from across the papers in this dissertation and demonstrate the overall contribution of the research in light of the aims and research questions presented in the foregoing section. This study adopts a pragmatism methodological approach to study Crop diversification, Food and Nutrition security by applying multiple methods of data collection and analysis.

This thesis comprises four stand-alone papers (all empirical papers).

The first empirical paper in Chapter two analysis crop diversification among wheat dominant producer rural households in the *Sinana District*, Bale Zone, Oromia Regional state, Ethiopia. It discusses the most important factors influencing crop diversification and intensities of crop diversification among wheat dominant producer rural households in Sinana District. Despite technological availability, crop farming still presents a tremendous risk enterprise due to reliance on the rain-fed production system, and inadequate market amongst smallholder farmers. In this study factors such as income, market, and labor supply would affect crop diversification (paper I). The influencing factors that were affecting crop diversification decisions identified by our model include age of household head, household size, plots fertility, extension services, and participation in off/non-farm activities impacted probability of crop diversification in the *Sinana District*. Age of household head and participation in off/non-farm activities negatively impacted probability of crop diversification while household size, plots fertility, and extension services positively affected probability of crop diversification. The results further revealed that labor availability, distance to nearest market, total annual income, and membership to farmers cooperatives, access to fertile plot, distance to farm plot and TLU significantly affected extent of crop diversification in the study area. The existence of homogeneous production pattern followed by the farmers in the District cannot be denied. The research also revealed that households continue to place priority on cereal farming. This further creates a perception that cereal farming is the best way to guarantee increased household food and nutrition security.

Chapter three of the thesis presents the second empirical paper. As part of its aim, this paper identifies contribution of crop diversification in improving household food security in the *Sinana District*. It investigates the contributions of crop diversification in improving household food

security using OLS methods. The finding indicates that only 7.3 percent of the respondent's food secure i.e., such households never experience or worried about any form of the food insecurity conditions. About 8.1 percent of the respondents were severely food insecure while about 50.0 percent and 34.6 percent of the respondents were mildly food insecure and moderately food insecure respectively. An assessment of the contribution of crop diversification on food security revealed that whilst crop diversification has the potential to contribute towards food security, various compounding factors need to be taken into account. Our model indicates a positive relationship between crop diversification and food security. Which implies that crop diversification contributes significantly in improving food security situations in the Sinana District. The result of the multinomial logit analysis identified that household food security were affected by age and education level of household heads, marital status, access to credit and irrigation farming, distance to nearest market, livestock holding in TLU and household income and access to agriculture information.

The third empirical paper in chapter four identifies determinants of household dietary diversity among wheat dominant producer rural households in *Sinana District*. The paper estimated the determinants of household dietary diversity in the *Sinana District*. About 13.6 percent of the respondents were found to consume less dietary diversity, implying they are more food insecure due to lack of the means to acquire and consume a variety of foods. Those who have medium level of DD account for 50.5 percent, and about 36.0 percent of the respondents have $DDS \geq 8$ that they were food secure. The study found marital status, education level of household head, land size, participating in an irrigation farming, membership to farmers cooperatives, distance to market, livestock holding in TLU, and remittance impacted household dietary diversity in Sinana district. With reference to dietary diversity status of households in the *Sinana District*, the paper suggests a low-quality diet mainly defined by starchy staples at the expense of protein sources (meats and dairy products).

Chapter five of the thesis presents the fourth empirical paper. As part of its aim, this paper identifies contribution of crop diversification to household nutrition security. It also identifies determinant factors influencing child malnutrition among rural farm households of *Sinana District*, Bale Zone, Oromia Regional state, Ethiopia. It investigates the contributions of crop diversification to household nutrition security using Pearson Correlation coefficients. The finding indicates that

crop diversification is negatively correlated with HAZ and WHZ and positively correlated with WAZ and CDDS. Binary logistic regression indicates that education level of household head, distance to health center, total annual income, mother education, and access to electricity significantly affected stunting in the bivariate analysis. Further, age of household head, education level of household head, number of children less than five-year, farm land size, TLU, access to potable water, availability of toilet and access to health service were significantly affected underweight in the bivariate analysis. The finding also indicates that age of household head, household size, number of children less than five years, participation on non-farm activities, mother education, child sex, access to health services and child dietary diversity were significantly affected wasting in the bivariate analysis.

6.3. Synthesis and Recommendations

6.3.1 Synthesis

Crop Diversifications

Yield stability is one of the most fundamental components targeted by most rural farm households in Ethiopia. The research questioned the determining factors for crop diversification (Paper I). Majority of farm households depend on seasonal yields for food and economic returns. Thus, the implications of yield fluctuation can be very profound since it means less food is available for the family and a lower income for other basic needs. Investment in crop diversification will help cushion farm households from food insecurity due to the likely general increase in yields, as reported by several previous studies (such as Cowger & Weisz, 2008), and bring yield stability and insurance effect (Yachi & Loreau, 1999), since if one crop fails they can still depend on the other crop. In a review of 100 studies of intraspecific mixtures of crops (mainly cereals and legumes), (Smithson etLenné, 1996) concluded that yields were often slightly higher compared to pure stands of component cultivars. Crop diversification depends on household characteristics, access to fertile farm plots, participation in off/non-farm activities and access to extension services, labor availability, membership to farmers cooperatives, and distance to market. In this study (Paper I) it can be synthesized that cereal farming households asserted that they hope with the incomes from cereal they can procure pulses and other food items. However, one critical factor which needs further reflection relates to the over exploitation of the environment to support preserving cereal

farming and access to market in such a remote area. Mitigation of this risk requires the improvement of market and other infrastructure among other strategies to enhance crop diversification. Infrastructure is widely acknowledged to be crucial for poverty alleviation (Antle 1983); basic water and sanitation infrastructure are essential for improving health, schools are required for improving education, and transport for trade, and so forth. In the case of agriculture, much research has been done to identify what kind of infrastructure. There is further evidence that improved road connectivity positively affects agricultural productivity and income levels by reducing travel time and transaction costs (Arndt *et al.*, 2012; Dorosh *et al.*, 2012; Stifel and Minten 2008). Our results also show that households with larger farms are more likely to adopt wheat cultivation. This is consistent with the theory; wealthier households are less vulnerable to crop and price risk (or less risk averse in general), and therefore more likely to take on a cash crop (Ullah *et al.*, 2016).

Crop Diversification and Food Security

Households with high level of crop diversity are more food secure than households with low levels of crop diversity. The research questioned the roles of crop diversification to achieve food security (Paper II). The households that engage in multiple cropping are diversifying the possible risk of a particular crop failure in a season. Households that cultivate multiple crops are better assured of food availability and access than household who practice mono cropping. For instance, in a season where one particular crop fails to give much yield, other crops may be better off on which farmers may rely on for survival. Multiple crop farmers may even produce cash crops with food crops whereby the cash crops can be used to acquire revenue for the household to cater for other food needs that cannot be gotten from own farm and can also cater for other non-food needs of the household.

The combination of various crops in agro ecosystems not only permits more efficient utilization of agro ecological processes, but also provides diversity for human diet or improves household income, allowing purchase of alternative food. Thus diversification of production and consumption habits to include a broader range of plant species they can contribute significantly to improving health and nutrition, livelihoods, household food security and ecological sustainability. Having direct access to a wider variety of food through direct production is definitely beneficial to rural households, which cannot always rely on trade and markets. A positive correlation between crop

diversification and dietary diversity in Malawi was found by Snapp and Fisher (2015). These authors estimated that one unit increase in the average number of intercrops per maize farm was associated to 2 percent increase in the Household Dietary Diversity Score and that increasing the number of non-maize crops grown on a farm by one was associated to 1 percent increase in the Food Consumption Score. Makate *et al.*, (2016) also found a significant positive impact of crop diversification on cereal crop productivity, on the food security, and nutritional indicators (food consumption score and household dietary diversity score) in Zimbabwe. In Nicaragua, Bacone *et al.*, (2014) confirmed the importance of mixing corn and beans, which Mesoamerican farmers have managed in their farming systems. Emanu *et al.*, (2015) observed that in the Humid Tropics of Ethiopia, more than 65 percent of all major vegetables produced during the study years have been sold in the market and that most families who produce vegetables for the market also consume some at home. They also observed that vegetables provided substantial cash income that enabled the farming community to access food and contributed substantially to food and nutrition security by complementing staple foods with vitamins and minerals.

Crop Diversification and Nutrition Security

It is possible to synthesize the results to bring out some central elements to help understand and act against child malnutrition. Crop diversification has been found to have a positive and statistically significant impact on food safety and nutritional indicators. This implies that in addition to improving productivity, increasing production and increasing income stability, crop diversification also has a direct effect on food availability and nutrition. This is mainly due to the fact that crop diversification will improve yields, bring stability of crop yield and that too crop insurance effect (Njeru, 2013), if one crop fails the farmer can depend on the other crop. This will have a direct impact on food security and nutrition in rural farm households since traditionally the main goal will be to support the family and sell the surplus when possible. According to Njeru (2013), crop diversification not only allows more efficient use of agro-ecological processes, but also provides diversity for human consumption and improve income, which improves the purchasing power of the family to purchase other foods.

In addition, the analysis showed that a more educated mother understands more clearly the lessons related to nutrition security. This could be the goal of good public policy action. It would involve strengthening policies aimed at improving the household education through training and informal

education. Second, we observed that household income influenced the nutritional state of children and that rural families do not have sufficient resources to adequately cover a child's nutritional needs. Policymakers should formulate policies to support rural families. For example, an aid which aims to increase the resources within a family. Third, make health care increasingly accessible to families in order to significantly reduce child malnutrition by, for example, expanding and improving the coverage of rural infrastructure (health posts, market, potable water, vaccination of infants).

6.3.2 Recommendations

The conclusions above indicate that some policy implications are cross-cutting while the rest are specific to topics of the examination. From policy perspectives, the findings suggest that policies that target achieving food and nutritional gains should focus on promoting crop diversification to improve the quality and variety of the products from own production. These needs supporting farmers through alleviating resource constraints and providing access to reliable price information and inputs. Integrating diversification strategies into the extension system of the country could also help promote diverse production systems that feature cereals, cash crops, and legumes. The results further suggest that policies that target crop diversification as a nutrition enhancing strategy need to take into account the economic and agroecological conditions that mediate the nutrition impacts of crop diversification.

In an effort to control food insecurity among rural households, is multiple cropping by smallholder farmers should be encouraged and modernized to take the fullest advantage that comes with the practice. Special program can be made as part of the current planting for food and jobs or any other farmers' intervention program to give more attention to smallholder farmers to boost crop diversification practices, be it education support, subsidy or new technologies on multiple crop management among others. This can bring on board more efficiency among multiple crop farmers in their diversification practices so as to enhance food availability.

As market infrastructure is seen to be important factor the government should consider bringing trading markets closer to the farmers given the fact that distance to the market is an indicator of market access, organized trade and proximity to economic resources. Much as the farmers farther away from markets are able to diversify for food and nutrition security. Farmers need increased

financial resources (cash) to send their children to school, to buy inputs and so on. Therefore, if markets are brought closer, then farmers will diversify for commercial purposes as well.

Considering the fact that a larger number of households kept livestock as a tradition, increasing the number of livestock kept as a means of boosting income should be prioritized. To this end, provision of support towards training and animal husbandry and pastureland development may enhance the livestock production and productivity and hence increase food and nutrition security.

Any effort to improve the long-term food and nutrition security of families must be focused on the development of irrigated agriculture as one of the determinants of food security. Precisely to say that irrigated agriculture greatly increases the state of food and nutritional security of families. Therefore, to increase food and nutrition security, measures should be introduced to improve irrigated agriculture.

