

**ADDIS ABABA UNIVERSITY  
COLLEGE OF DEVELOPMENT STUDIES  
CENTER FOR FOOD SECURITY STUDIES**

**URBAN EXPANSION AND ITS EFFECTS ON FOOD  
INSECURITY AND POVERTY: EVIDENCE FROM PERI-  
URBAN FARMERS IN AXUM, TIGRAY REGION, NORTHERN  
ETHIOPIA**

**BY  
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**ADDIS ABABA UNIVERSITY  
JULY 2021**

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SCHOOL OF GRADUATE STUDIES  
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### Declaration

I, the undersigned, declare that this Ph.D dissertation is my own course of study and research work except where indicated by a reference. All sources of information other than my own have been clearly acknowledged both in the text and references. This work has not been previously submitted to any other university for the award of any type of academic degree.

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As supervisors of the dissertation, we certify that we have read and evaluated the dissertation prepared by Shishay Kahsay Entitled ‘Urban Expansion and Its Effects on Food Insecurity and Poverty: Evidence From Peri-Urban Farmers In Axum, Tigray Region, Northern Ethiopia’ and recommend for Open Defense as fulfilling the requirement for the degree of Doctor of Philosophy in Development Studies (Food Security and Development).

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## List of Abbreviations and Acronyms

AFBD	African Development Bank
ASA	American Statistical Association
ATA	Agricultural Transformation Agency
ATT	Average Treatment Effect on the Treated
CCIP	Complementary Community Investment Program
CIAF	Composite Index of Anthropometric Failure
CRGE	Climate Resilient Green Economy
CSA	Central Statistical Agency
DRMP	Disaster Risk Management Program
EDHS	Ethiopia Demographic and Health Survey
EHNRI	Ethiopia Health and Nutrition Research Institution
EPRDF	Ethiopia People Revolutionary Development Front
FAO	Food and Agriculture Organization
FCS	Food Consumption Score
FDRE	Federal Democratic Republic of Ethiopia
FIVIMS	Food Insecurity Vulnerable and Information Mapping System
FS	Food Secured
GII	Gender Inequality Index
GTP I/II	Growth and Transformation Plan one/two
HABP	Household Asset Building program
HDDS	Household Dietary Diversity Score
HDI	Human Development Index
HFBM	Household Food Balance Model
HFIAS	Household Food Insecurity Access Scale
HHS	Household Hunger Scale
IFAD	International Fund For Agricultural Development
IFPRI	International Food Policy and Research Institution
IHDI	Inequality-adjusted Human Development Index
IRR	Impoverishment Risk and Reconstruction Model
Lu/Lc	Land use and Land cover
MFI	Mild Food Insecure
MCD	Multidimensional Child Deprivation
MODA	Multiple Overlapping Deprivation Analysis
MoFEC	Ministry of Finance and Economic Corporation
MoFED	Ministry of Finance and Economic Development
MoFI	Moderately Food Insecure
MoRAD	Ministry of Rural and Agricultural Development
MUDHCo	Ministry of Urban Development, Housing and Construction
MPI	Multidimensional Poverty Index
NNP	National Nutrition Program
PASDEP	Plan for Accelerated and Sustained Development to End Poverty
PSM	Propensity Score Matching
PSNP	Productive Safety net Program
RED/FS	Rural Economic Development/Food Security

SDPRP	Sustainable Development and Poverty Reduction Program
SPP	Social Policy Protection
TLU	Tropical Livestock units
TSA	Tigray Statistical Agency
UN DESA	United Nations Department of Economics and Social Affairs
UNDP	United Nations Development Programme
UNFPA	United Nations Population Fund
UNICEF	United Nations Children's Fund
VRP	Voluntary Resettlement Program
WFP	World Food Program
WHO	World Health Organization
WOARD	Woreda Office of Agriculture and Rural Development

## Abstract

*Spatial urban expansion in developing countries, not exceptional Ethiopia, puts immense pressure by taking peri-urban fertile agricultural land to buildups. Thus, this study aims to investigate the impact of urban expansion on household food insecurity and poverty. A mixed-method explanatory sequential research design was applied. Crossectional data were collected from 341 households where 101 partially displaced and 240 not-displaced households using a survey questionnaire and qualitative data were generated from focus group discussion and key-informant interviews. Food security status of households was measured using different indicators to capture the key dimensions of food security. Likewise, the nutritional status of children under five ages was measured using anthropometric measurements and composite index anthropometric failure. The determinants of food insecurity were analyzed using binary and ordered logistic regression models. The multidimensional Poverty Index was applied to measure household poverty. Similarly, binary logistic regression was applied to identify determinants of multidimensional poverty of households. Stochastic frontier analysis was employed to estimate production efficiency while associated factors that affect production efficiency were analyzed using the Tobit model. Lastly, a multivariate probit model was applied to examine agricultural technology adoption of smallholder peri-urban farmers. The impact assessment of food availability showed that displaced households consume 146 kcal less than non-displaced households with no statistical mean difference between displaced and non-displaced households. The prevalence of multidimensional poverty was higher among displaced households with a statistically significant mean difference between displaced and non-displaced households. Living standard and health dimensions highly contribute to overall household multidimensional poverty. The production efficiency showed non-displaced households were technically, allocatively, and economically efficient than displaced households. Displaced households' tendency to adopt agricultural technology was lower than non-displaced households. Generally, urban expansion intensifies poverty, reduces production efficiency and technology adoption of households. The researcher recommends Bureau of agriculture should tirelessly work to increase production efficiency as priority agenda to halt the food insecurity and poverty of the study area.*

**Keywords:** Agricultural technology; Production function; PSM; Regression; Stochastic frontier analysis; HFBM

## Chapter 1: Introduction

### 1.1 Background of the Study

Globally, human population is expected to reach 8.5, 9.7, and 10.9 billion by 2030, 2050, and 2100, respectively (UN DESA, 2019). The report showed from these, nearly 60 to 70% are expected to live in urban areas. Despite the global concern, urban population growth, and urban expansion are forecasted to be immense in developing countries, particularly in Asia, Africa, and Latin America (Seto *et al.*, 2012; UNDP *et al.*, 2009). This unrestricted urban expansion and sprawling waved heavy pressure on fertile agricultural lands. Terminski (2013) reported that close to 15 million hectares of agricultural land are transformed into development projects every year. He suggested that this displacement has a salient impact on old people, women, and children. Similarly, Aboda *et al.* (2019, p. 1) confirmed that 'in most developing countries, urban expansion has been noted for increasing ecological and social vulnerability, thus leaving the affected people displaced, disempowered and destitute'.

The unprecedented expansion of residential areas has put a burden on agricultural land and shifting the livelihood of peri-urban farming communities (Samat *et al.*, 2011). D'Amour *et al.* (2017) proved that fertile land, which was 1.77 times more productive compared to the world average, was continuously converted to built-up. Land available for crop production is congested and food production is declining (Chen *et al.*, 2009; Jiang *et al.*, 2013). This is mainly happening in developing countries, particularly in Africa, where tight competition is being created away land for agriculture, building, and construction (Montgomery, 2008). Due to the failure of urban planning, negative ramifications of urban expansion are reported in various developing countries.

Different perspectives have been growing about the impact of urban expansion on peri-urban farmers. Abdissa (2005) and Zasada (2011) criticized that urban expansion dwindles green open areas, demolished landscapes, and aggravated environmental degradation. Besides, it exposes to air pollution and open sewerage which affects food production, nutritional quality, food safety, and the food system in general (Ekpenyong, 2015; Holdaway, 2015). Others also stated that it affected

food production and food consumption habits of peri-urban farmers (Jiang *et al.*, 2012; Long & Zou, 2010; Mezgebo, 2014) and exacerbate poverty, food insecurity, exclusion, and alteration of livelihoods (IFAD, 2017; Osei-Asare & Eghan, 2013). Contrarily, Alaci (2010) assured that urban expansion had unprecedented role in transforming the economy of nations as it accounted for 50-80% of the Gross Domestic Product (GDP) of nations if properly managed. Otherwise, it opens a route to poverty and food insecurity (UN-Habitat, 2017). It strengthens peri-urban farmers by facilitating access to market, education, employment opportunity, technology, and health services (Abass *et al.*, 2013; Aberra & King, 2005; Ashong *et al.*, 2004).

Urban expansion and increasing individual income demand additional food production (Osei-Asare & Eghan, 2013; Satterthwaite *et al.*, 2010). Hence more food production is expected from the producer, which puts pressure on local food production and distribution systems (Frimpong, 2013). And land demand imbalance is created between construction and crop production (Ahmad *et al.*, 2016; Bagan & Yamagata, 2014; Thebo *et al.*, 2014). As a result, extended fertile agricultural land is converted to buildings, with a devastating impact on food security and poverty the peri-urban farmers', particularly in countries like Asia and Africa (D'Amour *et al.*, 2017; Puma *et al.*, 2015). As nearly 60% of the world's crop grown using irrigation is found near urban areas. Marshall and Randhawa (2017) buttressed poverty was intensified in peri-urban areas coupled with severe environmental degradation. In the future urban expansion utilizes 1.8-2.4% of available cropland (D'Amour *et al.*, 2017).

Ethiopia is the least urbanized (18%) in Africa and its economy heavily depends on agriculture (Alacia, 2010). Agriculture contributes about 34.1% of the Gross Domestic Product (GDP), 79% share of total employment, and generates 79% of the foreign exchange (Diriba, 2020). Besides, out of the total agricultural land devoted to food production, 90% is owned by smallholder farmers and produces about 85% of total agricultural output (FAO, 2015). Despite this, urban expansion in Ethiopia is increasing at an alarming rate and urban population grows by 5% per/year (MUDHCo, 2016). The same report revealed that Ethiopia's total population was about 90 million in 2015 of which urban population was 18 million people. However, in 2025 and 2035 urban population is estimated to be 30-35 and 49-55 million, respectively (MUDHCo, 2016). Imagine how much burden will be created in the peri-urban smallholder farmers' land in the near future. Urban expansion is inevitable and has a significant role in the economic growth of countries.

However, in countries like Ethiopia, where agriculture has a lion's share in the economic growth of the people, urban expansion should be handled in ways that improve the economy and social well-being of the urban and peri-urban communities. As urban expansion provides more room for the non-food producer, it also creates an extra burden on food demand (Satterthwaite et al., 2010). Unless urban expansion is going with proper planning, it will be a driving force to poverty, food insecurity, and environmental degradation (MUDHCo, 2016).

In Ethiopia, urban physical growth rate is higher than infrastructure development and service provision (Terfa et al., 2019). This is due to unregulated and unplanned urban expansion and the weak response of the government to urban expansion (Ayele & Tarekegn, 2020). Similarly, Ayele and Tarekegn (2020) stated that loss of agricultural land had direct consequences on food production of smallholder peri-urban farmers, and recommended that the government should aggressively work on unregulated horizontal urban expansion to agricultural land to mitigate bad outcomes.

As is the case in other parts of Ethiopia, outward urban expansion to peri-urban farmers is commonly practiced in cities and towns in Tigray. Urban boundaries are stretched aggressively to agricultural land and peri-urban farmers are shifting their livelihood to non-agricultural practices such as daily laborer and petty trading (Mezgebo, 2014). The rate of urban expansion in zonal cities including rural kebeles is alarming in the region. Addisu (2015) reported that farmers in the region lost fertile agricultural lands with minimal compensation.

The city of Axum is among the rapidly growing cities in Tigray. Its population increased from 63,435 to 74, 007 from 2014 to 2017 (CSA, 2017). Thus extra land is demanded in the outskirts for housing and other development projects. For different reasons, the city is expanding extensively along the south and southeastern direction by taking prime agricultural land. The existence of prominent hills (Bete-Giorgis and Mai-Qoho) and big gullies (Mai-Melahso) prevents the expansion of the city towards the north direction. Besides, archaeological sites and other historical heritages in the northwest direction, construction of multi-storeyed buildings that can block the sight of the historical sites of Axum, including the ark of the covenant of Mariam Tsion and the obelisks, is legally prohibited. Therefore, due to the above-mentioned geographical and legal barriers, the expansion of the city is confined only to the south and southeast direction.

Hatsebo and Modegue are the two *Tabias* located in the South and Southeast where the expansion is taking place. These *Tabias*<sup>1</sup> are known for their tef production. Besides, these *Tabias* have groundwater that encourages farmers to harvest twice or three times a year using irrigation. In light of this, investigating urban expansion and its implication to food insecurity, poverty, the pattern of resource utilization, and agricultural technology adoption is timely and demanded.

## 1.2 Statement of the Research Problem

The rate of horizontal urban expansion in Africa is unprecedented and has been increased over the years rapidly (Montgomery, 2008). What is most worrisome in the continent is that the modern sectors are not strong enough to utilize the additional labor coming out from the rural areas (Oqubay, 2019). Apart from this, the ever-expanding horizontal growth of urban areas shrinks the land size devoted to crop production and displaces smallholder peri-urban farmers who reside in the outskirts of urban areas. Unluckily, these rural households don't have adequate productive assets that enable them to participate in other off-farm activities and additional skills other than farming to be employed in industrial sectors (Mezgebo, 2014). Because of this, horizontal urban expansion is seen as one of the development challenges of African economies. Hence, the recent development pathways including SDGs-2030 (Goal 11) have explicitly considered sustainable cities and communities as one of the future development agendas of the developing countries (UNDP, 2015).

Ethiopia is not an exception and even, the problem might tend to be prominent as the country is one of the most populous countries in Africa with dramatic urbanization (MUDHCo, 2016). Ethiopia has a weak manufacturing sector which contributes only 6.8% to the GDP (NPC, 2019) with a marginal role in job creation and limited effect on stimulating domestic linkages (Oqubay, 2019). This is because the sector is dominated by small firms that do not utilize the excess labor coming out from the rural farming population.

Tigray, one of the regions in Ethiopia, has an economic structure more or less similar to the nation, with 0.75 ha average landholding per rural household, and horizontal urban expansion is mounting intensely (TSA, 2020). Especially, Axum city is among the spatially growing cities in Tigray, the satellite image of land-use/land-cover shows from 1980 to 2020 a total of 1748 hectares of land is

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<sup>1</sup> is a Tigrigna term which refers to the smallest local administrative unit in Ethiopia which defined geographic area.

converted to buildups and its population also increases from 63,435 to 74, 007 in the last three years from 2014 to 2017 (CSA, 2017). It is one of the main tourist destinations in Tigray where private sectors are demanding land to construct hotels and small enterprises, and the tef potential farming land is being converted to buildups. As a result, swift horizontal urban expansion is shrinking the average landholding of smallholder peri-urban farmers and displaces rural residents with insignificant compensation. It is known that poverty is atrocious in Tigray with a prevalence rate of 27% (World Bank, 2020). Thus efficient resource utilization and adoption of agricultural technology is key to improve the livelihood of households by enhancing food production to tackle food insecurity and poverty of smallholder peri-urban farmers.