The level of education of families has contributed to the state of food security. Therefore, any intervention aimed at supporting rural families by governmental and non-governmental entities should focus on capacity building through informal/alternative basic education and training. Informal education and training could create opportunities to acquire knowledge about the production and consumption of nutritious foods and to share experiences among farmers. Therefore, empowering farmers through adequate training and informal education has the potential to improve the food security conditions of families.

If we stick to the results of this study, access to health services implies contribution made by income was found significant and substantial in achieving nutrition security. This implies that efforts have to be made to improve income from crops production and non/off-farm activities to ensure nutrition security through promotion of input use and marketing facilities.

6.4. Suggested Future Research Area

The study was carried out in Oromia National Regional State, one District of Bale zone. Since crop diversification, food and nutrition security are influenced by demographic, environmental, and economic factors, the finding of the research may not fully represent farmers in different area.

This study has some limitations. Future research should focus 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.

Although efforts were made to ensure representativeness of eligible households in the study area, no attempt was made to address seasonal variation which can affect food availability that can in turn influence food and nutrition security. Moreover, there is difficulty to measure food compositions and dishes due to diverse cultures and different ways of traditional food preparations. For example, Daabboo (local name) is a food mostly consumed by the study participants. Daabboo can be prepared by composing different cereals which is differently composed in each household based on their economic ability to buy the different cereals.

Given the possibly high opportunity cost of crop diversification, further research is required to compare the nutrition impacts of crop diversification with other agricultural policies and interventions. This would help to identify complementary strategies that would improve the contribution of crop diversification to human nutrition.

References

- Abdulhalik Workicho, Tefera Belachew, Garumma Tolu, Beyene Wondafrash, Lachat C., Verstraeten, R., & Kolsteren, P. (2016). Household dietary diversity and animal source food consumption in Ethiopia: evidence from the 2011 welfare monitoring survey. *BMC Public Health*. 16:1192
- Abebe Dessie, Tadie Abate, Taye Mekie & Yigrem Liyew (2019). Crop diversification analysis on red pepper dominated smallholder farming system: evidence from northwest Ethiopia *Ecological Processes*. 8:50 <https://doi.org/10.1186/s13717-019-0203-7>
- Abera Demeke, Alwin Keil, & Zeller, M. (2011). Using panel data to estimate the effect of rainfall shocks on smallholder's food security and vulnerability in rural Ethiopia. *Clim. Chang*, 108, 185–206.
- Acharya, S. P., Basavaraja, L. B., Kunnal, S. B., Mahajanashetti, & Bhat, A. R. (2011). Crop Diversification in Karnataka: An Economic Analysis. *Agricultural Economics Research Review*, (24), 351-357.
- Achenef Motbainor, Alemayehu Worku, and Abera Kumie (2016). Level and determinants of food insecurity in East and West Gojjam zones of Amhara Region, Ethiopia: a community based comparative cross-sectional study. *BMC Public Health*. 2016. 16:503 DOI 10.1186/s12889-016-3186-7
- AfDB, OECD, UNDP. (2016). African Economic Outlook 2016: Sustainable Cities and Structural Transformation. <https://www.afdb.org/fileadmin/>
- Aidoo, R., Mensah, J. O, Tuffour, T. (2013). *Determinants of household food security in the Sekyere Afram plains district in Ghana*. Dept of Agricultural Economics, agri-business and extensions, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana
- Alderman, H., Hoogeveen, H., & Rossi, M. (2006). "Reducing child malnutrition in Tanzania: Combined effects of income growth and program interventions," *Economics and Human Biology*, Elsevier, 4(1), 1-23.
- Alpizar, C. (2007). *Risk coping strategies and rural household production efficiency: quasi experimental evidence from El Salvador*. (Electronic Thesis or Dissertation). Retrieved from <https://etd.ohiolink.edu/>
- Ame, Ch., Aung, T. & Stijn, S. (2016). Assessment of Household Food Security through Crop Diversification in Natmawk Township, Magway Region, Myanmar. Conference on International Research on Food Security, Natural Resource Management and Rural Development organised by the University of Natural Resources and Life Sciences (BOKU Vienna), Austria (September 18-21, 2016)

- Annet, A. (2016). Putting gender at the heart of Africa RISING research in the Ethiopian Highlands. *Transforming African agriculture through sustainable intensification. Research in Brief.*
- Antle, J. (1983). Infrastructure and Aggregate Agricultural Productivity: International Evidence. *Economic Development and Cultural Change*. 31(3): 609-619.
- Arimond, M., & Ruel, M. (2002). "Summary indicators for infant and child feeding practices: An example from the Ethiopia Demographic and Health Survey 2000", Food Consumption and Nutrition Division Discussion Paper, Washington, D.C.: International Food Policy Research Institute.
- Arndt, C., Chinowsky, P., Strzepek, K., & Thurlow, J. (2012). Climate Change, Growth and Infrastructure Investment: The Case of Mozambique. *Review of Development Economics*, 16(3), 463-475.
- Asante, B. O., Rene, A. V., George, B., & Lan, P., (2017). Determinants of farm diversification in integrated crop-livestock farming systems in Ghana. *Renewable Agriculture and Food Systems*, 33(2), 131.
- Ashfaq, M, S. Hassan, M. Z., Naseer, I. A. Baig, J. & Asma, J. (2008). Factors affecting farm diversification in rice-wheat. *Pak. J. Agri. Sci.*, 45(3): 91-94.
- Ayele Gelan, (2006). Cash or food aid? A general equilibrium analysis for Ethiopia. *Dev Policy Rev.*, 24(5):601–624
- Baba, A. R., & Abdulai, A. M., (2020). Determinants of Crop Diversification and Its Effects on Household Food Security in Northern Ghana. *Journal of Economic Theory and Practice*. DOI: 10.1177/0976747920936818
- Babatunde, R. O., & Qaim, M. (2010). Impact of off-farm income on food security and nutrition in Nigeria. *Food Policy*, 35(4), 303-311.
- Ballard, T. J., Kepple, A.W. & Cafiero, C. (2013). The food insecurity experience scale: development of a global standard for monitoring hunger worldwide. Technical Paper. Rome, FAO. (Available at <http://www.fao.org/economic/ess/ess-fs/voices/en/>).
- Bantamen, G., Belaynew, W., & Dube, J. (2014). Assessment of factors associated with malnutrition among under-five years age children at Machakel Woreda, Northwest Ethiopia: A case control study. *Nutr Food Sci* 2014; 4:1. Doi: 10.4172/2155-9600.1000256
- Barrett, B. C., & Maxwell, D, G. (2005). Food aid after fifty years-recasting its role. Routledge, London
- Barretta, C.B. Reardon, T. & Webb, P. (2001). Nonfarm income diversification and household livelihood strategies in rural Africa: concepts, dynamics, and policy implications. *Food Policy*, 26 (4) 315–331

- Basantaray, A. K., & Nancharaiah, G. (2017). Relationship between Crop Diversification and Farm. *Agricultural Economics Research Review*, 30, 45–58. <http://doi.org/10.5958/09740279.2017.00021.0>
- Basher, C. B., Reardon, T., & Webb, P. (2010). Nonfarm income diversification and household livelihood strategies in rural Africa: concepts, dynamics, and policy implications. *Food Policy*, 26(4), 315-331
- Baumgärtner, S., Quaas, M. F., (2008). Managing increasing environmental risks through agrobiodiversity and agri-environmental policies. Working paper series in economics 2008, University of Luneburg.
- Baye Birhan (2010). *Determinants of Nutrition and Health Status of Children in Ethiopia: A Multivariate Multilevel Linear Regression Analysis*. Addis Ababa University
- Bealu Betebo, Tekle Ejajo, Fissahaye Alemseged, & Desalegn Massa (2017). Household Food Insecurity and Its Association with Nutritional Status of Children 6–59 Months of Age in East Badawacho District, South Ethiopia. *Journal of Environmental and Public Health*, Article ID 6373595, 17 pages <https://doi.org/10.1155/2017/6373595>
- Becquey, E., Martin-Prevel, Y., Traissac, P., Dembélé, B., Bambara, A., & Delpeuch, F. (2010). The household food insecurity access scale and an index-member dietary diversity score contribute valid and complementary information on household food insecurity in an urban West-African setting. *J Nutr.*, 140(12):2233–40.
- Beka Teshome, Kogi-Makau, W., Zewditu Getahun, & Girum Taye (2009). Magnitude and determinants of stunting in children underfive years of age in food surplus region of Ethiopia: The case of West Gojam Zone. *Ethiop J Health Dev.* 23: 98-106.
- Belfield, S. & Brown, C. (2008). *Field Crop Manual: Wheat A Guide to Upland Production in Cambodia*, 1st Edition. 2008. Department of Primary Industries, State of New South Wales.
- Bellemare, M.F.; Barrett, C.B. (2006). An ordered Tobit model of market participation: Evidence from Kenya and Ethiopia. *Am. J. Agric. Econ.*, 88, 324–337.
- Benin, S., Smale B., M., Pender, J., Gebremedin Berhanu & Ehui, M. S. (2004). Determinants of cereal crop diversity on farms in the Ethiopian highlands. *Journal of Agricultural Economics*, 31(2-3): 197-208.
- Berry, E.M., Dernini, S., Burlingame, B., Meybeck, A., & Conforti, P. (2015) Food security and sustainability: Can one exist without the other? *Public Health Nutr*, 18, 2293–2302.
- Bhagowalia, P., Kadiyala, S., & Headey, D. (2012). Agriculture, income and nutrition linkages in India: Insights from a nationally representative survey. Technical Report. The International Food Policy Research Institute, Washington DC. <https://researchonline.lshtm.ac.uk/id/eprint/1440436>

- Bhat, C. R. (2003). Random utility-based discrete models for travel demand analysis. 2003. In: Goulias KG (ed) Transportation systems planning: methods and applications. CRC Press, Boca Raton, pp 10–30
- Birara Endalew, Mequanent Muche, Samuel Tadesse (2015). Assessment of food security in Ethiopia: A review. *Asian J. Agric. Sci.*, 9(2015):55–68.
- Black, R. E., Alderman, H., Bhutta, Z. A., Gillespie, S., Haddad, L., Horton, S., Lartey, A., Mannar, V., Ruel, M., Victora, C. G., Walker, S.P., & Webb, P. (2013). Maternal and child nutrition: building momentum for impact. *The Lancet*, 382(9890), 372-375.
- Block, S. & Timmer, P. (1994). Agriculture and economic growth: conceptual issues and the Kenyan experience. Development Discussion Paper No. 498. Cambridge, MA, USA.
- BOFED (Bureau of Finance and Economic Development). (2009) Physical and Socio-Economic Profile of Oromiya. The National Regional Government of Oromiya. Development-Regional Data and Information Core Process. Addis Ababa, Ethiopia.
- Bonham, C. A., Gotor, E., Beniwal, B. R., Canto, G. B., Ehsan, M. D., Mathur, P. (2012). The patterns of use and determinants of crop diversity by pearl millet (*Pennisetum glaucum* (L.) R. Br.) farmers in Rajasthan. *Ind J Plant Genet Resour*, 25(1):85–96
- Burke, W.J. (2009). Fitting and interpreting Cragg's Tobit alternative using Stata. *Stata J.*, 9, 584–592.
- BZADO (Bale Zone Agricultural Development Office). Annual Report 2017. Bale Zone Agricultural Development Office (Unpublished). Bale-Robe, Ethiopia.
- BZSP (Bale Zone Socio-Economic Profile) 2011. Bale-Zone Culture and Tourism office.
- BZSP (Bale Zone Socio-Economic Profile) 2015. Bale-Zone Agriculture and Natural Resource Office.
- Cameron, A. C & Trivedi, P. K. (1998). Regression Analysis of Counts Data. Cambridge University Press.
- Carletto, C., Zezza, A., Banerjee, R. (2013). Towards better measurement of household food security: harmonizing indicators and the role of household surveys. *Glob Food Secur*, 2(2013):30–40. <https://doi.org/10.1016/j.gfs.2012.11.006>.
- Caviglia, J. & Sills, E. (2005). Land use and income diversification: Comparing traditional and colonist populations in the Brazilian Amazon. *Agricultural Economics*, 32(3):221 – 237; DOI: 10.1111/j.1574-0862.2005.00238.x
- Clark, D. (2004). Sustainable Maize Production-Crop Rotation. Foundation for Arable Research (New Zealand).