The upswing of horizontal urban expansion lures researchers to investigate its impact on the livelihoods of rural residences and to reveal the ramifications on farmers' livelihood. For instance, Abdissa (2005), Addisu (2015), Bekele (2010), Ekpenyong (2015), Mengistu (2016), and Mezgebo (2014) researched on urban expansion nexus with land use, income diversification, food farming, environment, and farmers perception in Ethiopia and other countries. Apart from these, Addisu (2015) researched urban expansion and farmers' perception in Axum, and Mezgebo (2014) studied the effect of urbanization on welfare and income diversification strategies in peri-urban farmers in Tigray. These studies revealed that urban expansion changes food consumption behavior of households, decreases private assets and consumption expenditure. However, an explicit impact of urban expansion on household food insecurity and poverty is not fully addressed. Apart from these, nothing was done on the effect of urban expansion effect on technology adoption and pattern of resource utilization of smallholder peri-urban farmers in the study area. Land cover/ land use of the study is was not addressed so far. Additionally, the consequence of horizontal urban expansion on children's poverty and the nutritional status did not get attention so far in the study area.

Therefore, this study linked urban expansion to food insecurity, poverty, technology adoption, and pattern of resource utilization. Moreover, this study further applied the recently developed methods of measuring poverty notably the multi-dimensional poverty index, and employed multiple food security indicators to measure household food security and anthropometric measurements to capture the nutritional status of children.

### **1.3 Research Questions of the Research**

1. What is the level of food insecurity, and intensity and incidence of multidimensional poverty among displaced and non-displaced households?
2. Which dimensions and indicators are contributing more to household multidimensional poverty?
3. Does urban expansion increase/decreases the tendency of smallholder peri-urban farmers to adopt agricultural technologies?
4. Does urban expansion affect the production efficiency of smallholder peri-urban farmers?

### **1.4 Objectives of the Study**

The overall objective of the study is to investigate urban expansion and its implications to food insecurity, poverty, resource allocation, and agricultural technology adoption of smallholder peri-urban farmers.

The specific objectives are:

- ✓ Analysing the impact of urban expansion on food insecurity status and associated factors affecting the level of food insecurity of smallholder peri-urban farmers
- ✓ Examining the effect of urban expansion on household poverty status and its determinants
- ✓ Investigating differences in the pattern of resource allocation of smallholder peri-urban farmers, and
- ✓ Revealing the effect of urban expansion on agricultural technology adoption of smallholder peri-urban farmers.

## **1.5 Significance of the Study**

This study has paramount importance at the regional, national, and global levels. So far many studies apply a single food security component and measuring using that single pillar is commonly practiced. However, in this study, a combination of more than two pillars of food security was employed. This is rarely practiced methodological approach to measure food security. Therefore, this is one step forward for the flourishing of the discipline and opens a new opportunity for further advancement of other measuring techniques. Secondly, the impact of horizontal urban expansion has environmental, social, and political implications in the country. Therefore, assessing its impact on peri-urban farmers' food security and poverty advances the knowledge which is not yet studied in the study area. Therefore, the output of the study will boldly indicate to the Ministry of Urban Planning and Construction, policymakers, urban planners, and the Ministry of Agriculture to employ proper urban expansion strategies and to achieve sustainable urban expansion with a win-win approach to meet the requirement of both the urban and rural communities. Lastly, as theoretical and empirical literature in this area is scant, this study serves as an entry point for further studies and serves as additional reference materials.

## **1.6 Scope of the study**

This cross-sectional study was confined to the geographical area of central Zone of Tigray, Northern Ethiopia, which focuses on horizontal urban expansion and its effect on peri-urban smallholder farmers. Specifically, it addresses the impact of urban expansion on food security and poverty of displaced and non-displaced smallholder farmers, factors that affect food security and poverty, resource allocation difference, and technology adoption difference between displaced and non-displaced peri-urban farmers. Lastly, farmers who were already displaced but living in urban areas and whose main livelihood is not farming were not included. Besides, peri-urban farmers displaced after 2017 were not also considered in this study.

## **1.7 Organization of the Dissertation**

This dissertation has eight chapters. Background of the study, statement of the research problem, objectives, significance of the study, scope of the study, and structure of the dissertation are covered in Chapter One. Chapter Two consists of concepts and definitions of terms, theoretical, empirical, and conceptual frameworks of the study. Under Chapter Three, the physical description of the study area, demographic, and socio-economic characteristics of households, research

methodology particularly research approach, research philosophy, sampling procedure, tools, and techniques of data analysis are addressed. Chapter Four presents the result and discussion of urban expansion and its implications to household food security, particularly, the food security status of adults, anthropometric measurements, and determinants of food security with their respective econometric analyses. Results and discussions on impact assessment, multidimensional poverty at its determinants are placed under Chapter Five. Chapter Six presents technical efficiency, allocative efficiencies, and determinants of technical efficiencies. Chapter Seven covers technology adoption of peri-urban farmers. Lastly, conclusions and policy recommendations are organized in Chapter Eight.

### **1.8 Limitations of the Study**

This study fails to address the following issues. Urban expansion is a pressing issue across the Tigray region however the study was limited to Axum town. Financial constraints mainly limit the researcher to research the regional and national levels. Secondly, the lack of baseline data forces the researcher to use cross-sectional data. However, if data were not a constraint the study could reflect the picture of households' poverty and food insecurity before and after displacement. Lastly, the data were mainly derived from quantitative data because the objective of the study was to give a clear comparison among the displaced and non-displaced households. However, the above-mentioned limitations did not affect the quality of this study.

## **Chapter 2: Review of Related Literature**

### **2.1 Definitions of Basic Concepts**

#### **2.1.1 Displacement**

Displacement could be voluntary or involuntary. Voluntary displacement happens by the free will of the community whereas, involuntary displacement is forced displacement by the government due to development projects. It is important to note that for this study involuntary displacement is applied (Cernea, 2006). Displacement has not a single definition but for this study, two definitions were discussed. Two prominent debates were grown in defining displacement. In the first debate, a person is considered displaced if there is geographical relocation. Losing farming land does not mean a person is displaced as far as his homestead does not lose. The second debate, if a person has lost his farmland without being geographically relocated, he will be considered displaced. They lost part of their house is not only the roof above the head, but it is also land as well. The land is a priceless resource to smallholder farmers, losing their land is translated to decreasing annual food production. The AFDB came with a broad definition of displacement;

*Loss of assets or involuntary restriction of access to assets including national parks, protected areas, or of national resources; or loss of income sources or means of livelihood as a result of projects, whether or not the affected persons are required to move. (AFDB, 2003, p. 19)*

This definition is very broad and sided to protected areas. So the reliable definition underpins this study is When people lose part of their legal property either productive land or other income-generating assets without being geographically relocated (Cernea, 2006).

#### **2.1.2 Urban Expansion**

Urban expansion has not a single definition that all academia and policymakers agreed on in common. The term is also creating confusion with urbanization, urban growth, and urban sprawl (Satterthwaite *et al.*, 2010). Yar (2017) defined urban expansion as the spread-out of urban areas and its suburb to nearby areas through physical expansion coming from population soar or functional change due to space and land uses or a combination of both. Harper and Guttmann (1967) Urban sprawl outside the city boundaries or any expansion of urban structure of the city and spread by the sprawl process without being bound by the boundaries of the areas where the operation occurred” p.23.

Urban expansion varies from city to city depending on the size of the cities and population and different functions. For this study, urban expansion refers to the physical or spatial expansion of build-ups to agricultural lands. urbanization is a structural transformation, where the number of people living in urban areas increases and the number of people living in rural areas declines (Satterthwaite *et al.*, 2010). Whereas, urban growth refers to an absolute increase in the population of towns and cities (Bloch *et al.*, 2015). It is important to note that urbanization can occur as far as rural-urban migration and rural natural growth are there. And continues even after urbanization stops and without urban growth to promote a lower population density of a community (Bloch *et al.*, 2015).

urban sprawl is defined as “a low density, auto-dependent land development taking place on the edges of urban centers, often “leapfrogging” away from current denser development nodes, to transform open, undeveloped land, into single-family residential subdivisions, campus-style commercial office parks, and diffuse retail uses”(Soule, 2006, p. 23). Al Tarowneh (2014) also described urban sprawl as unregulated, uncoordinated, and uncontrolled expansion of urban areas to free land of suburban it might be to archaeological sites, potential water sources, and biodiversity-rich areas for constructions.

### **2.1.3 Food Security**

FAO defines food security exists “when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life”(FAO, 1996, p. 2). This definition has four important components of food security; (I) the availability of sufficient quantities of food bred from own production or supplied through imports; (II) access, an individual has the right to entitled to the five assets to produce the required foods items; (III) utilization, individuals should get an adequate diet (both in quantity and quality), clean water, sanitation, healthy and hygienic environment, and healthcare to reach a state of nutritional well-being to meet all physiological needs, and (IV) stability, a population, household or individual must have access to adequate food uninterruptedly (Simón, 2012). Therefore, individuals who failed to meet the above criteria are food insecure.

Based on the time frame, food insecurity could be chronic and transitory food insecurity. Chronic food insecurity is related to long-term or persistent inability to meet the minimum requirement or a continuous inadequate supply of diet resulting from lack of resources to produce or acquire food

whereas transitory food insecurity is a year to year or interim food deficit (Reutlinger, 1986). Devereux (2009) also defined chronic food insecurity as a long-term phenomenon affecting households that persistently lack the ability either to buy or reap enough food which is linked with poverty. Whereas, transitory food insecurity is a temporal or seasonal shortage of food resulting from unexpected factors for a short period associated with seasonal instability in food supply or availability and fluctuation in prices and incomes (Tolosa, 2002).

#### **2.1.4 Poverty**

There are two different and complementary approaches to define poverty namely welfare/monetary and non-welfare approaches. The welfarist defines poverty: Poverty is a lack of money to meet human necessities (Ravallion & Chen, 1997). Whereas the non-welfarist criticize merely a monetary-based definition of poverty though it is an integral component to define poverty. The non-welfarist treats poverty as a multidimensional deprivation and define; Poverty as a situation where people are exposed to low income, patchwork, low educational status and unable to send their children to school, poor health facilities, unsafe drinking water, and faces social exclusion and feel powerless, not exercising democracy, and living in a precarious environment (Abraham & Kumar, 2008; Alkire & Foster, 2011; Cohen, 2010; Klugman, 2011; Sen, 1999). Therefore, poverty encompasses different dimensions of deprivations that relate to human capabilities including consumption and food security, health, education, rights, voice, security, dignity, and decent work (Alkire & Santos, 2010).

#### **2.1.5 Technology Adoption**

Technology refers to the amalgamation of people, tools, knowledge, and systems or the environment to bring economic development and make life easy (Porter, 1985). Rogers (2003) also defined “an idea, practice, or object that is perceived as new by an individual or other units of adoption” (p.12). Whereas technology adoption refers to the best decision to use innovation optimally by different economic groups regularly (Rogers, 2003). Similarly, Feder *et al.* (1982) stated the integration of new technologies to farmers' farming practices for a long period. In general adoption of technology depends on farmers' capacity to use new technology and its timeliness (Sunding & Zilberman, 2001).

Agricultural technology refers to physical objects like high-yielding seeds, fertilizers, herbicides, pesticides, and farming systems to improve agricultural productivity (Baum, 2012; Shita *et al.*, 2018). Agricultural technologies have a different characteristic that influences the adoption capacity of farmers (Adesina & Baidu-Forson, 1995).

### **2.1.6 Technical and Allocative Efficiency**

Production efficiency is a means to boost productivity with small combinations of inputs and in the most profitable way (Johansson, 2005). Added also it has great importance to use limited resources devoid of wastage. Technical efficiency measures firms' ability to distribute a set of inputs to produce optimum output whereas allocative efficiency is about increasing profit with the most possible cost-minimizing combination of inputs (Farrell, 1957). While the product of technical and allocative efficiency measures yields economic efficiency. Therefore, increasing agricultural production efficiency helps farmers to produce more crops either for direct consumption or selling surplus products to diversify their food consumption thereby attaining household food security.

## **2.2 Concepts and Theoretical Foundation of the Research**

These four distinct but interrelated concepts in this research notably food insecurity, poverty, production efficiency, and agricultural technology adoption were reviewed. Thus important concepts and theories were entertained in connection with the effect of horizontal urban expansion on smallholder peri-urban farmers.

### **2.2.1 Concept of Rural-Urban Linkage**

Economic and social theory are among the theories which focus on how urban area is formed. Economic theories strongly argue that urban area is formed by producing surplus marketable agricultural products (Harvey, 1973). This, in turn, facilitates the growth of small towns to exchange excess products and to get other services. The social theory does not deny the importance of economic importance, but the core element for urban formation is through strong human and interpersonal interactions and social and cultural ties which encourage people to live compactly and concentrate in space (Clark, 2004).

Furthermore, theories like growth pole theory, urban-bias theory, and central place theories also try to link its consequences with poverty and food security of the people. A proponent of growth

pole theory argues that eradicating poverty in developing countries is realized through capital-intensive industries in the core and regional cities. This industry will have gradual changes in economic growth and performance of rural people by trickle-down effect, though it seems a top-down approach (Rondinelli, 2019; Unwin, 2017). Most of the time, its backwash effect is greater than its spread-out-effect by the exploitation of rural resources and expands rural poverty by creating a core-periphery relationship (Unwin, 2017; Zeleke, Trutmann, & Denekew, 2007). In general, though it is challenging to apply in populous countries, it is still working in developing countries as urban areas are considered as the center of modernity and technologies. Central place theory focuses on promoting market towns in rural areas to access goods and services to minimize the distance in getting goods and services between urban and rural areas (Webster, 2002). The main theme of this theory distance from the central area, those who are close to the central location have a large population and better access to goods and services than those found apart (Davies, 1992; Preston, 1971). This theory also does not consider purchasing capacity and price variation among market centers and the diversity of goods and services they get.

Urban-bias theory initiated by Lipton (1975) excludes the rural community;

*The most important class conflict in the poor countries of the world today is not between labor and capital. Nor it is between foreign and national interests. It is between the rural classes and the urban classes. The rural sector contains most of the poverty, and most of the low-cost sources of potential advance; but the urban sector contains most of the articulateness, organization, and power. ( p. 13)*

He critically criticized that resources are unevenly distributed between urban and rural areas, the government keeps the interest against rural people, policies and edicts are designed by the urban elite, and the urban get cheap food at the expense of the rural. Except the rural wealthier farmers get subsidies, the smallholder subsistence farmers are subjugated to sell their products at distress value to larger farmers or to join the rural-urban migrants (Unwin, 2017). Lofichie (1997) also claimed, for political survival, the government attains the economic interest of the urban affluent than devising an inclusive approach, which addresses the interest of rural smallholder farmers to address poverty and food insecurity.

In sum, the above theories, some of them are explaining how urban area is formed. The two theories are tried to link their role in addressing poverty and attaining food security through market integration and industrialization in urban areas. Urban-bias theory focuses on urban areas, even in the urban areas, better-off people are benefited. This was intentionally designed for political

survival of the ruling powers. Therefore, the above-stated theories do not explain properly the issues under investigation.

Compared to the above-stated theories, the rural-urban linkage is an appropriate theoretical foundation and shows the association of urban expansion and its possible implication to poverty and food security of peri-urban farmers. Rural-urban linkage becomes popular between the 1980 and 1990s. The critics of the above-stated theories and the contribution of pro-urban and anti-urban views take their lion's role for its popularity (Davoudi & Stead, 2002). Rural and urban are not only linked in production and consumption but also they are socially, politically, environmentally, physically linked (Zeleeke *et al.*, 2007). Besides, there is a flow of commodities, people, cash, information and services (Dávila, 2002; Tacoli, 2002).

However, previously it is uncommon harnessing and integrating rural and urban together. Urban planners only focus on issues about cities; similarly, rural development policies and strategies focus only on agricultural production and productivity, despite the impact on urban areas (Davoudi & Stead, 2002; Von Braun, 2007). Even big organizations like the World Bank were not designed synergetic strategies and goals to address rural and urban poverty, food insecurity, and environmental problems in common. Hence they designed separate development documents for urban and rural areas although the ideology is changed later. Proponents of the rural-urban approach boldly argue that an in-depth understanding of the uniqueness and similarity, and designing a holistic win-win system is necessary to tackle the prevalence of poverty, food insecurity, and degradation of resources in peri-urban farmers. As a result, most of the time rural-urban linkage is symbolized by the virtuous circle model to show the positive linkage between them. The central thesis of this model is; urban centers have a positive contribution to peri-urban farmers through market access to agricultural enhancing inputs, social services like education, health, extension, and credit institutions to produce a marketable surplus and to grow the rural income. Rural people demands, in turn, industrial consumer goods and services, this initiates non-farm income-generating activities and urban income also boosts (Evans, 1992). Finally, this will also increase the opportunity of non-farm income sources to the farmers (Webster, 2002). So to secure the full advantage of this model strong backward and forward sectorial linkages should be in place (Tacoli, 2002).

Many literatures imply the practical application of this model is questionable. Due to this, scholars and policymakers argue that rural-urban linkage has positive and negative implications on poverty and food security of peri-urban farmers as a consequence of urban expansion. The advocators of a positive result of rural-urban linkage justify their concern with evidence. Peri-urban farmers easily sell perishable and non-perishable surplus agricultural produce (Akkoyunlu, 2015) and get agricultural enhancing inputs with minimal transport costs (Berhane, 2016). Likewise, farmers get appropriate and timely information on the price of agricultural outputs and inputs (Tacoli, 2002) and easily access industrial consumption goods while urban people get agricultural produce at a reasonable price (Gehre-Egizabher, 2001). Also, change in consumption behavior of urban areas help peri-urban farmers to diversify the produce demanded products ( Zeleke & Trutmann, 2006).

The rural-urban linkage is also strengthened by migration. The small size of land and Landlessness are the pushing factors for young and adults' rural people for a better life (Gebre-Egziabher, 2005; Zewdu & Malek, 2010). Remittance generated from migrants reduces rural poverty (Deshingkar & Grimm, 2004) and in most cases helps rural senders adopt agricultural technologies and increases productivity, and reduces poverty and food insecurity (Tiffen, 2003). Particularly, peri-urban farmers are advantaged because they are close to urban and reduces costs related to migration and their close social ties as well as the practice of circular migration to access off-farm jobs and exit poverty than the remote rural farmers (Christiaensen *et al.*, 2013). In contrast, Ravallion and Chen (2007) criticize rural migrants for intensifying urban poverty because of their low skills and inability to cope with urban life. Similarly, a reverse transfer from rural to urban areas affects the livelihood of the smallholder farmers (Frayne, 2005) and seasonal food insecurity occurs when urban people migrate to their rural relatives (Djurfeldt, 2015). However, rural-urban migration significantly helps young females to increase their income from non-farm jobs (Berhane, 2016) and help also widowed women to engage in non-farm activities (Krüger, 1998).

Governmental policies and strategies are also important to strengthen the rural-urban linkage thereby fighting poverty and food insecurity of peri-urban farmers ( Zeleke *et al.*, 2007). Gebre-Egziabher (2005) argued, most development policies are inclined either to rural or urban and limit maximum resource utilization to combat poverty and food security. Inversely, (Zeleke & Trutmann, 2006) proved that there are inclusive governmental strategies, like PASDEP, that includes the necessary items for strong rural-urban-linkage, such as all-season roads, access to information,

extension services, facilitating credit centers, expanding primary educational coverage, and different sources of energy to alleviate poverty and food insecurity of rural smallholders. Tacoli (2007) stressed that the decentralization of institutions and power is mandatory for strong rural-urban linkage. She also adds a vertical relationship with the government and agencies to make the local economy flourish. And inter-sectorial backward and forward linkage between agriculture and manufacturing is also decisive because cities serve as an engine for agricultural growth by supplying basic agricultural inputs as agriculture helps for urban industrialization through providing raw materials and food items (Tacoli, 2003). If not, exclusively ill-conceived urban expansion inflicts pressure on natural resources and agricultural land, and peri-urban farmers are exposed to pervasive poverty and faced subsequent marginalization and food insecurity (IFAD, 2017).

Rural-urban linkage has negative consequences to peri-urban farmers emanated from urban expansion. Resource competition and drying of usual income sources of peri-urban farmers are creating a dispute between urban and peri-urban farmers (Zeleeke & Trutmann, 2006). Likewise, chemical substances released from factories and wastes from residential areas are contaminating water bodies used for drinking and irrigation (Azeb, 2006; McGregor *et al.*, 2001). Kelly (1998) stated that the government is focusing on industrialization at the expense of smallholder farmers' means of survival, as a result, farming land is fragmented and adversely affects food security of households. Others also claimed that, causing a change in agricultural practices due to excessive water extraction, intensive irrigation and intensive use of chemical fertilizers and pesticides which results in the chemical and physical change of soil and causes displacement of farmers who cannot afford capital-intensive farming. Smallholder farmers do not have adequate land for collateral to take a loan. As a result, the harvested produce is not sufficient for home consumption and to meet other industrial consumption goods and services (Tacoli, 1998). Moreover, they faced serious labor competition from nonfarm activities (Dávila, 2002). In general, weak rural-urban linkage occurred due to the injudicious distribution of resources, minimal productive assets, and fast urban expansion (DFID, 1999; Tacoli, 1998).

In conclusion, rural-urban linkage demand many inputs to function well and to utilize resources effectively. If the linkage is not integrated and harnessed, it will have negative consequences for

the peri-urban smallholder farmers. To this end, the hypothesis is whether the virtuous circle model works or not in this study area.

### **2.2.2 Concepts and Theoretical Foundation of Displacement**

Few theories are developed from development projects induced displacements. Because when farmers are displaced from their proper areas the issue of economies, environmental, social, and other related concerns are raised. Economists try to address economic issues but they do not address the social trauma of displacement and this calls also anthropologists and sociologists. Under this theory of displacement, only the Impoverishment Risks and Reestablishment Model (IRR) model was discussed. Because Chambers, Rowls, Scudder-Colson, and unbalanced Growth strategy do not systematically address and show the consequences of involuntarily displaced smallholder farmers. For instance, chambers deals with voluntarily displaced, Rowls focuses on the justice of displaced people if their economic status is not improved, an unbalanced growth strategy generally deals with infrastructure development of a country and its spillover effect on the displaced community. Lastly, Scudder-Colson does not understand in terms of economic, social and cultural impoverishment rather it looks at the similarities of people's reaction to involuntarily displacement.

Impoverishment Risks and Reconstruction Model (IRR): Cernea (2003) mentioned taking measures that fetter possible risks of displacement and reducing impoverishing is the central focus of development-induced displacement. This model identified eight important elements that could happen due to displacement landlessness, joblessness, homelessness, marginalization, food insecurity, increased morbidity, education loss, loss of access to common property resources, and social disintegration. The central concern of this theoretical model is forced displacement for the sake of development projects marginalizes and impoverishes more people compared to those who are in better status. Because they are forced to left their productive assets, income sources, and their livelihood in general (Cernea, 1999, 2003, 2006). Therefore, this research hypothesized that whether the IRR model works or not for this study.

### **2.2.3 Concepts and Theory of Food Security/Insecurity**

Poverty and food insecurity are interrelated concepts but food insecurity is the severe stage when households deplete necessary productive assets and consequence of poverty. Food insecurity

occurs when households have lost almost all productive assets. There are different theories of food security and poverty thus all relevant theories were discussed. Among the theory of food insecurity famine theory is one. Famine is the severe stage of food insecurity and natural or man-made factors or the combination of the two are the pushing factors (Webb & Braun, 1994). The funny part of this theory is, man-made factors lead to famine without aggregate reduction of food production at the global or national level due to intentional restriction-free movement of food by the government (Devereux & Maxwell, 2001). There is no single polarized and universally accepted theory of famine as the theory is explained differently depending on the interest and ideological differences of authors. Devereux (1997) breakdown famine theories into Food Availability Decline (FAD), Food Entitlement Decline (FED), and Political Economy Explanations theory.

**Theory of food availability decline (FAD):** the central idea of this theory is, a failure in the physical availability of food undermines the food security status of households. Devereux (1988) argues that anything which disrupts food production, for instance, drought, flood, or war can cause famine. The concept behind this is, natural or man-made disasters cause crop failure and cattle death thereby reducing the availability of food in the affected region, below the subsistence needs of a significantly large number of people for an extended period and famine becomes inevitable. However, this theory fails to consider food production is only one source of food, because local shortages of food can be met by purchasing from surplus production. Secondly, local food availability decline to be translated to famine other means of food access must dry. Lastly, this theory fail to consider vulnerability context local food shortage did not affect all communities equally.

Regardless of its limitation, this theory identifies that demographic factors and natural hazards are the key factors that inhibit attaining food security. These factors put pressure on natural resources and the ecosystem thereby decreases food availability at the household level. There are two contending theories on the effect of population growth on food availability. However, only demographic theory was reviewed as it has a direct linkage with this study. The demographic theory was initiated by Malthus (1798), population pressure competes for agricultural land and facilitates environmental degradation. In most cases, this directly translated to a reduction in agricultural production. The ever-growing population distorts the food supply and demand because

food production grows arithmetically and the population grows geometrically. Consequently, farmers are forced to cultivate marginal lands, fragmented lands, and arable land is split into plots that intensify land degradation and depletion of soil minerals. This reduces agricultural productivity and a critical food shortage will face and many people will be starved and famine becomes inevitable. Devereux (1997) stated that famine happens when there is no food in a given geographical location.

**Theory of food entitlement decline (FED):** this theory integrates both supply and demand sides. This theory brought a radical change in the thinking of food security by introducing the concept of access to food. In Sen's in his Essay on Entitlement and Deprivation food shortage is not a drop in the quantity of food, per se, but rather as a drop in the ability of certain people to "command" food. Certain members of a population could be short of food or starving while the region or nation still produces or imports sufficient calories to feed everyone. However, if a given person or even whole classes of people do not have the necessary capacity or influence to acquire food, they can still starve. There are many critics of Sen in the modern debate, the Essay on Entitlement has become one of the starting points for the discussions of contemporary food crises, just as the Brenner Debate was the starting point for medievalists until quite recently. Sen (1982) asserts that access to food has a significant role to improve the food security status of households. Thus food availability at a global or national level does not guarantee food security rather access to food also matters. He suggested that for instance, the Wollo famine (1972-74) that happened in Ethiopia was not due to local food availability decline rather it was due to transport services were poor that trade and aid transfer were restricted. Access to food is realized through trade, own production, job opportunity, and social networks (Devereux & Maxwell, 2003; Reutlinger, 1985).

**Theory of political economy:** the central idea of this theory is dysfunctional markets and poorly conceived government policies and strategies that lead households to food insecurity. World Bank (2000) evidenced that centuries of poor policies and institutional failure made Africa agriculture undercapitalized and uncompetitive. Therefore, poor urban planning and insignificant compensation are related to governmental policies that disturb the livelihood of smallholder farmers.

In general, though there is no single stand-alone theory of food insecurity, they comprehend the causes of food insecurity. Therefore, urban expansion squeezes landholding of peri-urban farmers, additional labor out of agriculture is not utilized due to weak performance of the industrial sector

of the nation, low educational level of rural households and poor urban planning are pressing issues of the study area. This implies causes of food insecurity are demographic, socioeconomic, and institutional factors, and identifying the determinants of food security is key to address food insecurity.

#### **2.2.4 Concepts and Theory of Poverty**

Internationally and nationally much has been done to eradicate poverty. As a result, poverty has been coming down significantly in developing countries though it remains a priority agenda of the 21<sup>st</sup> century (Headey, 2013). Currently, the sustainable development goal is in practice to eradicate poverty in all its forms everywhere by 2030 (UNDP, 2015). Most reports revealed that poverty is rooted in rural areas (Beegle *et al.*, 2016; Dercon *et al.*, 2008). For instance, in Sub-Saharan countries, about 50% of the rural population lives in less than 1.25\$ per day (World Bank, 2012). As stated by Ravallion and Chen (2007) in Sub-Saharan countries 70% of the poor lives in rural areas it will also remain a concern for the next 50 years. However, rural areas that live near big cities scored lower poverty (Ferré *et al.*, 2012).

Eradicating poverty is creating sectoral debates, whether agriculture or industries are playing a bold role in reducing rural poverty. This mainly emanated from the poor performance of agriculture in reducing poverty in rural areas because in developed countries 20% of the population lives in rural areas and only 5% of the working force engaged in farming whereas in developing countries particularly in South Asia and Sub-Saharan countries 50% of the working force participate in farming. Gordon *et al.* (2007) evidenced that in developing countries the probability of getting poor in rural areas is 40% whereas 10% in urban areas; children are highly affected by severe poverty similarly more girls and women are significantly exposed to absolute poverty. He stated also poverty increases linearly as the number of children in the household increases. Ravallion and Chen (2007) evidenced agricultural growth contributes four times to the reduction of poverty than industries. Another study conducted in India revealed that both agriculture and industries have a similar role in poverty reduction (Ravallion & Datt, 2002). Therefore, investing only in agriculture is not a solution to exit poverty rather investing in non-agriculture is also mandatory to reduce poverty (Dercon, 2009).

Five theories of poverty were reviewed notably: theory of individual deficiencies, theory of cultural beliefs, theory of economic, political, and social distortions, theory of geographical disparities, and theory of cumulative and cyclical dependencies.

**Theory of individual deficiencies:** reveals that individuals are accountable for their poverty situation (Bradshaw, 2006). Though individual motivation and hardworking overcome the problem of poverty, a low genetic quality that undermines intelligence is not easily reversed. This theory is also linked with religious doctrine and constructed individually where being rich or poor is the good will of God (Weber, 2001). Therefore, the dominant factor that pushes to poverty is individual's interest to change their welfare by making proper preferences and investments (Bradshaw, 2006). In some cases, being poor is not due to unable to work hard rather he/she is doing adequately opposite to the productive pathway (Gwartney & Mccaleb, 1985).

**Theory of cultural beliefs:** the central thesis of this theory is, poverty is a result of socially constructed beliefs, norms, and skills that have been passed from generation to generation (Bradshaw, 2006). This theory is derived from the concept of a “culture of poverty” people who live in poor communities will be poor (Lewis, 1966). “Individuals are not necessarily to blame because they are victims of their dysfunctional subculture or culture” (Bradshaw, 2006, p. 8).

**Theory of economic, political, and social distortions:** poverty is a manifestation of a flawed economic, political and social system that hindered opportunity and resources to generate income and improve wellbeing (Bradshaw, 2006). The problem of working poor is lower wage associated with structural obstacles that limit poor workers to access better jobs, limited work opportunities, and lack of growth in sectors that absorb unskilled workers (Tobin, 1993). The political system of the world, Africa in particular favors the wealthier, and participation of the poor is impractical or else deceptive. As a result voice of the poor is hardly addressed and canceled from various development programs that exclude the poor from economic benefits and justice (Addae-korankye, 2019).