- Clements, R., Haggan, J., Quezada, A., & Torres, J. (2011). *Technologies for climate change adaptation: Agricultural sector*. https://backend.orbit.dtu.dk/ws/portalfiles/portal/5706575/Technologies_for_Climate_Change_Adaptation_Agriculture_sector.pdf
- Coates, J., Swindale, A., & Bilinsky, P. (2007). Household Food Insecurity Access Scale (HFIAS) for measurement of food access: indicator guide. Washington, DC: Food and Nutrition Technical Assistance Project, Academy for Educational Development.
- Conley, G. & Udry, C. (2010). Learning About a New Technology: Pineapple in Ghana. *The American Economic Review*, 100(1), 35-69. <http://dx.doi.org/10.1257/aer.100.1.35>
- Cordero-Ahiman, O. V, Santellano-Estrada, E., & Garrido, A. (2017). Dietary diversity in rural households: The case of indigenous communities in Sierra Tarahumara, Mexico. *Journal of Food and Nutrition Research*, 5(2), 86–94.
- Cragg, J.G. (1971). Some statistical models for limited dependent variables with application to the demand for durable goods. *Econometrica*, 39, 829–844.
- Creswell, J. W., & Plano, V. L. (2011). *Designing and conducting mixed methods research* (2nd ed.). 2011. Thousand Oaks, CA: Sage.
- CSA (Central Statistical Authority) (2015). Ethiopia Socioeconomic Survey (ESS) wave two (2013/2014): Basic information document. Addis Ababa, CSA. <https://dhsprogram.com/pubs/pdf/FR328/FR328.pdf>
- CSA (Central Statistical Authority). (2014). Agricultural sample survey 2013/2014 (2006 E.C.): Volume IV – Report on land utilization (Private peasant holdings Meher season). 2014c. Statistical Bulletin number 446. Central Statistical Agency, Addis Ababa, Ethiopia.
- CSA (Central Statistical Authority). (2016). Ethiopia Demographic and Health Survey. 2016. Addis Ababa, Ethiopia. <https://dhsprogram.com/pubs/pdf/FR328/FR328.pdf>
- Das, S., Hossain, M. Z., & Islam, M. A. (2008). Predictors of Child Chronic Malnutrition in Bangladesh. *Proc.Pakistan Acad. Sci.*, 45(3): 137-155.
- Dasgupta, A. Parthasarathi, R. Ram P. V., Biswas, R. & Geethanjali, A. (2014). Assessment of under nutrition with composite index of anthropometric failure (CIAF) among under-five children in a rural area of west Bengal. *Indian Journal of Community Health*, 26(2):132–138.
- Davis, B., Di Giuseppe, S., & Zezza, A. (2014). Income diversification patterns in rural Sub-Saharan Africa: reassessing the evidence. World Bank Policy Research Working Paper No. 7108. Washington DC: World Bank.
- Davis, T., Schirmer, J., & Isabelle, A., (1987). Sustainability issues in agricultural development, Proceedings of seventh Agriculture Sector Symposium. World Bank, Washington DC.

- De Cock, N., D'Haese, M., Vink, N., Van Rooyen, C. J., Staelens, L., & Schönfeldt, H. C. (2013). Food security in rural areas of Limpopo province, South Africa. *Food Security*, 5(2):269–82.
- De Janvry, A., Fafchamps, M. & Sadoulet, E. (1991). Peasant household behavior with missing markets: some paradoxes explained. *Economic Journal*, 101(409):1400-1417.
- Degefa Tolossa (1996). *Belg Crop Production as a Strategy of Households' Food Security: A Comparative Study of Belg Grower and Non Belg Grower Farmers in Munessa woreda, Arssi Region*. M.A Thesis. Addis Ababa University, Addis Ababa.
- Degefa Tolossa (2002). *Household Seasonal Food Insecurity in Oromiya Zone, Ethiopia: Causes*. Social Science Research Report Series, No.26: OSSREA, Ethiopia, Addis Ababa
- Degefa Tolossa (2005). *Rural livelihoods, poverty and food insecurity in Ethiopia*. PhD Thesis, Norwegian University of Science and Technology, NTNU Trondheim
- Degefa Tolossa (2008). *Understanding the realities of Urban poor and their food security situations: A case study at Berta Gibi and Gemachu Safar in Addis Ababa City, Ethiopia*. VRF series No 440. Institute of Development Economics, Japan.
- Deitchler, M., Ballard, T., Swindale, A., & Coates, J. (2011). Introducing a simple measure of household hunger for cross-cultural use. Washington, DC: Food and Nutrition Technical Assistance.
- Devereux, S. (2000). Food Insecurity in Ethiopia: A Discussion Paper for DFID. Addis Ababa, Ethiopia. Available online: https://www.researchgate.net/publication/50200941_Accessed March 2019
- Di Falco, S., Jean-Paul Ch., & Melinda S. (2007). Farmer Management of Production Risk on Degraded Lands: The Role of Wheat Variety Diversity in the Tigray Region, Ethiopia.” *Agricultural Economics*, 36(2)147–56. doi:10.1111/j.1574- 0862.2007.00194.x.
- Dorosh, P., Wang, H.G., You, L. & Schmidt, E. (2012). Road connectivity, population, and crop production in Sub-Saharan Africa. *Agricultural Economics*, 43(2012): 89-103.
- Drescher, L. S., Thiele, S., & Mensink, G. B. (2007). A new index to measure healthy food diversity better reflects a healthy diet than traditional measures. *J Nutr.*, 137:647–651
- Ecker, O., Tan, F. T., Alpuerto, V., Diao, X. (2013). Economic growth and agricultural diversification matters for food and nutrition security in Ghana. Ghana strategy support program, discussion note number 031. IFPRI, Washington DC
- EDHS (Ethiopia Demographic and Health Survey). (2011). Ethiopia Demographic and Health Survey, Addis Ababa, Ethiopia.
- EDHS (Ethiopia Demographic and Health Survey). (2012). Ethiopia Demographic and Health Survey, Addis Ababa, Ethiopia.

- EIU (Economist Intelligence Unit). (2018). Global Food Security Index. New York, USA. <https://foodsecurityindex.eiu.com/Country/Details#Ethiopia>.
- Ejigayhu Sisay, & Abdi-Khalil Edriss (2012). Determinants of Food Insecurity in Addis Ababa City, Ethiopia. *Journal of Economics and Sustainable Development*. www.iiste.org ISSN 2222-1700 (Paper) ISSN 2222-2855. 3(3), 2012
- Ellis, F. (1993). *Peasant Economics: Farm household and agrarian development*. Cambridge University Press, UK.
- Ellis, F. (2000). The determinants of rural livelihood diversification in developing countries. *Journal of Agricultural Economics*, 51(2), 289-302.
- Engel, C.; Moffatt, P.G. Dhreg, Xtdhreg, and Bootdhreg. (2014). Commands to implement Double Hurdle Regression. *Stata J.*, 14, 778–797.
- EPHI (Ethiopian Public Health Institute) Ethiopia and ICF. (2019). *Ethiopia Mini Demographic and Health Survey: Key Indicators*. Rockville, Maryland, USA: EPHI and ICF.
- Faber, M., Schwabe, C., & Drimie, S. (2009). Dietary diversity in relation to other household food security indicators. *Int J Food Saf Nutr Public Health*, 2(1):1–15.
- Fafchamps, M. (1992). Cash Crop Production, Food Price Volatility, and Rural Market Integration in the Third World. *American Journal of Agricultural Economics*, 74(1): 90-99. <https://www.jstor.org/stable/1242993>
- Fahima, S., & Muntaha, R. (2019). Determinants of Household Dietary Diversity in Bangladesh. *Global Journal of HUMAN-SOCIAL SCIENCE: Economics*; 19 (9). Type: Double Blind Peer Reviewed International Research Journal Publisher: Global Journals Online ISSN: 2249-460x & Print ISSN: 0975-587X
- Fan, Sh. (2011). “Leveraging Smallholder Agriculture for Development,” speech given at the Chicago Council on Global Affairs Symposium on Global Agriculture and Food Security, “Progress to Date and Strategies for Success,” Washington, DC, May 14, 2011.
- FAO (Food and Agriculture Organization). (1996). Declaration on world food security. World Food Summit. Rome, Italy.
- FAO, IFAD, UNICEF, WFP & WHO. (2020). The State of Food Security and Nutrition in the World. Transforming food systems for affordable healthy diets. Rome: Food and Agriculture Organization of the United Nations
- FAO, IFAD, WFP. (2012). Strengthening the enabling environment for food security and nutrition. Rome: Italy
- FAO. (2016). Pulse contribution to Food Security: International Pulse Day. Rome-Italy

- FAO. (2001). Human Energy Requirements: FAO Food and Nutrition Technical Report Series 1. Rome-Italy.
- FAO. (2010). Guidelines for Measuring Household and Individual Dietary Diversity. Rome-Italy
- FAO. (2010). The state of food insecurity in the world: addressing food insecurity in protracted crises. Rome: United Nations' Food and Agricultural Organization.
- FAO. (2011). Guidelines for Measuring Household and Individual Dietary Diversity, Rome-Italy.
- FAO. (2013). The state of food insecurity in the World. 2013. The multiple dimensions of food security. Rome-Italy.
- FAO. (2018). Report on use of the household food insecurity access scale and household dietary diversity score in two survey rounds in Manica and Sofala Provinces, Mozambique, 2006–2007; 2008a http://www.fao.org/fleadmin/user_upload/eufao-fsi4dm/doc/training/moz_diet.pdf. Accessed February 2020
- FAO. (2018). The State of Food Security and Nutrition in the World: Building Climate Resilience for Food Security and Nutrition. Rome, 2018. <http://www.fao.org/3/I9553EN/i9553en.pdf> Accessed on Dec 2019
- FAO. (2019). Cropping systems diversification to enhance productivity and adaptation to climate change in Zambia. Economic and policy analysis of climate change. *Agricultural Development Economics Division (ESA)*, FAO. Retrieved December 20, 2019 from <http://www.fao.org/3/CA2572EN/ca2572en.pdf>
- FAO. Food insecurity in the World: addressing food insecurity in protracted crises 2010. Food and Agriculture Organization of the United Nations, Rome. Accessed July 10, 2019, from <http://www.fao.org/docrep/013/i1683e/i1683e.pdf>
- FDRE (Federal Democratic Republic of Ethiopia) Food & Nutrition Policy. 2018. Federal Democratic Republic of Ethiopia, Food and Nutrition Policy, Addis Ababa, Ethiopia.
- FDRE (Federal Democratic Republic of Ethiopia). (2013. Ethiopia National Nutrition Programme Implementing Sectors Declaration, “Government of the Federal Democratic Republic of Ethiopia (2013–2015)”.
- FDRE (Federal Democratic Republic of Ethiopia). (2016). Seqota declaration implementation plan (2016–2030): Summary program approach document. Addis Ababa: Ethiopia.
- Fekadu Alemu (2013). Assessment of the impact of malnutrition on children at Dilla referral hospital and unity pediatric clinic, Ethiopia. *Int J Nutr Metab*, 5(6): 105-113.
- Feliciano, D. (2019). A review on the contribution of crop diversification to sustainable development goal 1 “no poverty” in different world regions. *Sustainable Development*, 27(4), 795–808. <https://doi.org/10.1002/sd.1923>.