**Theory of geographical disparities:** focuses on the spatial distribution of poverty. People, institutions, and cultures in certain areas lack the necessary resources required to increase income and the privileges to claim reallocation of resources (Bradshaw, 2006). Therefore, the concentration of poverty in a specific location is derived from the economic agglomeration concept (Bradshaw et al., 1999). The concentration of similar firms attracts market and other service-providing sectors and pulls other similar firms, contrarily in areas where poverty prevalent, crime and poor social services

aggravate poverty and competitive areas attract more business clusters, drawing away from impoverished communities.

**Theory of cumulative and cyclical dependencies:** this theory is to some extent constructed from the above-discussed poverty theories. The cyclical explanation examines individual situations and community resources as mutually dependent, with a faltering economy. For instance, producing poor resource individuals who lack adequate resources to engage in the economy, worsens the economic survival of the community as people contribute small to the economy due to low tax payments (Bradshaw, 2006). Individual and community poverty are highly interlinked in a cascade of negative consequences, and factories may terminate or other risks can impose individual and community problems including migration of people from a community. Therefore, the interconnectedness of factors making poverty immediately accelerates once a cycle of decline is started (Myrdal & Sitohang, 1957). Others connected with a job opportunity and how it develops to cumulative and cyclical poverty which is the concern of the study area;

*For example, at the community level, a lack of employment opportunities leads to outmigration, closing retail stores, and declining local tax revenues, which leads to deterioration of the schools, which leads to poorly trained workers, leading firms not to be able to utilize cutting edge technology and to the inability to recruit new firms to the area, which leads back to a greater lack of employment. (Bradshaw, 2006, p. 14)*

Furthermore, this cycle also repeats itself at the individual level. Shortage of employment leads to reduction of consumption and expenditure coming from lower-income, and decline saving and spent less on capacity building which translated to low investment. This all also manifested at the community level, potential sources are dried which leads to health impairment, and unable to afford medical and balanced diet costs, and living in precarious areas. Similarly, they are unable to invest in their children due to this children become incompetent and vulnerable to diseases. Finally, determination and self-confidence deteriorated resulted from a lack of job and income. Then it will grow to the culture of poverty (Bradshaw, 2006). In conclusion, the theories of poverty might apply to different contexts or it may apply even in a single community. Some components of these theories are strong enough in underpinning the problem under investigation.

In conclusion, the poverty of Ethiopia is a manifestation of several factors. Therefore, these theories have a strong foundation to underpin the study.

### 2.2.5 Concepts and Theoretical Foundation of Production Efficiency

Production refers to the process of transforming inputs into outputs with a given level of technology (Malinga *et al.*, 2015). Productivity and efficiency are the two interlinked concepts in production theory. Productivity is the ability of smallholder farmers to produce maximum output per unit area (Fried *et al.*, 2008). Whereas production efficiency refers to applying a combination of inputs to produce possible output with reasonable costs (Førsund *et al.*, 1980). Farrel (1957) states that firms are efficient and any actual output variation from the frontier output is attributed to efficiency difference among producers. What is most important is, increasing agricultural production efficiency to compensate for the dispossession of farming land emanated from urban expansion to meet the household requirement.

Production efficiency is classified into technical, allocative, and economic efficiency. Technical efficiency (TE) refers to how best a combination of inputs produces an optimum possible output by firms/smallholder farmers (Malinga *et al.*, 2015). Ellis (1998) also explained it is the extent to which the maximum possible output is produced from the existing combination inputs. Allocative efficiency is the ability of smallholder farmers to produce maximum output at reasonable costs (Farrel, 1957). While economic efficiency is the product of technical and allocative efficiency (Aboki *et al.*, 2013). Bravo-Ureta and Pinheiro (1997) illustrated efficiencies graphically and presented how the efficiency is estimated from the graph.  $TE=OB/OA=CTE/COB$ ,  $AE=OD/OB=CEE/CTE$ ,  $EE=TE*AE=OD/OA=CEE/COB$ .

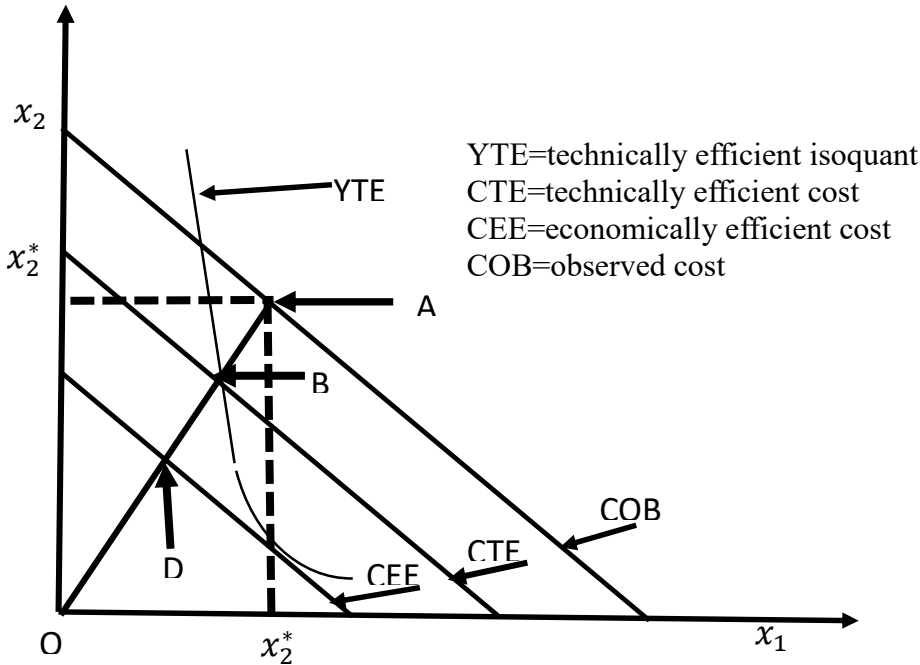


Figure 2.1: Graphical Presentation of TE, AE, and EE

Production efficiency is estimated using non-parametric and parametric approaches notably Data Envelopment Analysis (DEA) and Stochastic Frontier Analysis (SFA). The DEA focuses on the deterministic part of the production function that enhances the maximum possible output and production deviation from the frontier output is only due to external factors beyond the control of the producers but variation due to technical inefficiency is ignored (Coelli *et al.*, 2005). Besides it only consider linear programming and estimates non-parametric frontier output to make efficiency comparison across producers. Generally, DEA does not assume the error term, functional form is imposed to the frontier output, tests to select the best fit model, and producer in the frontier tend to increase with changes in the number of inputs and highly sensitive to input and output selection (Firomsa, 2019).

Aigner *et al.* (1977) are the prominent economists who split the error term into inefficiency and statistical noise/error applying the SFA. This approach allows hypothesis tests and a level of inefficiency about statistical noises. Under this approach, there are two models of production function specification namely Cobb-Douglas and Translog.

In general, urban expansion shrinks one of the important production factors of smallholder farmers. Hence attaining technical, allocative, and economic efficiency of smallholders of the study area is essential. Because efficient farmers boost output production and invest minimum production cost,

and increases household income. Besides the government has been worked to support smallholder farmers to improve productivity thereby overcoming food insecurity and poverty. Therefore, efficient utilization should be the habit of the farmers to tackle the ever-increasing urbanization.

### **2.2.6 Concepts and Theoretical Foundation of Technology Adoption**

Adoption of agricultural technology lures development economists as the majority of developing countries' livelihood relies on agriculture and adopting agricultural technologies enhances agricultural productivity (Feder *et al.*, 1985). Who conceptualizes lack of credit, inadequate farm size, and insufficient human capital are among the factors that hinder technology adoptions of smallholder farmers in Africa. Though there are efforts to solve the problem of market access, credit access, and human capital, however, expectations are marginally realized. Because timely uniform adoption of agricultural innovation is barely practiced among smallholder farmers. Most importantly agricultural technology adoption of smallholder farmers varies across socioeconomic groups (CIMMYT Economics Program, 1993). This is because, some agricultural innovations are disseminated adequately while other innovations are accepted by few groups of farmers (Feder *et al.*, 1985). For this study, Rogers's diffusion innovation (diffusion) theory was reviewed to underpin the research.

“Diffusion is the process by which an innovation is communicated through certain channels over time among the members of a social system”(Rogers, 1995, p. 5). This shows how, why, and at what rate new technologies and ideas are disseminated across the community. The introduction of new technology does not achieve equilibrium shortly due to the variation in the adoption pattern of farmers. Rather learning and demonstration of best works lead farmers to utilize effectively and reach equilibrium (Feder *et al.*, 1985). However, if new technology is modified time and again achieving equilibrium of technology is challenging. Because smallholder farmers hesitate to introduce new agricultural technologies diffused regularly. However, agricultural technologies disseminated in packages for instance pesticides, fertilizer, high yield varieties, and water harvesting technologies increase the probability of farmers adopting the full package or part of the packages. This facilitates the adoption and diffusion of agricultural technologies simultaneously. Generally, The intensity of adoption for the former type of innovation “can be measured at the individual farm level in a given period by the amount or share of farm area utilizing the technology or by the per hectare quantity of input used where applicable” (Feder *et al.*, 1985, p. 257).

Adoption of agricultural innovation will not happen overnight unless reasonably repeated trial and error are made. Rogers specified five hierarchical steps to disseminate an innovation, namely knowledge, persuasion, decision, implementation, and confirmation. Studies proved that successful innovation has S-shaped curve. Most of the time smallholder farmers' decision to utilize innovation depends on cost-benefit analysis. Thus innovation that enhances utility disseminated easily. Based on the bell shape of innovation into five groups namely, innovators, early adopters, early majority, late majority, and laggards. The adoption of agricultural technologies depends on their relative advantage, compatibility, complexity, trialability, and observability<sup>2</sup>.

### **2.2.7 Conceptualization of the Theories**

The different theories help to develop the conceptual framework of the study area. Urban expansion could have positive or negative consequences on dispossessed households. The displacement theory focuses on the negative consequences of urban expansion on peri-urban farmers. Dispossessed farmers are exposed to poverty and food insecurity because in developing countries there are not adequate manufacturing sectors to utilize excess labor coming out from the agricultural sector. Therefore, this theory has implications for poverty and food security in the study area. Similarly, the theory of food security shows the causes of food security and insecurity are diversified. Peri-urban farmers dispossessed from their farmland have a direct impact on the food production of the households resulted from the reduction of farmland size. On the other hand, the Food entitlement Decline shows dispossessed farmers might improve their purchasing power through labor wage, exchange of goods and services through trading, and transfers from inheritance and gifts. The Political Economy Theory proves governmental policies and strategies have an important role to improve or hinder poverty and food security. Urban planning strategies are partially coined and considered the effect on peri-urban farmers as extended agricultural land is converted to buildups with insignificant compensation. The theories of poverty also describe poverty as emanated from different factors, and theory of economic, political, social distortion and theory of geographical disparities, and theory of cumulative and cyclical dependencies were applied to underpin this study. The government has the mandate to reestablish the livelihood of displaced households but practically the support by the government is not adequate. In addition,

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<sup>2</sup> for detail refer Adoption of Agricultural Innovations in Developing Countries (Feder *et al.*, 1985)

due to financial constraints, some of the manufacturing sectors are concentrated in the capital city of Tigray. These affect the poverty of peri-urban farmers.

Urban expansion affects the production efficiency and agricultural technologies adoption of peri-urban farmers. Peri-urban farmers get access to agricultural inputs and outputs to increase agricultural production. Therefore, efficient utilization of resources helps farmers to boost agricultural productivity to reduce poverty and food insecurity in the study area. Moreover, urban expansion helps peri-urban farmers to adopt agricultural technologies to increase agricultural productivity to avert poverty and food insecurity in the study area. So these theories are reviewed to check whether they work or not in the study area.

## **2.3 Empirical Studies**

### **2.3.1 Global Urban Expansion**

In Africa and several Asian countries, urban expansion took place by encroaching peri-urban fertile agricultural land (Firman, 2009). African urban growth is predominantly initiated by natural increment, due to high fertility rates in contrast to Asian (Vimard, 2008). In Eastern Asia close to 40% -70% of the urban population lived in intruded peri-urban areas (Webster, 2002). Convenience to foreign direct investment and globalization makes it more preferred (Wu & Radbone, 2005). A study by Seto *et al.* (2011) on global urban expansion showed that global urban expansion reaches 58000 km<sup>2</sup> from 1970 to 2000 which was 1.3 times the size of Denmark. They also added a large ratio of urban expansion that happened in India, China, Africa, and North America. In their report they mentioned also an urban expansion in developed countries occurred based on their GDP growth rate whereas in developing countries occurred regardless of GDP growth rate. As a result, global urban expansion by 2030 will cover 430,000 km<sup>2</sup> to 12,568,000 km<sup>2</sup>. However, the rate of urban expansion will be varied among countries and regions. For instance, in China yearly rate of urban expansion will vary from 13.3% for coastal areas to 3.9% for the western regions whereas in North America will vary from 3.9 % to 2.2%. Similarly, in African countries will vary also between arid and non-arid areas (Jiang *et al.*, 2012).

Developing countries Compared to developed countries, urban expansion in developing countries occurred in the prime agricultural land (Seto *et al.*, 2000) while developed countries' expansion occurred in protected areas (Radeloff *et al.*, 2010). Empirical studies in different countries indicated that urban expansion has environmental, social, cultural, and economic implications for

peri-urban farmers. For instance, Thou (2013) mentioned that it increased local temperature coming from greenhouse gas emissions from vehicles, factories, and the clearing of vegetation. He added also in Kenya a pungent smell emitted from dairy cow farms to the environment conflicted dairy cow farm owners and non-farm owner residents. Similarly, a key informant in Kenya claimed that they were sick, due to the disposal of liquid and solid wastes to open-air which directly mixed into the drinking wells. Besides, another study in Kenya reported declining soil fertility and environmental degradation was common due to the decline of quality and quantity of arable land and intensified use of the limited land and continued to experience devastating and unpredictable drought and famine repeatedly (Thou, 2010).

Others critically criticize urban expansion and its impact on agricultural production and productivity and its economic impact. A panel econometric analysis study conducted in China indicated that it directly related to declining agricultural production (Jiang *et al.*, 2013) and forced farmers to use farming land intensively which exposed to serious soil degradation and reduce productivity (Ewert *et al.*, 2006). A study conducted by d'Amour *et al.* (2017) showed that in Asia and China 2% of cropland will be converted to development works whereas in Vietnam and Pakistan will cover 5-10%. Generally, the pressure of global urban expansion on agricultural land seemed modest but the impact is rampant among regions. For instance, African countries which are highly affected by this are Egypt, Nigeria, and the region surrounding Lake Victoria Basin in Eastern Africa whereas, in Asia, the hot spots of cropland loss are river valleys and coastlines. On the other hand, crop loss in Mexico and Australia's is very low. In general, 25% of the total global crop loss will occur in China mainly due to urban expansion which affects domestic food availability. Conversely, in countries like India, United States, and Brazil will experience high losses in absolute terms, but due to availability untouched croplands, it less likely threatened domestic food availability (D'Amour *et al.*, 2017).