- Fetien Abay, Bjornstad, A. & Smale, M. (2009). Measuring on farm diversity and determinants of barley diversity in Tigray, northern Ethiopia. *Momona Ethiopia Journal of Science*, 1(2): 44-66.
- Francesco, G. (1999). Agricultural Diversification and Rural Industrialization as a Strategy for Rural Income Growth and Poverty Reduction in Indochina and Myanmar. Markets and Structural Studies Division, International Food Policy Research Institute, 2033 K Street N.W. Washington, D.C.
- Frayne, B. and McCordic, C. (2015). Planning for food secure cities: Measuring the influence of infrastructure and income on household food security in Southern African cities. *Geoforum*, 65(2015); 1-11. <https://doi.org/10.1016/j.geoforum.2015.06.025>
- Gaiha, R., Kaieker, H., Imai, K. S., Kulkarni, V. S., & Thapa, G. (2012). Diet diversification and diet quality in India: an analysis. Discussion paper series RIEN DP 2012-30, Kobe University, Japan
- Gani, B.; Adeoti, A. (2011). Analysis of market participation and rural poverty among farmers in northern part of Taraba State, Nigeria. *J. Econ.*, 2, 23–36.
- García, B. (2013). Implementation of a Double-Hurdle Model. *Stata J.*, 13, 776–794.
- Gebremedhin, B.; Jaleta, M. (2010). *Commercialization of smallholders: Is market participation enough?* In Proceedings of the Joint 3rd African Association of Agricultural Economists (AAAE) and 48th Agricultural Economists Association of South Africa (AEASA), Cape Town, South Africa, 19–23 September 2010.
- Generoso, R. (2015). How do rainfall variability, food security and remittances interact? The case of rural Mali. *Ecol. Econ.* 114(2015):188–198.
- Geremew Motuma Jebessa, Akalu Dafisa Sima & Beneberu Assefa Wondimagegnhu (2019). Determinants of household dietary diversity in *Yayu* Biosphere Reserve, Southwest Ethiopia. *Ethiop. J. Sci & Technol* 12(1): 45-68, 2019 45
- Gero, C., Alberto, Z., & Raka, B. (2013). Towards Better Measurement Of Household Food Security: Harmonizing Indicators And The Role Of Household Surveys. *Global Food Security* 2(1):30–40: DOI: 10.1016/j.gfs.2012.11.006
- Getachew Teferi, Degefa Tolossa & Negussie Semie (2018). Food insecurity of rural households in Boset district of Ethiopia: a suite of indicators analysis. *Agric & Food Secur* (2018) 7:65 <https://doi.org/10.1186/s40066-018-0217-x>
- Ghandilyan, A., Vreugdenhil, D. & Aarts, M. G. (2006). Progress in the genetic understanding of plant iron and zinc nutrition. *Physiol Plant*, 126: 407-17.
- Gibbs, A., (1997). Focus Groups, Social Research Update, 19(1997), University of Surrey <http://sru.soc.surrey.ac.uk/SRU19.html> accessed on 5 August 2018

- Girma Nega, Melkie Endris, Degnet Teferi, Amanuel Nana, & Rigbe W/Michael (2015). Dietary Diversity and Associated Factors among Rural Households in South Gondar Zone, Northwest Ethiopia. Feed the Future Research Award
- Girma Woldemariam & Timotiows Genebo (2002). Determinants of Nutritional Status of Women and Children in Ethiopia. Calverton, Maryland, USA: ORC Macro.
- Gitagia, M., Ramkat, R, Mituki, D., Termote, C., Covic, N., & Cheserek, M. (2019). Determinants of dietary diversity among women of reproductive age in two different agro-ecological zones of Rongai Sub-County, Nakuru, Kenya. *Food Nutr Res*, 63(2019): 1553 <http://dx.doi.org/10.29219/fnr.v63.1553>
- Goss, J. D. & Leinbach, T. R. (1996). 'Focus groups as alternative research practice' 28 (2): 115-23.
- Greene, W, H. (2012). *Econometric analysis, 7th edn.* 2012. Prentice-Hall, New Jersey
- Greene, W. H. (2008). *Econometric analysis, 6th edn.* 2008. Prentice-Hall, New Jersey
- Ground, M.; Koch, S.F. (2008). Hurdle models of alcohol and tobacco expenditure in South African households. *S. Afr. J. Econ.*, 76, 132–143.
- Gugsa Yimer (2000). Malnutrition among children in Southern Ethiopia: Levels and risk factors. *Ethiop J Health Dev.* 14(3):283-92.
- Gujarati, D, N. (1995). *Basic econometrics. 3rd Edn.* McGraw-Hill Inc., New York., ISBN-13:9780070252141, p 838
- Headey, D., & O. Ecker. 2013. Rethinking the Measurement of Food Security: From First Principles to Best Practice. *Food Security* 5: 327–343.
- Heckman, J, J. (1979). Sample selection bias as a specification error. *J. of Econometrica*, 47(1):153-162.
- Herforth, A. (2010). Promotion of traditional African vegetables in Kenya and Tanzania. A case study of an intervention representing emerging imperatives in global nutrition: Cornell University
- Hirschman, O., and Albert O., (1964). The paternity of an index. *Journal of American Economic Review*, 54(5): 761.
- Hirvonen, K., & Hodidinott, J. (2017). Agricultural production and children's diets: evidence from rural Ethiopia. *Agricultural Economics* 48(4): 469-480.
- Horton, S., & Ross, J. (2003). The Economics of Iron Deficiency. *Food Policy*, 28, 51-75. [http://dx.doi.org/10.1016/S0306-9192\(02\)00070-2](http://dx.doi.org/10.1016/S0306-9192(02)00070-2)

- Isik-Dikmelik, A. (2006). *Trade reforms and welfare: an ex-post decomposition of income in Vietnam*. World Bank Policy research working paper. 2006. Washington DC: World Bank.
- Jensen, R., and N. Miller. 2010. *A Revealed Preference Approach to Measuring Hunger and Undernutrition*. NBER Working Paper 16555. Cambridge, MA, US: National Bureau of Economic Research.
- Joachim, V. B, & Getaw Tadesse (2012). *Global food price volatility and spikes: an overview of costs, causes, and solutions*. ZEF-Discussion Papers on Development Policy. Bonn: ZEF.
- Jodlowski, M., Winter-Nelson, A., Baylis, K., & Goldsmith, P.D. (2016). Milk in the Data: Food Security Impacts from a Livestock Field Experiment in Zambia. *World Dev.* 77(2016), 99–114.
- Jones, D., Shrinivas, A. & Bezner-Kerr, R., (2014). Farm production diversity is associated with greater household dietary diversity in Malawi: Findings from nationally representative data. *Food Policy*, 46: 1-12: <https://doi.org/10.1016/j.foodpol.02.001>
- Joshi, P. K, Ashok, G., BIRTHAL, P. S, Tewari, L. (2006). Agriculture diversification in South Asia: patterns, determinants, and policy implications (No. 57), Washington, D.C. 20006.
- Kafle, K., Winter-Nelson, A., & Goldsmith P. (2016). Do 25 cents more per day make a difference? The impact of livestock transfers and development in rural Zambia. *Food Policy*. 2016; 63, 62–72.
- Kalkuhl, M., Kornher, L., Kozicka, M., Boulanger, P., & Torero, M. (2013). Long-Term Drivers of Food and Nutrition Security. FOODSECURE working paper no.06. The Hague: LEI Wageningen UR.
- Kalkuhl, M., Kornher, L., Kozicka, M., Boulanger, P., & Torero, M. (2013). Long-Term Drivers of Food and Nutrition Security. FOODSECURE working paper no.06. The Hague: LEI Wageningen UR.
- Kalle, H., Alemayehu Seyoum, & Ibrahim Worku (2015). *Seasonality and household diets in Ethiopia*. Ethiopia Strategy Support: Ethiopian Development Research Institute. Working Paper 74
- Kalle, H., Alemayehu Seyoum, & Ibrahim Worku (2015). *Seasonality and household diets in Ethiopia*. Ethiopia Strategy Support: Ethiopian Development Research Institute. Working Paper 74
- Kandala, N., Fahrmeir, L. & Klasen, S. (2010). Geo-additive Models of Childhood Undernutrition in Three Sub-Saharan African Countries. Sonderfor
- Kandala, N., Madungu, T., & Emina, J. (2011). Malnutrition among children under the age of five in the Democratic Republic of Congo (DRC): Does geographic location matter? *BMC Public Health* 2011; 11: 1-15

- Kebede Mengistu, Kassahun Alemu & Bikes Destaw (2013). Prevalence of malnutrition and associated factors among children aged 6–59 months at hidabu abote district, north shewa, Oromia regional state. *Journal of Nutritional Disorders & Therapy*, vol. T1, article 001, 2013.
- Kefyalew, G. (2012). Analysis of Smallholder Farmer’s Participation in Production and Marketing of Export Potential Crops: The Case of Sesame in Diga District, East Wollega Zone of Oromia Regional State. Master’s Thesis, Addis Ababa University, Addis Ababa, Ethiopia, 2012.
- Kibrom Sibhatu, Krishna, V., & Qaim, M. (2015). Production diversity and dietary diversity in smallholder farm households. *Proceedings of the National Academy of Sciences* 112(34): 10657-10662
- Kitzinger, J. (1995). ‘Introducing focus groups.’ *British Medical Journal*, 311: 299-302.
- Kiwanuka, R.N.; Macheche, C. (2016). Determinants of smallholder farmers’ participation in Zambian dairy sector’s interlocked contractual arrangements. *J. Sustain. Dev.*, 9, 230–245.
- Komarek, A. (2010). The determinants of banana market commercialization in Western Uganda. *Afr. J. Agric. Res.*, 5, 775–784.
- Koppmair, S., Kassie, M., & Qaim, M. (2016). Farm production, market access and dietary diversity in Malawi. *Public Health Nutrition*, 20(2), 325–335. doi:10.1017/S1368980016002135
- Kravdal, Ø., & Kodzi, I. (2009). Children’s stunting in sub-Saharan Africa: Is there an externality effect of high fertility? *Demographic Research*. 2011; 25: 18.
- Kurosaki, T. (2003). Specialization and Diversification in Agricultural Transformation: The Case of West Punjab, 1903-1992. *American Journal of Agricultural Economics* 85(2). DOI: [10.1111/1467-8276.00126](https://doi.org/10.1111/1467-8276.00126).
- Leedy, P. D. (1993). *Practical research. 5th edition*. New York: Macmillan.
- Lighton, D., & Emmanuel, G. (2016). Factors Influencing Smallholder Crop Diversification: A Case Study of Manicaland and Masvingo Provinces in Zimbabwe. *International Journal of Regional Development*, 3(2): 2373-9851,
- Liu, J., Gerald, E. & James, K. (2014). Access to variety contributes to dietary diversity in China. *Food Policy*, 49(2014), 323-331, <https://doi.org/10.1016/j.foodpol.2014.09.007>
- M’Kaibi, F. K., Steyn, N. P., & Ochola, S. A. (2016). The relationship between agricultural biodiversity, dietary diversity, household food security, and stunting of children in rural Kenya. *Food Sci Nutr*. 2016. DOI:10.1002/fsn3.387
- MacIntosh, J. (1981). ‘Focus groups in distance nursing education’, *Journal of Advanced Nursing* 18: 1981-85.

- Maddala, G. S., (1999). *Limited dependent and qualitative variables in economics*. Cambridge UK, Cambridge University Press, pp. 1- 231.
- Magurran, A. (1988). *Ecological diversity and its measurement*. Princeton, NJ, USA: Princeton University Press.
- Makate, C., Wang, R., Makate, M., & Mango, N. (2016). Crop diversification and livelihoods of smallholder farmers in Zimbabwe: adaptive management for environmental change. *SpringerPlus*. 2016; 5(1):1–18. <https://doi.org/10.1186/s40064-016-2802-4>.
- Malik, D. P., & Singh, I. J., (2002). Crop diversification-An economic analysis. *Indian J Agric Res* 36(1):61–64
- Maluccio, J. A., Hoddinott, J., Behrman, J. R., Martorell, R., Quisumbing, A. R., & Stein, A. D. (2009). The impact of improving nutrition during early childhood on education among Guatemalan adults. *The Economic Journal*, 119(537), 734-763.
- Mandal R., & Bezbaruah, M. P. (2013). Diversification of cropping pattern: its determinants and role in flood affected agriculture of assam plains. *Indian J Agric Econ*. 2013;68(2):169–81
- Mango, N., Zamasiya, B., Makate, C., Nyikahadzoi, K., & Siziba, S. (2014). Factors influencing household food security among smallholder farmers in the Mudzi district of Zimbabwe. *Dev South Afr.*, 31(4):625–40. <https://doi.org/10.1080/0376835X.2014.911694>.
- Martey, E.; Al-Hassan, R.M.; Kuwornu, J.K. (2012). Commercialization of smallholder agriculture in Ghana: A Tobit regression analysis. *Afr. J. Agric. Res.*, 7, 2131–2141.
- Masresha Tessema, Tefera Belachew, & Getahun Ersino (2013). Feeding patterns and stunting during early childhood in rural communities of Sidama, South Ethiopia. *Pan African Medical Journal – ISSN: 1937- 8688 (www.panafrican-med-journal.com)* Published in partnership with the African Field Epidemiology Network (AFENET). (www.afenet.net)
- Matshe, I., Young, T. (2004). Off-farm labour allocation decisions in small-scale rural households in Zimbabwe. *Agric. Econ.*, 30, 175–186.
- McKillip, J. (1987). *Need analysis: Tools for the human services and education*. Newbury Park, CA: Sage.
- Melaku Desta, Mohammed Akibu, Mesfin Tadese, & Meskerem Tesfaye (2019). Dietary Diversity and Associated Factors among Pregnant Women Attending Antenatal Clinic in Shashemane, Oromia, Central Ethiopia: A Cross-Sectional Study. *Journal of Nutrition and Metabolism*. Volume 2019, Article ID 3916864, 7 pages <https://doi.org/10.1155/2019/3916864> Accessed April 2020
- Menale Kassie, Bekele, Shiferaw, & Muricho G. (2011) Agricultural technology, crop income, and poverty alleviation in Uganda. *World Development*, 39(10), pp. 1784–1795. <https://doi.org/10.1016/j.worlddev.2011.04.023>

- Menale Kassie, Moti Jaleta, Bekele Shiferaw, Frank, M. & Mulugeta Mekuria (2012). Technological Forecasting and Social Change Adoption of interrelated sustainable agricultural practices in smallholder systems: Evidence from rural Tanzania. *Technological Forecasting & Social Change*, 80(3), 525–540. <http://doi.org/10.1016/j.techfore.2012.08.007>
- Meskerem Abi and Degefa Tolossa (2015). Household Food Security Status and Its Determinants in Girar Jarso *Woreda*, North Shewa Zone of Oromia Region, Ethiopia. *Journal of Sustainable Development in Africa*, 17(7): 1520-5509
- Messay Mulugeta (2009). Causes of Rural Household Food Insecurity: A Case from Kuyu District, Central Ethiopia. *Journal of Sustainable Development in Africa*, 11 (4). Clarion University of Pennsylvania, Clarion, Pennsylvania
- Michlera, J. D. & Josephson, A. L. (2017). To specialize or diversify: Agricultural diversity and poverty dynamics in Ethiopia. *World Dev.*;89, 214–226.
- MoFED (Ministry of Finance and Economic Development). (2015). Growth and Transformation Plan (GTP) 2015/16-2019/20. Addis Ababa, Ethiopia.
- Moffatt, P.G. (2005). Hurdle models of loan default. *J. Oper. Res. Soc.*, 56, 1063–1071.
- Morse, J. M., & Niehaus, L. (2009). *Mixed methods design: Principles and procedures*. Walnut Creek, CA: Left Coast Press.
- Muhammad B.K., Schilizzi, S. & Pandit, R. (2012). *The determinants of rural household food security in the Punjab, Pakistan: an econometric analysis*, Working Paper 1203, 2012. School of Agricultural and Resource Economics, University of Western Australia, Crawley, Australia.
- Mussie Alemayehu, Fitwi Tinsae, Kiday Hailelassie, Oumer Seid, Gebremedhin Gebregziabher, Henok Yebyo. (2013). Nutritional status and associated factors among under-five children, Tigray, Northern Ethiopia. *International Journal of Nutrition and Food Sciences*. Jul-Aug 2015; 31(7-8):964-70. doi: 10.1016/j.nut.2015.01.013. Epub 2015 Feb 26.
- Nelson, Gerald C. (2009). Agriculture and Climate Change: An Agenda for Negotiation in Copenhagen. (2009). 2020 Focus Brief 16. Washington, DC: International Food Policy Research Institute.
- Nguyen, H. Q. (2014). Crop diversification, economic performance and household's behaviors: Evidence from Vietnam. *SSRN Electronic Journal*, 1–25
- Nigatu Regass (2011). Small Holder Farmers Coping Strategies to Household Food Insecurity and Hunger in Sidama *Woreda* Southern Ethiopia. *Ethiopian Journal of Environmental Studies and Management*, 4(1):39–40.

- Nigusse Reta, Samson Gebremedhin, Kaleab Baye, Tilahun Bekele, Manisha Tharaney, Yonas Asrat, & Yewelsew Abebe (2017). Predictors of dietary diversity in children ages 6 to 23 mo in largely food-insecure area of South Wollo, Ethiopia. *Nutrition*. 33, 163–168. <http://dx.doi.org/10.1016/j.nut.2016.06.002>
- Njeru, E. M. (2013). Crop diversification: a potential strategy to mitigate food insecurity by smallholders in sub-Saharan Africa. *J Agric Food Syst Community Dev*. 2013;3(4):63–9. <https://doi.org/10.5304/jafscd.2013.034.006>. Accessed January 2020
- Ochieng, J., Victor, A. S., Lukumay, P. J., & Dubois, T. (2017). Determinants of dietary diversity and the potential role of men in improving household nutrition in Tanzania. *PLoS One*, 12(12), Article ID e0189022.
- Ojo, M., Ojo, A., Odine, A., & Ogaji, A., (2014). Determinants of crop diversification among small – scale food crop farmers in north central, Nigeria. *Production Agriculture and Technology Journal*, 10(2), 1-11.
- Pangaribowo, E. H., Gerber, N., & Torero, M. (2013). Food and nutrition security indicators: a review. FOODSECURE working paper no. 05, FOODSECURE project, The Hague: LEI Wageningen UR
- Pellegrini, L., & Tasciotti, L. (2014). Crop diversification, dietary diversity and agricultural income: empirical evidence from eight developing countries, *Canadian Journal of Development Studies* 35(2) 211-227, DOI: 10.1080/02255189.2014.898580
- Pieters, H., Guariso, A., & Vandeplass, A. (2013). *Conceptual framework for the analysis of the determinants of food and nutrition security*. FOODSECURE Working paper no. 13. The Hague: LEI Wageningen UR.
- Piya, L., & Lall, K. (2013). Determinants of adaptation practices to climate change by Chepang households in the rural Mid-Hills of Nepal. *Regional Environmental Change*, 437–447. <http://doi.org/10.1007/s10113-012-0359-5>
- Poudel, S., Basavaraja, H., Kunnal, L., Mahajanashetti, S. & Bhat, A. (2012). *Crop diversification in Karnataka: An economic analysis*. Department of Agricultural Economics, University of Agricultural Sciences, Dharwad, Karnataka.
- Powell, R.A. & Single H.M. 1996. ‘Focus groups’, *International Journal of Quality in Health Care* 8 (5): 499-504
- Rabia Fentaw, Ayalneh Bogale, & Degnet Abebaw (2013). Prevalence of child malnutrition in agro-pastoral households in Afar Regional State of Ethiopia. *Nutrition Research and Practice (Nutr Res Pract)* 2013; 7(2):122-131: <http://dx.doi.org/10.4162/nrp.2013.7.2.122> pISSN 1976-1457 eISSN 2005 6168
- Rahm, R. & Huffman, E. (1984). The Adoption of Reduced Tillage: The Role of Human Capital and Other Variables. *American Journal of Agricultural Economics*, 66(4): (Nov., 1984), pp. 405-413. <http://www.jstor.com/stable/1240918>

- Rahman, A. & Chowdhury, S. (2007). Determinants of Chronic Malnutrition among Preschool Children in Bangladesh. *Journal of Biosocial Science* 39(2):P.161-173.
- Rashid, D. A., Smith, L., & Rahman, T. (2011). Determinants of dietary quality: evidence from Bangladesh. *World Dev.* 39:2221–2231
- Rehima Mussema, Belay Kassa, Dawit Alemu & Rashid S. (2013). Factors affecting farmers' crops diversification: Evidence from SNNPR, Ethiopia. *Int. J. of Agric. Sci.* 3(6): 558-565.
- Rehima Mussema, Belay Kassa, Dawit Alemu & Rashid S. (2015). Determinants of Crop Diversification in Ethiopia: Evidence from Oromia Region. *Ethiop. J. Agric. Sci.* 25(2) 65-76
- Rose, D., & Chariton, K. E. (2002). Quantitative indicators from food expenditure survey can be used to target the food insecure in South Africa. *J Nutr.* 2002; 132:3235–3242
- Ruben, R., and Van den Berg, M., (2001). Nonfarm employment and poverty alleviation of rural farm households in Honduras. *World Development*, 29(3), 549-560.
- Ruel, M. (2003). “Operationalizing Dietary Diversity: A Review of Measurement Issues and Research Priorities.” *Journal of Nutrition* 133: 3911S–3926S.
- Ruel, M. T. (2003). Operationalizing dietary diversity: a review of measurement issues and research priorities. *J Nutr.* 133(11 Suppl 2):3911S–26S.
- Ruel, M. T., Nguyen, P. H., Avula, R., Saha, K. K., Ali, D., & Tran, L. M. (2013). Maternal and child dietary diversity are associated in Bangladesh, Vietnam, and Ethiopia. *J Nutr.* 143(7):1176–83.
- Ruel, M., J. Harris, & Cunningham, K. (2013). *Diet Quality in Developing Countries*. In *Diet Quality: An Evidence-Based Approach*, edited by V. R. Preedy, 239–261. New York: Springer.
- Saaka, M. & Osman, S. M. (2013). “Does household food insecurity affect the nutritional status of preschool children aged 6–36 months?” *International Journal of Population Research*, vol. 2013, Article ID 304169, 12 pages, 2013.
- Sandretto, C.L., Mishra, A.K., & El-Osta, H.S. (2004). Factors affecting farm enterprise diversification. *Agricultural finance review*, 64(2): pp. 151
- Santeramo, F. G., Goodwin, B. K., Adinolfi, F., and Capitanio, F. Farmer participation, entry and exit decisions in the Italian crop insurance programme. 2016. *Journal of Agricultural Economics*, 67(3), 639-657
- Sasha, F. (2009). *An Analysis of Under-Five Nutritional Status in Lesotho: The Role of Parity Order and Other Socio-Demographic Characteristics*.