In general future urban expansion will take place in the prime agricultural land which resulted in 3.7% drop in total crop production (Ahmad *et al.*, 2016; Bagan & Yamagata, 2014) and average land loss for urban expansion was 1.77 more fertile than the average (D'Amour *et al.*, 2017). Their projection for 2030 indicated that 84% of global crop loss will happen in Asia and Africa. A study conducted in China strengthened this, food self-sufficiency is not a concern now but if urban

expansion is continuing at this pace being self-sufficient is questionable shortly (Wu *et al.*, 2011). Another key informant woman from Ghana described her fear as follows;

*It has become difficult to make a living because you can eat only when you have money to buy food. Previously the entire new site was farmland. I grew my own food. I could get vegetables and foodstuffs from the farm without paying it, but now I virtually buy everything even pepper since I no longer have land to farm. We are suffering.* (Abass *et al.*, 2013 p. 7)

Lie and Bin (2008) argued there will be no land for farming if urban expansion is not managed. Another study conducted in Ghana also strengthened this, agricultural land is congested due to urban expansion as a result crop productivity and production were radically dropped but food security programs and intervention minimized the impact resulted from food shortage (Naab *et al.*, 2013). They implied also peri-urban farmers faced one or more of the following; residential house loss, change means of income, jobless, food insecurity, agricultural intensification and commercialization, environmental pollution and degradation, and declining the economic role of agriculture. A study in Ghana strengthened this, more than 50% of households displaced from their farming land were engaged in small-scale business and construction, while 28% were unemployed (Kasanga, 1998). A Similar study conducted in Ghana by Nguyen, Zoomers, and van Westen (2015) showed 23.8% lost their income and 27.5% were exposed to serious food shortages. They also added increased food prices combined with land loss due to urban expansion were suffered by food insecurity.

Others also claimed that urban expansion reduces the labor force in agriculture which finally leads to agricultural food production loss. A study conducted in China showed that diversified off-farm income sources reduced laborers engaged in farming activities (Wu *et al.*, 2011). In Ghana also showed a similar result, farming communities decreased from 89.3% to 40%, whereas non-farming increased from 10.7% to 60% (Abass *et al.*, 2013). Similarly, in Kenya, the number of farmers reduced from 90% in 1970 to 49% with a devastating impact on poverty and food security resulted from the declining economic value of agriculture and decreased households engaged in farming as full-time economic (Mandere *et al.*, 2010). Contrarily, other studies advocate its role in transforming and improving the national economy and well-being of the community. A case study in Kenya and Malaysia implied it created decent jobs for those previously working as farmers and

laborers in farming (Samat *et al.*, 2014; Thuo, 2013). They also added, it provided a better working environment to work on formal work like small-scale business and construction where such activities were absent before. Consequently, their income was increased and livelihoods were improved as well. Another study conducted in Kenya also showed farmers have improved their income sources particularly when the price of agricultural produce was low (Tacoli, 2002). Besides, it helped to decrease vulnerability to seasonal drought and shocks and normalized income variation unless it varies seasonally, and benefited by renting houses to compensate for the reduction of food grains from their farmland (Thou, 2010). It helped easily access the market particularly for agricultural inputs and perishable agricultural products (Njiru, 2016; Thuo, 2013). Moreover, people have practiced zero-grazing and intensified dairy cow farming and improved their nutrition by consuming livestock products, and income sources by selling dairy products, even farmers easily get concentrate animal feed from different agro-processing factories (Njiru, 2016).

In sum, a country-level analysis of data generated from world development indicators and the United Nations' World Urbanization prospects at macro level study indicated the significant negative impact of urban expansion on food security (Szabo, 2016). He further clarified that rapid urban expansion with a poor human development index will experience devastating food insecurity. Moreover, another study in Nigeria also revealed that unplanned urban expansion exposed peri-urban farmers to extreme poverty (Lasisi *et al.*, 2017). However, these limited findings could not lead to extrapolate urban expansion hurts household poverty reduction and food security. Rather it needs further detailed analysis and evidence well.

In conclusion, despite various empirical studies in different countries had been conducted, nothing was said about its clear-cut implication to food security and poverty, whether it has positive or negative consequences. Some studies dictated both the merit and demerit of urban expansion to the farming community. Others also reported more on the negative side of urban expansion. In contrast, many studies also supported the positive impact on farmers' livelihood. Therefore the conclusion is uncovered whether the positive side weighs or negative sides on peri-urban farmers' food security and poverty.

### **2.3.2 Urban Expansion in Ethiopia**

Although Ethiopia is the second populous country in Africa, it is the least urbanized. It ranked behind Sub-Saharan countries, in the level of urbanization (Arup, 2014). However, the MUDHCo

(2016) affirmed that urbanization in Ethiopia is growing fast even in the coming two decades it will grow at a 5% rate which is higher than the average urban growth rate of Sub-Saharan countries. However, a critical issue is raised on the physical urban expansion to agricultural lands. This is mainly, the growth of Physical urban expansion is higher than the urban population growth due to poor urban planning (World Bank, 2015). This report evidenced that the built-up area was increased from 146 people/hectare to 136 people in Addis Ababa.

The level of urbanization has a significant difference among regions in Ethiopia. According to CSA, (2008) reported that stage of urbanization, Addis Ababa (28.4%) Amhara 17.32%) Oromia 17% SNNPR 15.2%, Tigray 15.2% and Gambella 9.62% respectively. This difference in the level of urbanization is prominently due to; infrastructure development, geographical suitability, availability of industries, and rural-urban migration and flow of people (Kassa, 2014). The problem in horizontal urban expansion in Ethiopia does not consider the morale and interest of peri-urban farmers. Rather it going in line with the urban natural growth rate and market development of the urban community, but it is creating conflict between residential people and peri-urban farmers as the planners are ignoring the usufruct right to use the land (Adam, 2014). He added also urban development in Ethiopia seems neglecting usufruct land rights and livelihoods of the local peri-urban communities and is skewed to the urbanities than the local peri-urban farmers. Because peri-urban farmers are exposed to income insecurity and severe food insecurity in Ethiopia (Abdissa, 2005).

Case studies had been conducted on urban expansion and its implication on the livelihood of peri-urban farmers in Ethiopia. Most of the studies used simple descriptive statistics some others also used inferential statistics and econometric models to see the impact. In general, the studies showed that urban expansion in Ethiopia has social, economic and environmental impacts on peri-urban farmers. A study conducted in Sebeta revealed that evicted farmers extremely suffered from social impoverishment (Nigusie, 2011). He justified that displaced farmers were not easily interacted and joined social ceremonies and other income-generating activities. Bekele (2010) also strengthened that they are exposed to social exclusion because they have limited familiarity with people outside them, as a result, they have cohesive intra social networking and relationship than inter-social interactions. Moreover, other social activities like patronal support were broken due to displacement from their natal place. Mezgebo (2014), and Paulos and Thomas (2017) also

indicated that female-headed households are severely exposed to poverty and food insecurity than their counterparts male-headed households in Tigray and Wolaita Sodo. It also expanded crime, diseases, and scarcity of affordable housing (Tessema, 2017).

However, most researchers emphasized its economic and environmental impact rather than the social impact. For instance, Niguise (2011) asserted that farmers produced inadequate food to feed their families and unable to rent another farming land due to a shortage of money to compete in the market. Similarly, Addisu (2015) accounted for 55% of displaced households who did not feed themselves more than half a year in Axum. For this reason, about 84.27% strictly opposed overtaking their land to the government for development activities. He also claimed livestock ownership was sharply decreased almost by half. Besides he mentioned that food insecurity increasing as you going away from the rural and close to the urban area peripheries. Another study in Wolaita Sodo revealed that urban expansion and economic performance were inversely related (Paulos & Thomas, 2017). Similarly, it exposed farmers to severe food insecurity and a thin livelihood base in Kombolcha (Belay, 2014). Studies conducted in Addis Ababa evidenced that regardless of the amount of compensations, dispossessed farming households have low income-generating opportunities, and were severely exposed to food insecurity (Leulseged *et al.*, 2012). Another study, researched in Addis Ababa revealed that dislocated farmers were engaged in low income-generating activities like selling local beverages and water (Abdissa, 2005). He also added this economic opportunity was for survival than a choice economic activity to improve and change their life permanently.

Few empirical studies were also reported the positive role of urbanization to improve the livelihood of encroached farmers. For instance, a study conducted in Sebeta showed that it increased access to electricity, communication, market and credit access (Niguise, 2011). Similarly, studies conducted in south Ethiopia Wolaita Sodo and Areka proofed that urban expansion creates job opportunities and access to credit, education, health facilities as well as market access (Paulos & Thomas, 2017; Tessema, 2017).

Others also criticized the compensation system in Ethiopia. The compensation provided to evicted farmers does not consider feeling and wellbeing. In general, it is criticized mainly; the compensation does not cover exactly the resources taken, it is regardless of fertility of the land, family size and current price, inconsistency among regions and within a region, does not consider

moral values, voice, and adequate participation of farmers (Kosa *et al.*, 2017). In Ethiopia, the government is following the win-loss approach in urban expansion. This is mainly, the government does not properly accommodate the issue of peri-urban farmers rather it is biased and pro-urban advantage (Bekele, 2010; Kosa *et al.*, 2017; Mengistu, 2016). On top of this, urban expansion is neither participatory nor done honestly to farmers because they are the third person in their resources. All in all estimation of their resources is based on the good and bad deeds of the experts included in the committee (Kosa *et al.*, 2017). They emphasized that according to the EPRDF proclamation any person displaced from his/her land should be provided compulsory compensation either land or cash or a combination of the two. However, farmers were compensated in cash which is not an appropriate mechanism to rehabilitate farmers due to utilization problems and not adequate to start another means of livelihood. A study conducted in Mekelle reported that 75% of the money was used for buying of food grains (Gebregziabher *et al.*, 2014). Therefore, the non-integrative type of urban development-induced displacement disturbs on those marginalized rural communities and forces them to live in poverty, food insecure and hopelessness. Peri-urban farmers' livelihood only dependent on agricultural before expropriation. After they were evicted from their land, they are hopeless and live in poor economic conditions. Most of the displaced peri-urban farmers are living in economic poverty which needs due attention from all stakeholders.

In sum, in most cases, valuation farmers' resources were highly corrupted. As the estimation is subjective and the number of experts who participated is few. Usually, farmers are complaining about the estimation procedures, amount of compensation, guidelines, and implementation but nobody responded to their cases. Besides, the expropriation process and follow-up process are weak. As a result, they are vulnerable to social, economic and environmental problems and victimized by poverty and food insecurity (Kosa *et al.*, 2017). Gebregziabher *et al.* (2014) stressed the non-scientific valuation of resources, delayed payment, and lack of training are also the problems that jeopardize poverty and food insecurity of peri-urban farmers.

### **2.3.3 Technical and Allocative Efficiency Tef**

Kassa *et al.* (2019) studied the technical efficiency of tef in smallholder farmers in Ethiopia. They found that tef producers were technically inefficient with a mean efficiency of 73% and ranges from 0.13 – 0.92%. Majority of the producers produced above the mean efficiency level but still, there is a potential of increasing by 27%. Besides agro-ecology zones, age, extension, seed type,

and other income were identified as the determinants of efficiency tef production. A study conducted in Jamma, South Wollo by Dessale and Tegegne (2018) the mean tef production efficiency was 78%. And land size, organic fertilizer, availability of labor, and the number of oxen were the associated factors that influence the technical efficiency of tef. However, Aregaw (2017) found 59.5% of technical efficiency from the same zone of different woreda. Stated also educational status of the household head, age of household head, possession of oxen, and farmland size were determinants of tef inefficiency.

Bachewe *et al.* (2015) conducted a study on tef efficiency from high potential tef producer districts using data envelopment analysis. The result showed the efficiency of tef was less than half as of the potential. The educational status of household head, specializing in few crops, access to credit, access to information to modern agricultural technologies were factors that determine tef inefficiency. Another study conducted on technical efficiency and determinants of tef in Ethiopia reported 63.5% efficiency (Wassie, 2014). He identified except non-farm income that positively affects tef production inefficiency, the rest age of household head, the slope of the plot, Possession of livestock, and educational status of household head were negatively correlated to tef inefficiency. Likewise, Abera (2019) found 79% tef efficiency in Debrelibanos, Oromia Region. He explained sex of the household head, educational status of household head, participation in off-farm activities positively affect technical efficiency but farmland size is negatively correlated.

Yesgat (2020) reported a mean technical and allocative efficiency of 81 and 11% respectively in Gojjam, Amhara Regional State. Besides, access to credit, soil fertility, educational status of household head, farmland size, access to extension services, market distance, and farming experience were factors that affect the technical efficiency of tef but only farmland size influences allocative efficiency of tef. Getahun and Mebratu (2019) researched on technical efficiency of tef in the highlands of Ethiopia and found a mean technical efficiency of 81.6%. Livestock possession, participating in tef demonstration field days, farming structure, and adopting improved varieties were significantly and positively influence tef technical efficiency.

Overall, regardless of the geographical locations of the study area, tef technical efficiency is low, which is restricted in the mean range of 59.5-81.6%. Therefore, there is 18.4- 40.5% of tef production inefficiency, and more coordinated effort is demanded to boost tef efficiency nationally. Similarly, the factors that influence tef efficiencies/inefficiencies are diversified depending on the

type of covariates used by researchers. But household head age, extension services, farmland size, educational achievement of household head, number of oxen, and modern agricultural inputs were the most determinants of tef technical inefficiency in Ethiopia.

## **2.4 Policies and Strategies of Food Security and Poverty in Ethiopia**

Ethiopian rural development policy describes swift and sustainable economic development would be ensured through agriculture-led and rural-centered development. Because small and micro enterprises and industries grow rapidly parallel with agriculture by getting necessary row inputs and enhance the local economy (MoARD, 2009). Hence, to realize these various policies and strategies a fixed period has been developed regularly to eradicate poverty to achieve food security. To do this, the government of Ethiopia has a strong motive to eradicate poverty and achieve food security by investing in health, education, agriculture and natural resources, and rural roads and urban construction (Anderson & Elisabeth, 2015). The main policies related to food security and poverty reduction are; SDPRP implemented from 2002-2005, PASDEP implemented from 2006-2010 (MoARD, 2009), and GTP I from 2011-2015, and Growth and GT PII from 2016-2020 (FDRE, 2016). In all these strategies agriculture plays its prime role with a special focus on rural well-being.

RED/FS was one element of PASDEP. Under this unit there is agricultural growth - both for high-value crops and for transforming subsistence farming, attaining food security, and improving the natural resource base (MoARD, 2009). In the GTP in the PSNP four main programs have developed to achieve food security and reduce poverty. These are; NNP, CRGE, SPP, and DRMP (Anderson & Elisabeth, 2015). The national nutritional program intends to reduce stunting and wasting and under-nutrition with a special focus on the first 1000 days of life with a focus on children younger than 2 years, pregnant and lactating women and adolescent girls to break the vicious cycle of malnutrition. In general, the aim of food security program minimizes chronically food insecure households reach a level of food security necessary for an active and healthy life through safety net programs, resettlement, and other food security interventions. In general, due to the implementation of various strategies poverty is significantly reduced starting from the MDGs (UNDP, 2015). The GTP II report indicates that the level of poverty in GTP I reduce to 23.4 and expected to be 16.7 by the end of GTP II (FDRE, 2016). This is mainly the government is strongly working to realize the sustainable development goals by 2030. On the other hand, the above-stated

strategies are criticized due to their inclusiveness. For instance, Woldehanna et al. (2017) mentioned that the policies and strategies do not specifically address the issue of child poverty. Because the proportion of poverty reduction between adults and children is quite different (MoFEC, 2015).

In addition to the above common strategies, there are also important components of food security programs. These programs include; PSNP, HABP, VRP, and CCIP. PSNP is a means to exit households from chronic food security. It might be through unconditional transfer to those who have not able-bodied, and conditional transfer to those who have able-bodied by engaging in different development works. Previously this program was exclusively rural-based however starting from 2016 urban PSNP is also under implementation. HABP under this, different packages are designed and implemented to strengthen the livelihood of the food insecure people through asset building. Hence VRP is mainly implemented in the highland areas where farming land is scarce and in the lowland with moisture deficient areas, to areas where arable land is underutilized and has a small population compared to the land resource. Whereas CCIP is intensively focused on the development of different capital-intensive development activities by the beneficiary of PSNP in food-insecure *Woredas* (Mulugeta, 2018).

In conclusion, in every phase of policies and strategies, important components are included but still, some problems must be addressed. The first thing is, documents are well organized but some implementation problems were reported. Second, still in the documents, the material necessity of the people is boldly emphasized because poverty is beyond material necessity. Thirdly, the food security program is all about the safety net, it good because it comprises important components to solve chronic food insecurity, however, little emphasis is given toward the quality of diet and safety issues of the food. Lastly, the reports on poverty reduction are good but child poverty should be described in number because child poverty retards mental development which will be forestalled to realize sustainable development goals of 2030.

## **2.5 Peri-Urban Land Tenure Related Issues of Ethiopia**

Nega *et al.* (2003) classified the land tenure system into imperial (pre-1974), Derg (1974-1991), and EPRDF (since 1991) regimes. In the feudal regime, land was distributed by kinship and social class, in the Derg regime land was state property and distributed to landless tenants, and after 1991 land was a state and public property, and users have usufruct rights (Adam, 2014). However, the

current government has full-fledged power to expropriate land for a public purpose with possible compensation (Lamson-Hall *et al.*, 2019). Literature proved that no land tenure system in peri-urban land. It is administered either by a rural or urban tenure system. If it is under rural administration land certification was granted to use and not merchandising. But transferred to eligible members while urban land is distributed through the lease system (Adam, 2014). He strengthened that soaring demand for land in peri-urban areas leased to urban expansion. Lack of strong law enforcement and commitment, peri-urban land in Ethiopia is almost distributed informally (Lamson-Hall *et al.*, 2019).

As stated above, the administration power of peri-urban areas is granted to rural landholding systems if not included in the urban master plan. Mounting demand of urban leasehold system due to massive population growth, peri-urban land is continuously trespassing for buildups (Adam, 2014). He suggested also Ethiopian urban expansion strategy is mainly through encroaches of farming land from nearby farmers by the leasehold system. Consequently, the loss of land rights and livelihoods of the local landholders/owners is growing. In sum, no clear and conflicting land tenure system in Ethiopia makes understanding and conceptualization of the peri-urban land tenure system complex. Even no commonly agreed approaches to investigate the peri-urban land tenure. Hence, the government of Ethiopia should prepare a strategy for handling peri-urban land and keep the necessary benefits to the peri-urban farmers to minimize the burden growing from displacement.

## **2.6 Analytical Framework**

It has been indicated development-induced displacement has its repercussion on farmers' technology and resource utilization. This will likely affect the food security and poverty status of smallholder peri-urban farmers. Apart from this, there are diversified demographic, socioeconomic, and institutional factors that enhance or bottleneck poverty, food security, production efficiency, and agricultural technology adoption of peri-urban farmers (Figure 2.2). Feleke *et al.* (2005) identified technology adoption, farming system, soil fertility, availability of market, annual crop production, family size, and farmland size that affect household poverty and food security either positively or negatively. Sani and Kemaw (2019) confirmed the age of the household head, family size, and off-farm and non-farm income positively affected the extent of households' food insecurity; whereas access to irrigation, farm income, distance to market, and access to credit

negatively affected the extent of households' food insecurity. Households with large family size, households who cannot read and write and old household heads are more likely to be food insecure than their counterparts (Mota *et al.*, 2019). Similarly, Tsegamariam and Berhanu (2019) evidenced dependency ratio, high ceremonial expenses, low income, low level of education, low access to technologies, absence of rural financial institution, poor market integration, improper land distribution, poor family planning, poor infrastructure development and fear to take credit found to negatively affect household food security. In general, depending on the study area and context of the community household food security-enhancing and limiting factors are unnumbered.

Wassie (2014) researched production inefficiencies and identified non-farm income that positively affects tef production inefficiency while the age of household head, the slope of the plot, Possession of livestock, and educational status of household head were negatively correlated to tef inefficiency. Likewise, Bachewe *et al.* (2015) revealed educational status of the household head, specializing in few crops, access to credit, access to information to modern agricultural technologies were factors that determine production inefficiency.

The strength of urban-rural linkage is key to adopt agricultural technologies, improve production efficiency, and minimizing poverty and food insecurity. The principle of the virtuous circle model shows urban centers have a positive contribution to peri-urban farmers through market access to agricultural enhancing inputs, social services like education, health, extension, and credit institutions to produce a marketable surplus and to grow the rural income. Rural people demands, in turn, industrial consumer goods and services, this initiates non-farm income-generating activities and urban income also boosts (Evans, 1992). However, in reality, achieving this mutual benefit is challenging. Urban expansion creates a favorable environment for selling and buying agricultural products and agricultural inputs to boost agricultural productivity and efficiencies thereby enhance poverty reduction and food security of peri-urban farmers (Njiru, 2016; Thuo, 2013). At the bottom pushing factors to urban expansion are listed.

Contrarily, the development-induced displacement approach criticizes it causes food insecurity, landlessness, joblessness, marginalization of people, social disconnection, limiting access to natural community resources, and homelessness. Cernea (1995; 1999) and Terminski (2013) confirmed displacement depletes household assets, increases poverty, and food insecurity among displaced households.

In conclusion, the conceptual framework below summarizes does rural-urban linkage has a significant contribution to production efficiency, technology adoption, reducing food insecurity, and poverty or not. Secondly, Does the IRR model works in this study or not. Finally, to draw a learning lesson on how the interaction of different factors influences peri-urban farmers.

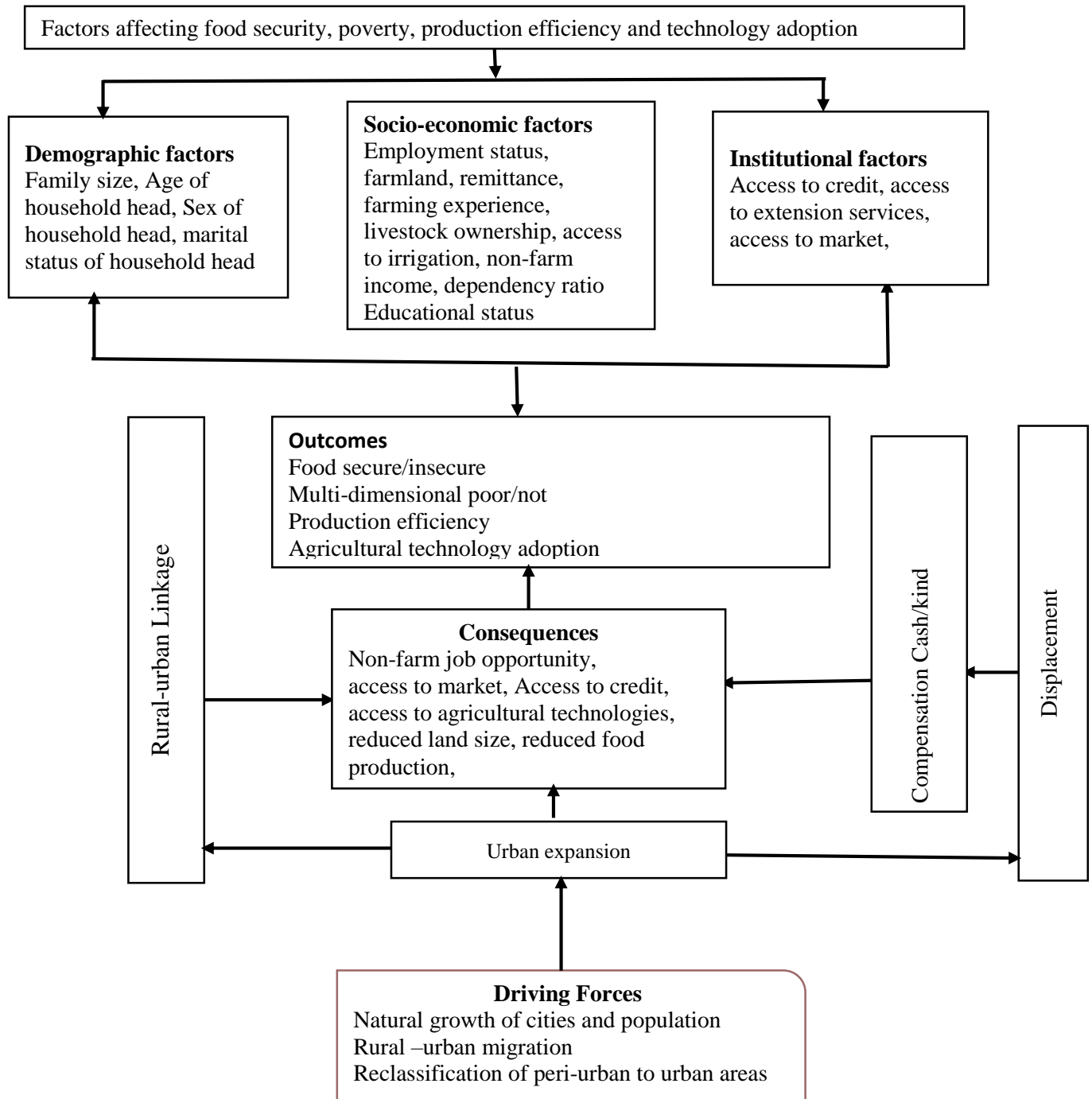


Figure 2.2: Conceptual framework of the study  
Source: From literature and author understanding (2021)

## Chapter 3: Research Methodology

### 3.1 Physical Description of the Study Area

Laelay Maichew *Woreda* is part of the Central zone Tigray regional State. It locates 1043 km away from Addis Ababa and 245 km northwest of Mekelle, the capital city of Tigray. It is found on the main road of Adwa and Shire. It is bounded by Merebleke in the north, Adwa in the east, Werileke and Nader Adiet in the south, and Tahtay Maichew in the west. And suited at a latitude of 14°6'0"-14°9'0"N and longitude of 38°42'0"-38°45'0"E. Agroecology of the *woreda* is characterized as *woinadega* and *Kolla*. *Woinadega* is the dominant agroecology of the *woreda* which is suitable for growing Tef, Sorghum, Barley, Wheat, Beans, millet, and maize. The topography of the area is classified as rugged and gentle slope arable land. The elevation of the area varies from 1375-2450 meters above sea level. The climatic condition of the area is comfortable and overcast during the rainy season, and warm and partly cloudy during the dry season. The temperature varies from 18°C-25°C with an average annual rainfall of 937.4 mm (NMAE, 2019).

### 3.2 Demographics

The Central Statistical Agency of Ethiopia 2014-2017 projection indicated the *woreda* has 15 *tabia* and 49 *kushet*<sup>3</sup> with a total population of 78, 626 (39,797 female and 38,829 male) (CSA, 2017) however, the WOARD (2019) data reported a total population of 80, 445 (40, 694 female and 39,751 male). The population density of the *woreda* is 147.1/km<sup>2</sup> (CSA, 2017). It has 17, 488 households of this 4, 721 female-headed and 12, 767 male-headed households, respectively. It covers a total area of 53, 833 hectares of this 13,937 hectares are arable land, 275 grazing land, 33,553-hectare forest land, and 14,231 hectares not yet utilized. It has 1, 316.3 hectares of potential land for irrigation currently only 945.6 hectares of land is covered by irrigation (WOARD, 2019).

### 3.3 Socioeconomics

The livelihood of the people mainly depends on subsistence agriculture and petty trading, daily laborer, mining and other sources of income are secondary sources of income of the *woreda*. Poverty and food insecurity are prevalent due to small landholding per household, lack of improved agricultural technologies and inadequate extension services. It has 120,531 cattle, 55,875 sheep, and 88,188 goats, 125,000 chicken, and 23,755 pack animals. Tef, barley, wheat, sorghum,

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<sup>3</sup> Tigrigna term which refers to a part of a *tabia*.

finger millet, and beans are the major crops grown in this area. The productivity of the crops is tef 16.5 quintals/hectare, wheat 17.6 quintals/hectare, sorghum 23.65 quintals/hectare. The average size of cultivated land own by a household with five family sizes is about 0.75 hectares (WOARD, 2019).

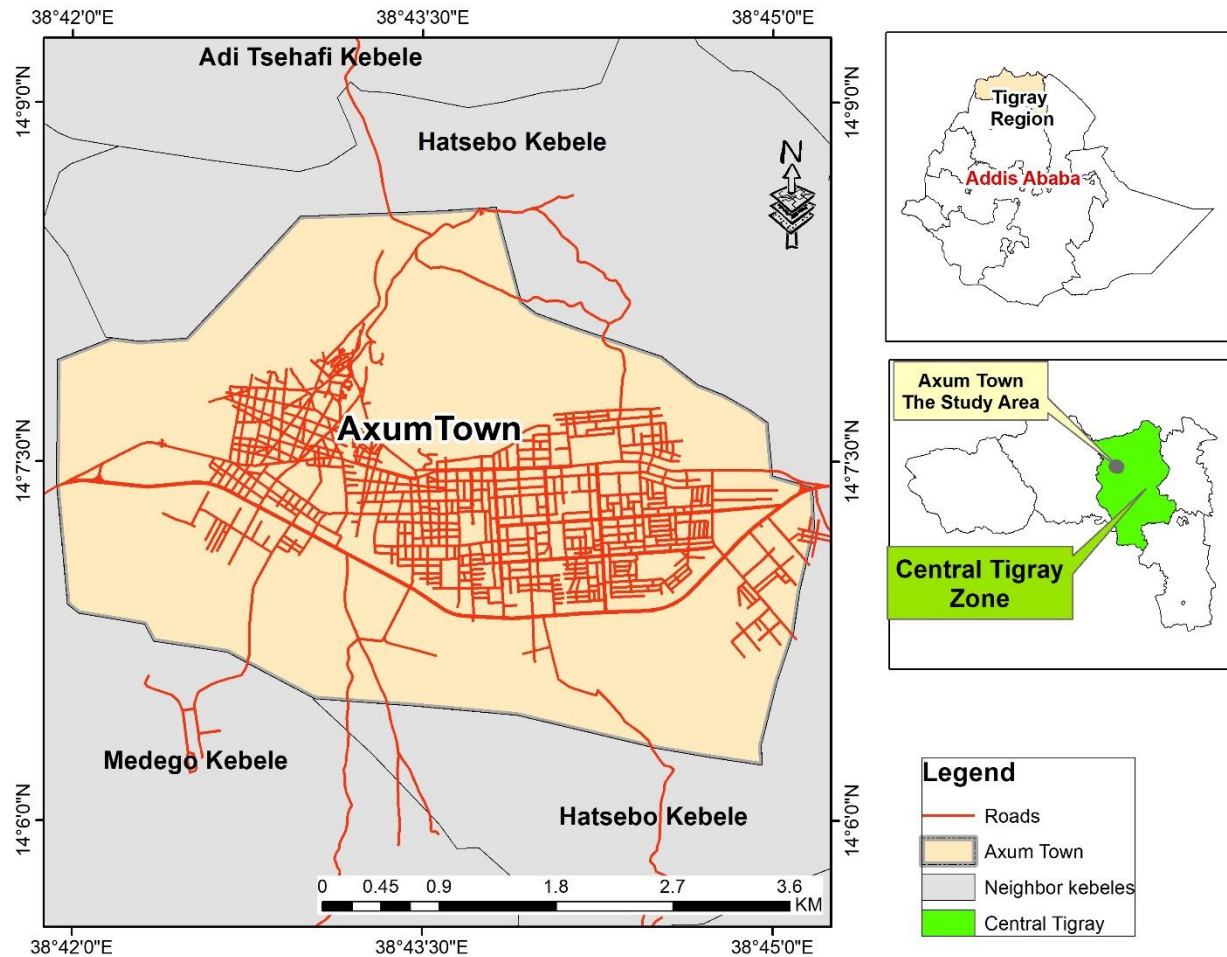


Figure 3.1: Location map of the study area, Axum town, Tigray region  
Source: Own construction (2019)

### 3.4 Research Design

Mixed-methods research was applied where the majority of the data is generated from quantitative data and underpinned by qualitative data to support and elaborate statistical results deeply (Creswell *et al.*, 2003). The reason behind using this approach is, on one hand, data related to poverty, food security, production efficiency, and technology can be measured quantitatively by taking different measurable variables. For instance, demographic, socio-economic, and

agricultural production data were measured using a quantitative approach. On other hand, the general understanding, perceptions, and feelings about urban expansion and its impact can be assessed using qualitative instruments. This cross-sectional study demands a combination of quantitative and qualitative data to explore the study deeply.