- Sebanjo I. O., Adeodu, O. O. & Adejuyigbe E. A. (2009). *Influence of socio-economic factors on nutritional status of children in a rural community of Osun State, Nigeria*, 2009.
- Sebsibe Tadesse & Yinges Alemu (2015). Urban-rural differentials in child undernutrition in Ethiopia. *International Journal of Nutrition and Metabolism*, 7(1):15–23.
- Sekhampu, T. (2013). Determinants of the Food Security Status of Households Receiving Government Grants in Kwakwatsi, South Africa. *Mediterranean J Soc Sci.*, 4(1):147–53
- Sereebutra, P., Solomons, N., Aliyu, M.H., & Jolly, P.E. (2006). Socio-Demographic and Environmental Predictors of Childhood Stunting in Rural Guatemala. *Nutrition Research*, 26(2):65-70. <https://doi.org/10.1016/j.nutres.2006.02.002>
- Seydou, Z., Liu, Y., Baohui, S. (2014). Factors influencing household food security in West Africa: the case of southern Niger. *Sustainability*. 2014; 6:1191–1202. <https://doi.org/10.3390/su6031191> Accessed December 2019
- Sichoongwe, K. Laqrene, M., Ng'ng'ola, D., and Temb, G., (2014). The Determinants and Extent of Crop Diversification among Smallholder Farmers. A case study of Southern Province, Zambia, Malawi Strategy Support Program, Working Papers 05, Washington DC.
- Singh, I., L. Squire and J. Strauss. (1986). *Agricultural household models: extensions, policy and applications*. John Hopkins University, Baltimore
- Sisay Belay (2012). Food insecurity and coping strategies: A perspective from Kersa district, East Hararghe Ethiopia. *Food Science and Quality Management*, 5: 19-26.
- Sisay Debebe (2016). *Agricultural Technology Adoption, Crop Diversification and Efficiency of Maize-Dominated Smallholder Farming System in Jimma Zone, Southwestern Ethiopia*. (Electronic Dissertation). Haramaya University, Haramaya, Ethiopia
- Smith, L. C., Ruel, M. T., & Ndiaye, A. (2005). Why is child malnutrition lower in urban than in rural areas? Evidence from 36 developing countries. *World Development*, 33(8), 1285-1305.
- Stifel, D., & Minten, B. (2008). Isolation and agricultural productivity. *Agricultural Economics*, 39, 15.
- Strauss, A. & Corbin, J. (1990). *Basics of qualitative research*. London: Sage Publications.
- Stringer, E.T. & Genat, W. J. (2009). *Action research in health*. New Jersey: Donnell and Sons.
- Stuart, G., Jody, H., & Suneetha, K., (2012). *The Agriculture-Nutrition Disconnect in India, What Do We Know?* IFPRI Discussion Paper 01187
- Swades, P. & Shyamal, K., (2012). Implications of the methods of agricultural diversification in reference with Malda district: drawback and rationale. *International Journal of Food, Agriculture and Veterinary Sciences* 2 (2):97-105 <http://www.cibtech.org/jfav.htm>.

- Swindale, A., & Bilinsky, P. (2006). *Household Dietary Diversity Score (HDDS) for Measurement of Household Food Access: Indicator Guide (v.2)*. Food and Nutrition Technical Assistance (FANTA) Project. Washington, DC: Academy for Educational Development.
- Tagel Alemu (2018). *Agricultural Technology Adoption, Commercialization and Food Security linkage: Micro Evidence from Boricha Wereda, Sidama Zone SNNPR Ethiopia*. A Thesis Submitted to College of Development Studies, Center for Food Security in Partial Fulfillment of The Requirements for The Degree of Master of Science in Food Security and Development Studies. Addis Ababa University, Ethiopia
- Taruvunga, A., Muchenje, V., & Mushunje, A. (2013). Determinants of rural household dietary diversity: the case of Amatole and Nyandeni districts, South Africa. *International Journal of Development and Sustainability*, 2(4): pp. 1–15.
- Tassew Woldehanna, & Behrman, J. R. (2013). *What determines Ethiopian children's dietary diversity?* Paper presented at center for the study of African Economics (CSAE) held at St. Catherine's college Oxford 17-19 march 2013
- Taylor, J., & Adelman, I., (2003). Agricultural Household Models: Genesis, Evolution, and Extensions. *Review of Economics of the Household*, 1(1), 33-58.
- Tesfamicheal Wossen, Tahirou Abdoulaye, Arega Alene, Mekbib Haile, Shiferaw Feleke, Adetunji, O., Victor, M. (2017). Impacts of extension access and cooperative membership on technology adoption and household welfare. *Journal of Rural Studies*, 5(4): 223-233. <https://doi.org/10.1016/j.jrurstud.2017.06.022>
- Tesfamicheal Wossen, Tahirou Abdoulaye, Arega Alene, Mekbib Haile, Shiferaw Feleke, Adetunji, O., Victor, M. (2017). Impacts of extension access and cooperative membership on technology adoption and household welfare. *Journal of Rural Studies*, 5(4): 223-233. <https://doi.org/10.1016/j.jrurstud.2017.06.022>
- Tesfaye Besha (2003). *Understanding Farmers: Explaining soil and water conservation in Konso, Wolaita and Wello, Ethiopia*. PhD Thesis, Wageningen University and Research Centre
- Teshale Fikadu, Sahilu Assegid, & Lamessa Dube (2014). Factors associated with stunting among children of age 24 to 59 months in Meskan district, Gurage Zone, South Ethiopia: a case-control study. *BMC Public Health*.
- Thow, M. A., Fanzo, J., & Negin J. (2016). A Systematic Review of the Effect of Remittances on Diet and Nutrition. *Food Nutr. Bull.* 2016;37, 42–64.
- Tizita Damtew (2017). *The Effect of Small-Scale Irrigation on Household Food Security in Bona-Zuria Woreda, Sidama Zone, Southern Ethiopia*. A Thesis Submitted to The School of Environment, Gender and Development Studies. Addis Ababa University, Addis Ababa, Ethiopia.

- Tura, E.G.; Goshu, D.; Demisie, T.; Kenea, T. (2016). Determinants of market participation and intensity of marketed surplus of teff producers in Bacho and Dawo Districts of Oromia State, Ethiopia. *J. Agric. Econ. Dev.*, 5, 20–32.
- Turyashemererwa, F. Kikafunda, J., Annan, R. & Tumuhimbise, G. A. (2013). Dietary patterns, anthropometric status, prevalence and risk factors for anaemia among school children aged 5-11 years in Central Uganda. *Journal of Human Nutrition and Dietetics*, 26(2013) , p. 73.
- Turyashemererwa, F., Kikafunda, J., & Agaba, E. (2009). Prevalence of Early Childhood Malnutrition and Influencing Factors in Peri Urban Areas of Kabarole District, Western Uganda. *African Journal of Food Agriculture Nutrition and Development*, 9: 975-989
- UNDP (United Nation Development Program). (2016). *Towards building resilience and supporting transformation in Ethiopia*. Annual Report, 2016.
- UNICEF (2009). *Tracking Progress on child and maternal nutrition: A survival and development priority*.
- United Nations. (2015). *Transforming our world: the 2030 Agenda for Sustainable Development*. Division for Sustainable Development Goals. New York: United Nations
- USAID. (2003). *RCSA Food Security Strategic Option: synthesis of selected readings*. Report prepared by Nathan and Associates for USAID Regional Centre for South Africa.
- Vakili, M., Abedi, P., Sharifi, M., & Hosseini, M. (2013). Dietary Diversity and Its Related Factors among Adolescents: A Survey in Ahvaz-Iran. *Global Journal of Health Science*, 5(2), pp. 2013.
- Wamani, H., Tylleskär, T., Åström, A.N., Tumwine, J. K., & Peterson, S. (2004). Mothers' education but not fathers' education, household assets or land ownership is the best predictor of child health inequalities in rural Uganda. *Int J Equity Health*, 3(1):9.
- Wanyoike, F.; Mtimet, N.; Ndiwa, N.; Marshall, K.; Godiah, L.; Warsame, A. (2015). Knowledge of livestock grading and market participation among small ruminant producers in northern Somalia. *East Afr. Agric. For. J.*, 81, 64–70.
- Webb, C., & Kevern, J. (2001). Focus groups as a research method: a critique of some aspects of their use in nursing research. *Journal of Advanced Nursing*, 33(6), 798-805
- Winters, P., Cavatassi, R., & Lipper, L., (2006). *Sowing the seeds of social relations: The role of social capital in crop diversity*. ESA Working Paper No. 6, (16): pp. 1- 40.
- Wondimagegn Mesfin, Bekabil Fufa, & Jema Haji (2011). Pattern, trend and determinants of crop diversification: Empirical evidence from smallholders in Eastern Ethiopia. *Journal of Economics and Sustainable Development*, 2(8), 78–89.

- Wondimagegn Mesfin, Bekabil Fufa, & Jema Haji (2011). Pattern, trend and determinants of crop diversification: Empirical evidence from smallholders in Eastern Ethiopia. *Journal of Economics and Sustainable Development*, 2(8), 78–89.
- Yamane, T. (1967). *Statistics, an introductory analysis*. 2nd Ed. New York: Harper and Row.
- Yami, M., Teklu, T., Adam, B. (2013). Determinants of farmers' participation decision on local seed multiplication in Amhara region, Ethiopia: A double hurdle approach. *Int. J. Sci. Res.*, 2, 423–430.

Appendices

Appendix I: Conversion factor for livestock unit

Table A 1. 1: Conversion factor for livestock unit

Animals	Livestock Units
Cow and Oxen	1.00
Heifer	0.75
Calf	0.25
Weaned Calf	0.34
Horse	1.00
Donkey (Adult)	0.7
Donkey (Young)	0.35
Camel	1.25
Sheep and Goats (Adult)	0.13
Sheep and Goats (Young)	0.06
Chicken	0.013

Storck *et al.* (1991)

Appendix II: Collinearity statistics for variables in the models

Table A 2. 1: Collinearity statistics for variables in the double hurdle model

Variable	VIF	1/VIF
Oxen	2.31	0.433
TLU	2.27	0.440
Land size	2.26	0.443
Remittance	1.82	0.551
Total Annual income	1.76	0.569
Number of plots	1.72	0.582
Participation in non/off farm	1.64	0.608
Household size	1.50	0.666
Member to farmer	1.50	0.667
Cooperatives		
Distance to nearest market	1.49	0.671
Age of household head	1.45	0.692
Access to irrigation farm	1.35	0.738
Distance to farm	1.27	0.790
Labor used	1.26	0.791
Extension visit	1.17	0.857
Access to credit	1.15	0.871
Sex of household head	1.12	0.895
Mean VIF	1.59	

Table A 2. 2: Collinearity statistics for variables in the multinomial analysis

Variable	VIF	1/VIF
Total annual income/Nincome	1.66	0.604
Access to Remittance/ Remit	1.59	0.628
Participation on off/non-farm activities/ Nonfarm	1.57	0.637
Farm land size/Lsize	1.56	0.642
Household Size/Hsize	1.37	0.731
Age of household head/Age	1.36	0.735
Member to farmers cooperatives/Coops	1.28	0.781
Access to irrigation farm/Iuse	1.28	0.783
Distance to nearest Market/Market	1.27	0.784
Livestock holding in TLU	1.24	0.804
Production per year/Prodpyear	1.21	0.826
Education level of household head/Edu	1.18	0.848
Marital status/Mstatus	1.15	0.869
Sex of household head/Gender	1.13	0.882
Agriculture information/agrinform	1.13	0.886
Crop Diversification index/CDI	1.09	0.921
Access to credit/Cuse	1.08	0.926
Mean VIF	1.29	

Table A 2. 3: Collinearity statistics for variables in the Zero-truncated analysis

Variable	VIF	1/VIF
Non/off-farm income (nonfarm)	1.62	0.619
Remittances (Remit)	1.61	0.621
Farm size (Lsize)	1.55	0.645
Total net income (Nincome)	1.55	0.645
Household size (Hsize)	1.36	0.737
Distance to the nearest market (Market)	1.34	0.746
Age of household head (Age)	1.33	0.752
Membership to farmers cooperatives (Coops)	1.30	0.772
Participation in irrigation farming (Iuse)	1.27	0.787
Livestock holding in TLU	1.23	0.816
Education level of household head (Edu)	1.16	0.866
Extension visit (Extenvisit)	1.14	0.876
Sex of household head (Gender)	1.14	0.881
Marital status (Mstatus)	1.12	0.890
Crop Diversification Index (CDI)	1.09	0.918
Use of credit (Cuse)	1.06	0.941
Mean VIF	1.30	

Table A 2. 4: Collinearity statistics for variables in the multivariate analysis

Variable	VIF	1/VIF
Distance to market	4.31	0.232
Distance to health	4.08	0.245
Access to potable water	2.44	0.410
Availability of Toilet	2.25	0.444
Morbidity	2.00	0.499
Household size	1.88	0.532
Participation in off/non-farm	1.56	0.641
Age of household head	1.51	0.663
Children less than five year	1.43	0.699
Total annual income	1.42	0.704
Education of household head	1.41	0.711
TLU	1.39	0.719
Child dietary diversity	1.35	0.742
Access to Electricity	1.29	0.775
Education of mother	1.29	0.776
Farm land size	1.26	0.791
Child sex	1.26	0.794
Access to health services	1.23	0.811
Child age	1.17	0.854
Crop diversification index	1.08	0.923
Mean VIF	1.76	

Table A 2. 5: Correlation matrix of residuals:

	Stunting (HAZ)	Underweight (WAZ)	Wasting (WHZ)
Stunting (HAZ)	1.0000		
Underweight (WAZ)	-0.1685	1.0000	
Wasting (WHZ)	0.0699	-0.0701	1.0000
Breusch-Pagan test of independence: chi2 (3)		= 7.215,	Pr = 0.0654

Appendix III: The questionnaire used for the survey

Crop Diversification, Food and Nutrition Security among wheat dominant producer Rural Households in Sinana District, Bale Zone, Oromia Regional State, Ethiopia

PhD Dissertation Research

Survey Questionnaire

My name is _____ I am working as data collector in the survey. This questionnaire is prepared to generate firsthand data that will be used for the PhD dissertation writing on the topic indicated above. It will help to gather information on households' socio-economic status, agricultural and non-agricultural activities, access for services, asset ownership, food and nutrition status, and other important information. To attain this purpose, your honest and genuine participation by responding to the questions prepared is very important.

I would like to inform you that some personal issues, your answers and ideas are completely confidential and secured. Your name will not be written on this form. I appreciate your kindness to be part of the study. The interview will take about 20-30 minutes.

Questionnaire Identification	
Date	____/____/____
Questioner Identification	_____
Kebele	_____
Gott	_____
Interviewer Name	_____
Sign	_____
date	_____
Supervisor Name	_____
Sign	_____
date	_____

Part I: Household Characteristics

Section I: Demographic and Socio-economic Characteristics			
S.N	Questions	Options of Answer	Skip Rule
1	sex of household head	1 Male <input type="checkbox"/> 2 Female <input type="checkbox"/>	
2	Age of Household head	(_____)	
3	Marital Status	Single <input type="checkbox"/> Married <input type="checkbox"/> Divorced <input type="checkbox"/> Widowed <input type="checkbox"/> Separated <input type="checkbox"/>	
4	What is your Religion?	Muslim <input type="checkbox"/> Orthodox <input type="checkbox"/> Protestant <input type="checkbox"/> Waqefata <input type="checkbox"/> Other	
5	Education Level of household head	Read and write <input type="checkbox"/> Primary school <input type="checkbox"/> Secondary school <input type="checkbox"/> Tertiary school <input type="checkbox"/> Illiterate <input type="checkbox"/>	
6	Number of years of formal education	(_____)	
7	Total number of persons attended formal education in the household	(_____)	
8	What is your household size	Male _____ Female _____	
9	Household size by age category	(_____)	

	Children 5 years age and below	(_____)	
	Children 6-10 years of age	(_____)	
	Children between 11-14 years of age	(_____)	
	A male family member (15-64)	(_____)	
	A female family member (15-64)	(_____)	
	A family member above 65 years of age	(_____)	
10	Main occupation of household head	Farmer <input type="checkbox"/> Civil servant <input type="checkbox"/> Business man <input type="checkbox"/> Employee in private company <input type="checkbox"/> Others	
11	Do you hold land	No <input type="checkbox"/> Yes <input type="checkbox"/>	Go to Q 13
	Land size in ha	(_____)	
	Cropping land	(_____)	
	Grazing land	(_____)	
	Fallow land	(_____)	
	Forest		
	Others		
12	How many plots of land do you own on separate places	_____	
13	Do you use tractors for land preparation?	No <input type="checkbox"/>	Go to Q 16

		Yes <input type="checkbox"/>	
14	Is it easily available for hiring tractors?	No <input type="checkbox"/> Yes <input type="checkbox"/>	
15	If yes to Q number 16 how do you access it	Hiring	
		Cooperative	
		Union	
		Others	
16	Do you use combine harvesters?	No <input type="checkbox"/> Yes <input type="checkbox"/>	
17	Farming experience of the household head?	(_____)	
18	Participation in any irrigation activities	No <input type="checkbox"/> Yes <input type="checkbox"/>	
19	Types of labor used for crop production during current farming season?	Hired labor <input type="checkbox"/> Family labor <input type="checkbox"/>	
Section II: Institutional Characteristics			
1	Did you obtain credit?	No <input type="checkbox"/> → Go to Q 5 Yes <input type="checkbox"/>	
2	Credit is given in what form?	Seed <input type="checkbox"/> Cash <input type="checkbox"/> Fertilizer <input type="checkbox"/>	
3	Amount of credit received	_____	
4	For how many years did you receive credit?	_____	

5	If you have not received credit what are the reasons?	Fear of risk <input type="checkbox"/> Not qualified <input type="checkbox"/> Reason not known <input type="checkbox"/> Religion <input type="checkbox"/> Credit services not available <input type="checkbox"/> Others	
6	Do extension workers visited your farm?	No <input type="checkbox"/> → Go to Q 8 Yes <input type="checkbox"/>	
7	Can you estimate the number of times visited by the extension agents during the cropping seasons?	Once a week <input type="checkbox"/> Twice a week <input type="checkbox"/> Twice a month <input type="checkbox"/> Three times a month <input type="checkbox"/> Once a month <input type="checkbox"/>	
8	Are you member of farmers' cooperatives?	No <input type="checkbox"/> Yes <input type="checkbox"/>	
9	Are you member of local <i>equb</i> and <i>Edir</i>	No <input type="checkbox"/> Yes <input type="checkbox"/>	
10	How far is the nearest market center from your house	____ km ____ walking hrs	
11	How far is the main road from your farm?	____ km ____ walking hrs	
12	How far is Woreda Administrative town from your home?	____ km ____ walking hrs	
13	How far is FTC from your home?	____ km ____ walking hrs	

14	How far is your home from Research Institution?	_____ km _____ walking hrs	
15	How far is the Health center from your home?	_____ km _____ walking hrs	

Part II: Income Generating Activities, Food and Non-food expenditure

1. How many times do you produce within a year? _____

2. Income from crop production (in 2018)

S.N	Types of crop	Plot size/timad		Total production		Consumed at home	Sold	
		Season 1 st	Season 2 nd	Season 1 st	Season 2 nd		amount	Value
A	Cereal							
	Wheat							
	Barley							
	Maize							
	Teff							
	Other							
B	Pulses							
	Faba bean							
	Field pea							
	Harricoat bean							
	Shunburaa							
	Other							
C. Vegetables and Fruits								
	Tomato							
	Pepper							

	Onion							
	Cabbage							
	Potato							

3. Do you rear livestock k? 1. Yes 2.

4. If yes to Q No 3 which of the following domestic animals do you rear?

S.N	Type of animal	Number	If there is any sold Animal	
			Amount sold	Value (in birr)
1	Ox			
2	Cow			
3	Calf			
4	Heifer			
5	Bull			
6	Mule			
7	Horse			
8	Donkey			
9	Goat			
10	Sheep			
11	Poultry			
12	Bee colony			

5. Household Income from sales of livestock in 2018

S.N	Livestock type	Number sold	Amount in Birr

6. Household income from livestock output in the last 12 months

S.N	Commodity Types	Amount Produced (Liter,Kg.,No)	Consumed (Liter,Kg.,No)	Sold (Birr)
1	Dairy Out put			
	Milk			
	Butter			
	Yoghurt			
	Cheese			
	Others			
2	Poultry			
	Egg			
	Chicken			
3	Honey Bee			
	Honey			
	Bee Wax			
	Bee Colony			
4	Animal byproducts			
	Hide and Skin			

7. Did you obtain Gift/remittance in the last 12 months? 1. No Yes

8. If Yes amount of Gift/remittance in birr _____

9. Do you or any member of your family has involved in the last 12 months on non/off farm activities? 1. Yes 2. No

10. If the answer is yes, in which one from the next table

S.N	Off-farm/ non-farm activities	Tick \checkmark mark	Annual income in birr
1	Rent from agricultural machinery, Rent from draft power, and others		
2	Daily laborer on construction or other non- farm activities		
3	Self-employment in manufacturing e.g. Artisan (weaving, pottery)		
4	Sales of wood (Charcoal)		
5	Sales of local drink		

6	Transporting using Carts		
7	Salary from temporary or permanent employment		
8	Trade		
9	Others		

11. Household food and non-food expenditure

11. 1. Household expenditure on purchased food items in 2018

S.N	Type of crops, vegetables and others	Consumed from purchased	
		Amount (Kg)	Value (birr)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

11.2. Household's expenditure on non-food items

S.N	Item	Expense
1	Clothing	
2	Transportation and communication	
3	Education	
4	Heath care	
5	Animal health expenses	
6	Gas and other fuel	
7	Social expenses	
8	Government tax	
9	Others	

12.3. Cost of Production for two seasons

S.N	Decryptions	Cost in Birr	
		Season 1 st	Season 2 nd
1	Cost of seed		
2	Cost of fertilizer		
3	cost of pesticides		
4	cost of harvesting		
5	cost of labor involved in man/days		
6	Marketing cost		
7	Transportation cost		
8	Machinery operational cost		
9	Others (specify)		

Part III: Cropping pattern and related activities

1. What is your main crop of production?
2. What are the main constraints for cropping?
3. What are your suggestion to overcome those constraints?
4. If you practice only limited crop what are the reasons?
5. What factors do you take into consideration when deciding what type of crop to grow on a plot? (For example, marketability of crop, soil type, yield, maturity, security, food preference, nutrition, size of plot in relation to quantity and so on)
6. What factors do you consider when deciding how produce will be used?