### **3.5 Research Philosophy**

A combination of qualitative and qualitative research approaches is important to answer valuable questions in research even if it does not work always. However, researchers are simply using mixed approaches without critically appraising the merit and demerit behind using merely qualitative and quantitative techniques (Sale *et al.*, 2002). A common debate is raised in research is; there is a single reality and there is no single reality (Guba, 1990). Positivism believes that there is a single reality that can be measured objectively and the hypothesis is tested and validated, knowledge is independent of human interaction there is a clear boundary between the researcher and the researched (Guba *et al.*, 1994). Similarly, Creswell (2009) boldly mentioned positivism philosophy is good at showing the cause-effect relationship and yielding a result for prediction and generalization as it undergoing random sampling and empirically tested.

On the other hand, constructivism arguing that there is no single reality rather there is multiple reality that can be measured subjectively and internally constructed knowledge with the person under investigation, which cannot be measured objectively. Besides, there is no access to a reality independent of our mind, no external referent to which to compare to claim to the truth. The emphasis of constructionism approach is the process and the meaning attached to them and key informant interview, in-depth interview, focus group discussion and transect observation is used in generating the data. Moreover, results are not generalized to a large population (Frowe, 2001). Pragmatism view as a condition when none of the two techniques failed to address a certain research problem fully. It is clear that methods are constructed by the research philosophy and the next question after philosophy is decided. Besides the qualitative paradigm has its own worldview not masked and epitomized by the quantitative paradigm (Guba & Lincoln, 1989).

Therefore, this study can be hypothesized, tested, and validated objectively and could be subjectively interpreted to construct knowledge. Hence, a pragmatism view was applied in the research.

### 3.6 Sampling Techniques and Sample Size Determination

A multi-stage sampling technique was applied to select the study area, *tabias*, and epitome of the target group. The study area was purposively identified referring to its rapid urban expansion demographically and spatially only towards the prime agricultural land. Besides, it is a tourist site, as a result, private sectors and government bodies are demanding more land for housing development every year. Secondly, urban dwellers in historical sites are relocated to the periphery of the farmers' prime farming land. Lastly, compared to another part of Tigray the area where urban expansion currently encroaching is, fertile agricultural land known for its tef production.

The population and unit of analysis of the study were households in the peri-urban *tabias* where their main livelihood depends on agriculture and has common boundaries with Axum town. Hence, Hatsebo and Modegue were selected purposively because the town is expanding only to these two *tabias*. Then households are classified into partially displaced/dispossessed and non-displaced to see the effects and the associated impact of displacement. Households were also stratified into male and female-headed households. Because there are many female-headed households in the study area. Finally, simple random sampling was used to take representatives of non-displaced households from each *tabia*.

The sample size determination formula developed by Chochran (1977) was used to estimate the sample size of the finite population and presented as follows;

1, if the population is infinite, the formula is;

$n_0 = \frac{z^2 pq}{e^2}$ ,  $n_0$  is a sample size,  $z$  is the selected value of desired confidence level,  $p$  is the estimated proportion of an attribute that is present in the population,  $q=1-p$ , and  $e$ , the desired level of precision.

2, if the population is finite the sample size is estimated as follows;

$$n = \frac{n_0}{1 + \frac{(n_0 - 1)}{N}}$$

$n_0$ , sample size derived above,  $N$  population size therefore, a total of 341 households were taken. Since households were stratified into male and female-headed households. A proportional allocation method was employed to get representative households of the *tabia*. The formula

is,  $n_i = n \frac{N_i}{N}$ , where n=sample size,  $N_i$  =population size of the  $i^{\text{th}}$  strata and N population size,  $i = 1, 2, 3$ . Finally, 101 displaced and 240 non-displaced households were taken. The majority of the participants were non-displaced households because the number of displaced households whose livelihood depends on agriculture is small in the study area.

Table 3.1: Household size and sample size

<i>Tabias</i>	Population size			Sample households		
	Male	Female	Total	Male	Female	Total
Hatsebo	1,183	491	1,674	133	55	188
Medogue	995	368	1,363	112	41	153
<b>Total</b>	2,178	859	3,037	245	96	341

Source: Computed from Laelay Maichew WOARD (2019)

### 3.7 Techniques of Data Collection

To meet the general and specific objectives of the study, quantitative and qualitative data were gathered. Primary quantitative data were collected using a structured survey questionnaire through a personal interview. Babbie (1992) clarified that filling questionnaires by personal interview is important to avoid misinterpretation and understanding of questions by the interviewee. Likewise, primary qualitative data was generated from Focus Group Discussion, key-informant interviews, and participant observations. Whereas secondary data were collected from published and unpublished documents, articles, and websites, particularly, demographic, socioeconomic, climate data, etc.

**Structured survey questionnaire:** The questionnaire was developed in English and interviewed in Tigrigna. Ten enumerators were used to collect the data. A pilot test was conducted on 50 households to check whether the questionnaire is well understood by the interviewee. A structured questionnaire is crucial to avoid variations among the respondents' understanding of the questions. A total of 341 questionnaires were distributed to collect household data on demographic, socioeconomic, agricultural productivity, and technology adoption data.

**Interviews:** In addition to the survey questionnaire qualitative interviews were also conducted to generate additional information that is not addressed by the questionnaire and to support the quantitative data. Under this key informant was conducted out of the sampled households to

generate diversified data and to enrich quantitative data. Participants were purposively selected. This method is effective in investigating the real living, life experiences, vivid picture, and livelihood of the participant (Kvale, 2006). Kvale also added it helps to explicitly understand the lived experience of participants. Key-informants participants from the community were selected those who have a rich and deep understanding of the issue; peasant association, head of the *woreda* office of Agriculture, *woreda* land administrator officer, experts of Axum municipal, early warning and food security coordinator of the *woreda*, *woreda* agriculture and rural development experts, and development agents, as well as *Tabia* administrators. In general, a total of 12 respondents were taken. Data related to poverty, food security, and technology adoption among displaced and non-displaced households were generated from key informants.

**Focus Group Discussion:** Diversified composition of focus group discussants in one group helps to generate rich data (Mack, 2005). Moreover, deciding the size of the focus group is crucial as small size is important for effective management of candidates and large enough group size is also important to generate diversified and rich data. According to the ASA (1997), an appropriate number of participants in one group should be not less than six and more than twelve. Focus group discussants were selected purposively from different economic statuses, different age groups, different religions, different educational levels, and different sex and different positions have participated. Three groups of FGD were formed (female group, male group, and mixed group). Accordingly, a total of 6 focus group discussions with 10 participants, 2 from each kebeles were held. Discussants were purposively selected. To minimize dominance and biasness equal chances were provided to each participant and their opinions, ideas and understandings were documented by the moderator electronically.

**Observation:** This helps to capture candid data by observing the real setup of the environment and activities of the community and important to raise questions during the key informant interview and focus group discussion. Because observation is not only a tool of data collection tool rather it also helps to formulate questions for a better understanding of the situation being studied (Mack, 2005).

### **3.8 Data Analysis Method**

Descriptive statistics, inferential statistics, and econometric models were used to analyze data. Stata version 14, frontier, and WHO Anthro soft wares were used to carry out the quantitative analysis and manage data. Likewise, qualitative data was analyzed contextualized, transcribed, and triangulated to quantitative data. The detailed econometric models applied for each specific objective are listed and discussed in their respective chapters.

**Objective 1:** To investigate the impact of urban expansion on households' food security was analysed using PSM. Similarly, different indicators of food security were applied to measure food security at the household and intra-household levels. There is no single and complete standalone indicator to measure food security rather; different indicators should be supplemented to each other to get a better picture of household food security. Therefore, to capture the important dimensions of food security different food security indicators were applied. These are HFBM, HFIAS, FCS, and HDDS to measure adult food security whereas anthropometric measurements (Wasting, Stunting and Under-weight) were used to measure child nutritional status.

**Objective 2:** To explore the impact of urban expansion on household poverty was evaluated using the newly developed poverty assessment method MPI. This method has three dimensions with equal weight and ten indicators, indicators within the same dimension have equal weight and households were classified as poor and non-poor based on the number of deprivations.

**Objective 3:** To investigate differences in resource allocation. Stochastic frontier analysis was employed. Hence technical and allocative efficiencies were used to assess resource allocation differences. Farrell 1957 summarizes as; Technical efficiency is related to the capacity to produce within the isoquant areas whereas allocative efficiency is all about producing output using a cost-minimizing of inputs.

**Objective 4:** To reveal the effect of displacement on technology adoption. Multivariate probit analysis was applied to see agricultural adoption pattern households. This model is used to estimate several correlated binary outcomes together.

### **3.9 Reliability, Validity and Ethical Consideration of the Study**

This study considers the issue of reliability, validity and research ethics. Reliability “concerns the extent to which an experiment, test, or any measuring yields the same result on repeated trial” (Carmines & Zeller, 1979, p. 11). He also added any measurement always contains a certain

amount of error and the goal of error-free measurement never attained in any area of scientific investigation rather the degree of error varies it might be large or small. Therefore to attain reliability of the study, participant were asked their convenient time to give the interview, participants have informed the purpose of the study to avoid false responses, reducing the number of interviewees per day and responses were documented curiously by the researcher. Besides Cronbach's alpha test was conducted and the same procedure was applied from inception to the final stage of the data collection period.

Validity shows how accurately a method measures what is planned to measure in the actual area investigation (Ghuri & Gronhaug, 2005) or how accurate the measure is (Field, 2005). This tells does the collected data reflect the reality under investigation. To overcome the problem of validity, the questionnaire was pre-tested and the researcher supervises the enumerators regularly.

Applying research ethics is basic in any research to protect the dignity, rights and welfare of the participants. To do so, a letter was collected from the woreda administrator and dispatched to respective *tabia* leaders. The researcher gave a dictation about the purpose of the research and its contribution to the leaders. Then, the leaders, share the information with the community and get informed to provide necessary support to the researcher. Finally, the researcher guarantees their data is not transferred to third parties without their willingness and an anonymous name was provided to individuals not interested to give their name for security purposes.

## **Chapter 4: Impact of Urban Expansion on Household Food Insecurity in Axum, Tigray Region**

### **4.1 Introduction**

Food security is, physical and economic access to balanced and adequate food to all people at all times uninterrupted (FAO, 1996) yet this issue has remained unsolved. Half decades after the world promised to end hunger, food insecurity, and all forms of malnutrition, it is ambitious to achieve this objective by 2030. Reports showed that the world is attaining neither SDG target 2.1, of guaranteeing access to safe, nutritious, and sufficient food for all people uninterrupted, nor target 2.2, of eliminating all forms of malnutrition (FAO *et al.*, 2020). FAO *et al.* (2019) reported that close to 2 billion people are under moderate or severe food insecure and Africa takes the lead in the number of food-insecure people. The report also mentioned, globally, the prevalence of food insecurity is remaining higher among female-headed households. Food insecurity magnifies the risk of child malnutrition as it affects diet quality and quantity, and the health of people. Hence, it is excruciating and remains a burden and threat to the world. FAO *et al.* (2020) revealed that 21.3% of children under five ages were stunted, 6.9% wasted, and 5.6% underweight, while about 340 million children were suffered from hidden hunger. The report also added, due to the pandemic COVID-19 additional 83 to 132 million people were faced undernourished.

Urban expansion takes agricultural land and explicitly or implicitly disturbs the food production system by consuming fertile land, particularly in countries where population size is high and landholding is small (Seto & Ramankutty, 2016; Wei *et al.*, 2015). Naab *et al.* (2013) confirmed that annually in developing countries nearly 475,000 ha of land was taken to urban expansion and puts a burden on attaining food self-sufficiency of peri-urban farmers (Godfray *et al.*, 2010; Nellemann, 2009). Thus urban expansion degrades peri-urban farmers' livelihood and soars food insecurity (Lasisi *et al.*, 2017; Wang, 2019). Similarly, Adeboyejo and Abolade (2009), and Angel *et al.* (2005) stated that urban expansion in sub-Saharan countries forced peri-urban farmers to change their livelihood strategies permanently. In general, though many factors affect food production in low and middle-income countries, overpopulation and urban expansion are the most threatening factors (Babatola & Babatola, 2015). This is associated with the land-use shift and has a detectable impact on food production and the local economy of peri-urban farmers (Simon, 2008) and displaces from their productive assets (Cernea, 1997).

Ethiopia is one of the second populous countries in Africa next to Nigeria, where most of its population resides in rural areas and, compared to other countries the number of urban dwellers is very small (CSA, 2016). MUDHCo (2016) reported that in the last 6 decades urbanization accelerated from 5% to 19% and in the coming years from 2025-2035, close to 3.9-8.9 million accommodations will be required. This intrudes additional farming land for development projects. Therefore, the pressure on the livelihood of peri-urban farmers will rise. Because urbanization in Ethiopia is mainly taking place through horizontal expansion to prime agricultural land, peri-urban farmers are frequently displaced from their subsistence farming lands. The Compensation proclamation of Ethiopia No. 455/2005, describes only paying compensation is not enough but also displaced should be supported to restore their normal livelihood to ameliorate the negative consequences of displacement (FDRE, 2005). So, when farmers are displaced from their farming land, compensation shall be equivalent to ten times the average annual income, the holder gained in the last five years before the expropriation of the land. But whether this amount of compensation is adequate to sustain their hitherto livelihood is questionable.