7. Please fill the following Table for the types of crops produced during the current farming season?

Categories of crop grown	Yes	No	Land size in ha/timad
1. Types of Cereal crop produced			
Wheat/qamadii			
Barleygarbuu			
Maize/boqqoolloo			
Teff/xaafii			
Sorghum/mishingaa			
Oats/a'aja			
2. Types of pulses and oil seed produced			
Faba Bean/baaqelaa			
Field Pea/atara			
Harricot beans/akuwaa atar			
Chickpeas/shunburaa			
Lentils/misira			
Soya beans/ suufii			
Nueg/nuugii			
Rapeseed/talbaa			
3. Types of Vegetables produced			
Head cabbag/ raafuu maramaa			
Lettuce/salaxaa			
Habesha gommen/raafuu			
Tomato/timaatimi			
Green pepper/qaaraa			
Red paper/barbarree			
Others/kan biro			
4. Root crops produced			
Potato/dinnicha			
Onion/qullubbii			
Carrot/kaarotii			
Garlic /shunkurtii			
Sweet potatoes/ shuukar dinnichaa			
Others/kan biro			

Part IV: Food Security Questionnaire

1. Do your families encounter food scarcity within the last 12 months? 1) Yes 2) No
2. If your answer is yes, for how many months? _____
3. Have you or your HH been involved in any food security program in the ‘Woreda’? 1. Yes
2. No
4. If ‘yes’ for Q 3, in which of the following food security programs has your HH been involved?
 1. Productive safety net package program (PSNP)
 2. Enhanced outreach strategy for under 5 children
 3. Relief
 4. Income generation activities
 5. Others, specify
5. How long does your food store usually last after harvest?
 1. Less than two months
 2. Two to four months
 3. Five to eight months
 4. Nine to twelve months

6. Household Food Insecurity Access Scale (HFIAS) Measurement Tool

S.N	Questions	Response Option	Skip Rule
1	In the past four weeks, did you worry that your household would not have enough food?	1 No 2 Yes	Go to Q 2
1 a	How often did this happen?	1 Rarely (1 OR 2) <input type="checkbox"/> 2 Sometimes (3 to 10) <input type="checkbox"/> 3 Often (>10) <input type="checkbox"/>	
2	In the past four weeks, were you or any household member not able to eat the kinds of foods you preferred because of a lack of resources?	1 No 2 Yes	Go to Q 3
2a	How often did this happen?	1 Rarely (1 OR 2) <input type="checkbox"/> 3 Sometimes (3 to 10) <input type="checkbox"/> 3 Often (>10) <input type="checkbox"/>	

3	In the past four weeks, did you or any household member have to eat a limited variety of foods due to a lack of resources?	1 No _____ 2 Yes	Go to Q 4
3a	How often did this happen?	1 Rarely (1 OR 2) <input type="checkbox"/> 2 Sometimes (3 to 10) <input type="checkbox"/> 3 Often (>10) <input type="checkbox"/>	
4	In the past four weeks, did you or any household member have to eat some foods that you really did not want to eat because of a lack of resources to obtain other types of food?	1 No _____ 2 Yes	Go to Q 5
4a	How often did this happen?	1 Rarely (1 OR 2) <input type="checkbox"/> 2 Sometimes (3 to 10) <input type="checkbox"/> 3 Often (>10) <input type="checkbox"/>	
5	In the past four weeks, did you or any household member have to eat a smaller meal than you felt you needed because there was not enough food?	1 No _____ 2 Yes	Go to Q 6
5a	How often did this happen?	1 Rarely (1 OR 2) <input type="checkbox"/> 2 Sometimes (3 to 10) <input type="checkbox"/> 3 Often (>10) <input type="checkbox"/>	
6	In the past four weeks, did you or any other household member have to eat fewer meals in a day because there was not enough food?	1 No _____ 2 Yes	Go to Q 7
6a	How often did this happen?	1 Rarely (1 OR 2) <input type="checkbox"/> <input type="checkbox"/> 2 Sometimes (3 to 10) 3 Often (>10) <input type="checkbox"/>	

7	In the past four weeks, was there ever no food to eat of any kind in your household because of lack of resources to get food?	1 No _____ 2 Yes	Go to Q 8
7a	How often did this happen?	1 Rarely (1 OR 2) <input type="checkbox"/> 2 Sometimes (3 to 10) <input type="checkbox"/> 3 Often (>10) <input type="checkbox"/>	
8	In the past four weeks, did you or any household member go to sleep at night hungry because there was not enough food?	1 No _____ 2 Yes	Go to Q 9
8a	How often did this happen?	1 Rarely (1 OR 2) <input type="checkbox"/> 2 Sometimes (3 to 10) <input type="checkbox"/> 3 Often (>10) <input type="checkbox"/>	
9	In the past four weeks, did you or any household member go a whole day and night without eating anything because there was not enough food?	1 No (quest. is finished) 2 Yes	
9a	How often did this happen?	Rarely (1 OR 2) <input type="checkbox"/> Sometimes (3 to 10) <input type="checkbox"/> Often (>10) <input type="checkbox"/>	

Part V: Dietary Diversity Questionnaire

Write down all food and drinks consumed by the respondent or any household members in last seven days.

S.N	Questions	Example	Yes	No
1	Cereals	maize, rice, wheat, sorghum, millet or any other grains or foods made from these (e.g. bread, porridge or other grain products) + local foods e.g. porridge, pasta, Bread		
2	White tuber and roots	White potatoes, or other foods made from roots.		
3	Vegetables	carrot, squash, or sweet potato that are orange inside + other locally available vitamin A rich vegetables (e.g. red sweet pepper); Dark green leafy vegetables, including wild forms + locally available vitamin A rich leaves such as amaranth, cassava leaves, kale, spinach; other vegetables (e.g. tomato, onion, eggplant) + other locally available vegetables.		
4	Fruits	ripe mango, cantaloupe, apricot (fresh or dried), ripe papaya, dried peach, and 100% fruit juice made from these + other locally available vitamin A rich fruit; other fruits.		
5	Meat	Liver, kidney, heart or other organ meats or blood-based food; Beef, pork, lambs, goat, chicken, other birds, insects.		
6	Eggs	Eggs from chicken or any other egg		
7	Fish	Fresh or dried fish or shellfish		
8	Legumes, nuts and seeds	Dried beans, dried peas, lentils, nuts seeds or foods made from these (e.g. hummus, peanut butter).		
9	Milk and milk products	Milk, cheese, yogurt or other milk products,		
10	Oils and fats	Oil, fats or butter added to food or used for cooking		
11	Sweets	Sugar, honey, sweetened soda or sweetened juice drink, sugary foods such as chocolates, candies, cookies and cakes		

12	Spices, condiments and beverages	Spices (black pepper, salt) condiments (soy sauce, hot sauce), coffee, tea, alcoholic beverages.		
----	----------------------------------	--	--	--

Part VI: Household and Child Characteristics

Section I: Socio-Demographic characteristics			
S/N	Questions	Option of Answer	Skip rule
1	Education level of household head	_____ years	
2	Education level of mother	_____ years	
3	Child's Sex	_____	
4	Child's age	_____ years	
5	Height of child	_____ cms	
6	Weight of Child	_____ Kg	
7	Was (<i>the baby</i>) breastfed or did he or she consume breast milk yesterday during the day or at night?	Yes <input type="checkbox"/> No <input type="checkbox"/>	
8	How many times did (<i>the baby</i>) eat foods that is meals and snacks other than liquids yesterday during the day or at night?	Number of times __ Don't know/no answer __	
Section II: Household access to sanitation, health and other public services			
1	Electricity	Yes <input type="checkbox"/> No <input type="checkbox"/>	
2	Clean Water	Yes <input type="checkbox"/> No <input type="checkbox"/>	
3	Toilet	Yes <input type="checkbox"/> No <input type="checkbox"/>	
4	Health access	Yes <input type="checkbox"/> No <input type="checkbox"/>	
5	Radio access	Yes <input type="checkbox"/> No <input type="checkbox"/>	
6	Mobile telephone	Yes <input type="checkbox"/> No <input type="checkbox"/>	
7	TV access	Yes <input type="checkbox"/> No <input type="checkbox"/>	

Section III: Recent health characteristics			
1	Do any members of your family be exposed to infectious diseases?	Yes <input type="checkbox"/>	No <input type="checkbox"/>
2	Do any members of your family be exposed to water borne diseases?	Yes <input type="checkbox"/>	No <input type="checkbox"/>
3	Had Child diarrhea recently	Yes <input type="checkbox"/>	No <input type="checkbox"/>
4	Had fever recently	Yes <input type="checkbox"/>	No <input type="checkbox"/>
5	Had cough recently	Yes <input type="checkbox"/>	No <input type="checkbox"/>

Part VII: Child Nutrition and related Questionnaire

1. In your opinion, what types of food are good for children to eat?
2. For each type of food mentioned, why is this type of food good for children?
3. What constraints are there to feed the kind of food you mentioned?
4. Do you make any special efforts to feed your children any of the good foods you just mentioned?
5. What role do you play in determining what children eat?

Part VIII: Child Dietary diversity

Yesterday during the day or at night, did (*name of the baby*) eat the following food group?

<i>Group</i>	Food lists	Yes	No
Group 1: Grains, roots and tubers	Porridge, bread, rice or other foods made from grains		
	potatoes, cassava or any other foods made from roots		
Group 2: Legumes and nuts	Any foods made from beans, peas, lentils, nuts or seed		
Group 3: Dairy products	Infant formula	How many times? ___	
	Milk, such as tinned, powdered or fresh animal milk	How many times? ___	

	Yogurt or drinking yogurt	How many times? __	
	Cheese or other dairy products		
Group 4: Flesh foods	Liver, kidney, heart or other organ meats		
	Any meat, such as beef, pork, lamb, goat, chicken or duck		
	Fresh or dried fish, shellfish or seafood		
Group 5: Eggs	Eggs		
Group 6: Vitamin A fruits and vegetables	carrots, sweet potatoes that are yellow or orange inside		
	Any dark green vegetables		
	Ripe mangoes (fresh or dried [not green]), ripe papayas (fresh or dried)		
	Foods made with red palm oil, red palm nut or red palm nut pulp sauce		
Group 7: Other fruits and vegetables	Any other fruits or vegetables		
Others (not counted in the dietary diversity score)	Any oil, fats, or butter or foods made with any of these		
	Any sugary foods, such as chocolates, sweets, candies, pastries, cakes or biscuits		

Appendix II: FGDs Guide

1. How would you describe your farming technique?
2. What is your main crop of production?
3. Is your main activity agriculture or other off/non-farm activities?
4. What are the main constraints for cropping?
5. If you practice only limited crop what are the reasons?
6. Participation in irrigation activities?
7. What factors do you take into consideration when deciding what type of crop to grow on a plot? (For example, marketability of crop, soil type, yield, maturity, taste preference, size of plot in relation to quantity and so on)
8. For a given crop, who in the household makes the decision regarding how the produce will be used? (For example, will the crop be sold for profit, consumed, stored, given away and so on)
9. In your opinion, what types of food are good for children to eat?
10. For each type of food mentioned, why is this type of food good for children?
11. Do men and women have different opinions about what type of food children should eat?
12. Are there any other things that you would like to share with us?
13. Do you have any questions regarding today's discussion?