For many reasons, food insecurity is pervasive in rural Ethiopia. A recently published report by WFP and CSA (2019) showed that the prevalence of food insecurity in Ethiopia was 31% with 33% mainly in rural areas. Besides, the anthropometric analysis result of the report showed that 38.4% and 10% of children under five years were stunted and wasted, respectively, with a higher prevalence rate in rural areas. Studies showed that the causes of food insecurity in Ethiopia were associated with large family size, low educational level, higher age, small land size, low livestock possession, and lack of money (Mota *et al.*, 2019; WFP & CSA, 2019). Eshetu and Guye (2021) identified that age of household head, family size, access to safety net program, distance from healthcare, and mortality of household members increases food insecurity, Whereas, farm income, access to irrigation use, and credit improves food security. Similarly, Kassegn and Endris (2021) underscored the spread of pandemic COVID-19, repeated drought, conflict, low household income, high price of nutritious food, and knowledge on nutritious food were the determinants of food security. In sum, several studies have been conducted on determinants of food security but no universally agreed determinants of food security were identified in Ethiopia.

Studies (Addisu, 2015; Mezgebo, 2014; Nigusie, 2011) have been conducted so far to investigate the effect of urban expansion on; farmers' level of perception on compensation and displacement,

income diversification, and implications to farming livelihood. Besides, several studies have been conducted on determinants of food security. However, the impact of horizontal urban expansion on food security of peri-urban farmers was barely examined. Studies conducted so far failed to combine different measurements of food security indicators to examine household food security in the study area. And the determinants of household food security/insecurity were investigated irrespective of food security measurements applied. The studies Abdissa (2005), Addisu (2015), and Mezgebo (2014) conducted so far said nothing about the effect of urban expansion on household food security using comprehensive econometric analysis in Ethiopia. Lastly, the impact of urban expansion on children under five ages was also hardly studied in Ethiopia. Therefore, this study tries to fill the above-mentioned gap by analyzing the impact of urban expansion on household food security and their members. This issue is timely and addresses a comprehensive domain of knowledge to provide policy recommendations and fill the limited reference materials in urban expansion nexus food security.

## **4.2 Methodology**

### **4.2.1 Land Use/Land Cover Dynamics in Axum Town**

Urban expansion of the town was vast since 1980, thus data for LULC changes were taken from 1980 with an interval of 20 years. Google earth pro was used to generate a very high-resolution imageries Geo-eye for 2020. Earth explorer (earth explorer USGS.Gov.) was used to get Landsat imageries Landsat TM for 1980, Landsat 7ETM + for 2002, and Landsat 8 OLI/TRS for 20220. A mixed visual interpretation and supervised classification was used to classify the Landsat imageries into six LULC classes: forest/plantation (includes natural and plantation- eucalyptus), grassland (includes areas covered with grass and shrub land), bare land (areas with no vegetation, degraded or quarries, or road segments), cropland (mosaic of smallholder farms dominantly), rural settlement (small villages or areas with an agglomeration of tukuls (huts) or iron-roofed houses but at a distance of at least 200m from urban built-up structures, and urban built-up area (urban built-up iron-roofed houses and roads structures).is The Lu/Lc classes: forest/plantation (includes natural and plantation- eucalyptus), grassland (includes areas covered with grass and shrub land), bare land (areas with no vegetation, degraded or quarries, or road segments), cropland (mosaic of smallholder farms dominantly), rural settlement (small villages or areas with an agglomeration of tukuls (huts) or iron-roofed houses but at a distance of at least 200m from urban built-up structures, and urban built-up area (urban built-up iron-roofed houses and roads structures).

The geo-eye imageries were used to classify the area into six LULC categories. Besides the accuracy of the classification of Landsat imageries of 2020 was made based on sample points detect (200) from these imageries. Arc GIS ver 17.1 software was applied to sketch and Excel was used to generate summary tables and graphs.

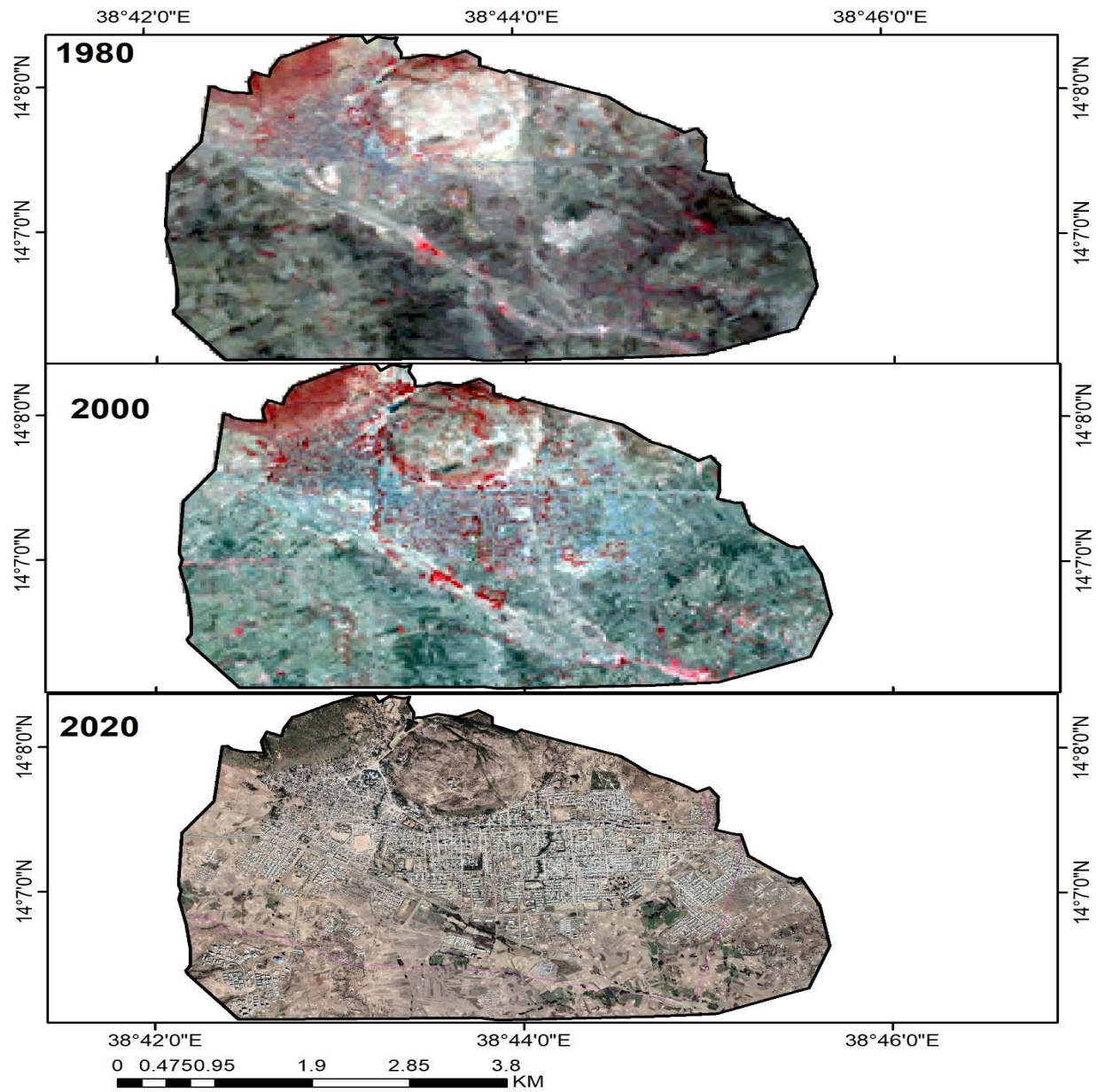


Figure 4.1: False Color Composite (FCC), display of Landsat images of Axum town and surrounding area in 1980, 2000, and 2020.

Source: Earthexplorer-USGS.Gov for the Landsat imageries (1980 & 2000), Google earth pro for Geo-eye imageries (2020)

#### 4.2.2 Food Security Measurements

Food security is defined as “when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life”(FAO, 1996, p. 2). This definition holds four basic dimensions (Availability, access, utilization, and stability). Hence addressing these all dimensions are challenging because there is no one inclusive agreed measurement to capture all these. As a result, diversified indicators are used by various institutions depending on the objective of the assessment (Carletto *et al.*, 2013). This is because the availability of food at the national and the household level is mandatory but does not guarantee food access likewise accessibility does not compensate for utilization (Barrett, 2010). For instance, FAO uses minimum calorie requirement measurement to measure food security but many developing countries' nutritional or calorie requirement is not their main problem rather inadequate food nutrient composition is their cause of nutritional impairment (Ruel, 2003). Therefore, this measurement will be important if linked with anthropometric and dietary diversity measurement which shows nutritional outcomes (Hoddinott & Yohannes, 2002). Therefore, a single indicator does not address the four intrinsic components (FIVIMS, 2002). Due to this, a collection of indicators is necessary to address all dimensions of food security (Jones *et al.*, 2013).

An empirical study conducted by Hoddinott and Yohannes (2002) showed household dietary diversity and per capita consumption are significantly correlated. Similarly, a study conducted in Tigray using seven indicators (CSI, rCSI, HFIAS, HHS, FCS, HDDS, and a self-assessed measure of food security) of food security are significantly correlated (Maxwell *et al.*, 2013). However, the degree of cohesiveness varies among indicators. For instance, the coping strategy index, reduced coping strategies, and household food insecurity access model scale is strongly correlated. Similarly, Food consumption scores are highly correlated with household dietary diversity scores than with either household food insecurity access model or coping strategy index (Maxwell *et al.*, 2013). Another study conducted by Wiesmann *et al.*, (2009) found a positive association between FCS and Calorie consumption in Burundi and Haiti. In sum, while combining different indicators considering the context is mandatory because some measurements are not uniformly applicable everywhere. For instance, Wiesmann (2007) found sub-Saharan Africa has fewer food diversified dishes than South Asia, therefore, the indicator should be modified based on the specific region.

Today validations are conducted to check the applicability of the indicators across regions. HFIAS. Validation was conducted in Latin America and sub-Saharan Africa and found to be reliable and valid (Knueppel *et al.*, 2010). Besides, a study published in 2009 by Maes *et al.*, (2009) determined the HFIAS (translated into Amharic) was a valid tool for ascertaining food security among community health volunteers in Addis Ababa, Ethiopia, with high internal consistency.

In conclusion, relying on only one measure of food security in analysis and program design creates the risk of serious misclassification of food secure and insecure people due to its multidimensional nature. However, in the ground, combining multiple indicators to capture the pillars, most of the time it is challenging to know which combination of indicators is best applicable to the context. Similarly, the indicators give different results and create confusion to estimate the prevalence this is mainly due to the application of different methods employed. Therefore, whatever confusion and challenges are arising combining different should be tolerated to avoid misclassification of households.

Thus the multidimensional nature of food security calls different types of food security measurements to get a clear and vivid picture of household food security. Therefore, HFBS was applied to measure food availability, HFIAS was applied to measure food access, and FCS and HDDS were used to measure food utilization.

**HFBS** captures the food availability dimension of food security at the household level. This model was adopted from (Tolossa, 1996) who conceptualized the FAO national food availability measurement concept to the household level. This approach has been used by researchers to measure food availability at household level. For instance, Mulugeta (2010), and Agidew and Singh (2018) applied in kuyu, Central Ethiopia, and South Wollo Zone, Ethiopia to assess rural household food security, respectively. This model allows researchers to include different sources of food depending on the context of the study area. Therefore, for this study, the model is presented below.

$$NFA = [GP + GB + FA + GG + FW + MP + DP + HP] - [HL + GU + GS + GSE + HS]$$

NGA = Net Food Availability, GP = Total Grain Production, GB = Total Grain Bought  
 FA = Quantity of Food Aid Obtained, GG = Total Grain Obtained by Gift and Remittance  
 FW = Food for Work, MP = Total Meat Products, DP = Total Dairy Products, HP = Total Honey Product, HL= Post-harvest Losses, GU = Quantity of Grain Reserved for Seed, GS = Amount of Grain Sold, GV = Grain Given to Others, GSE = Grain Used for Social Events

A series of recipes were followed to compute HFBM. First, the family size was converted to adult equivalent. Then the total food production of households was collected, calculated, and converted to their respective calorie equivalent using the food composition table developed by EHNRI (2000). Finally, a 2100 kcal/adult equivalent/day was set as a minimum gold standard weighted average calorie requirement (Kakwani & Son, 2015; MoFED, 2002). Depending on the kcal score households have been classified into food secure and food insecure. Hence those households with greater/equal to 2100kcal given a value of one, zero otherwise.

Since the outcome variable a binary, a logit model was applied.

$F(X) = \{1 \text{ if } Y \geq 2100Kcal \text{ and } 0 \text{ if } Y < 2100Kcal\}$ . So, Gujarati (2004) specified binary logistic model as follows;

$$P(x) = \Pr(T = 1/X), P_i = E(Y = 1/X_i) = \beta_1 + \beta_2 x_1 \dots \dots \dots Eq. (1)$$

Where x is the independent variable and y is the dependent variable with a value of 0 or 1,

$$P_i = E\left(y = 1/X_i\right) = \frac{1}{1+e^{-(\beta_1 + \beta_2 X_i)}} \dots \dots \dots Wq. (2).$$

$$P_i = \frac{1}{1+e^{-z_i}} = \frac{e^z}{1+e^z} \dots \dots \dots Eq. (3), \text{ where } z_i = \beta_1 + \beta_2 X_i, \text{ if } p_i \text{ is the probability of being food}$$

$$\text{secure and the probability of food insecure is } 1 - p_i = \frac{1}{1+e^{z_i}} \dots \dots \dots Eq. (4)$$

$$\frac{p_i}{1-p_i} = \frac{1+e^{z_i}}{1+e^{-z_i}} = e^{z_i}, \dots \dots \dots Eq. (5), \text{ the natural logarithm of equation 5 gives,}$$

$$l_i = \ln\left(\frac{p_i}{1-p_i}\right) = z_i = \beta_1 + \beta_2 x_i + \dots \dots \beta_n x_n$$

HFIA model was used to evaluate household access to food security. This model captures food preferences, quality and quantity partially. Every household was asked the nine generic questions (Appendix I, D) and categorized into four food security categories. Coates *et al.* (2007) categorized that, Category=1 if [(Q1a=0 or Q1a=1) and Q2=0 and Q3=0 and Q4=0 and Q5=0 and Q6=0 and Q7=0 and Q8=0 and Q9=0] HFIA category = 2 if [(Q1a=2 or Q1a=3 or Q2a=1 or Q2a=2 or Q2a=3 or Q3a=1 or Q4a=1) and Q5=0 and Q6=0 and Q7=0 and Q8=0 and Q9=0] HFIA category = 3 if [(Q3a=2 or Q3a=3 or Q4a=2 or Q4a=3 or Q5a=1 or Q5a=2 or Q6a=1 or Q6a=2) and Q7=0 and Q8=0 and Q9=0] HFIA category = 4 if [Q5a=3 or Q6a=3 or Q7a=1 or Q7a=2 or Q7a=3 or Q8a=1 or Q8a=2 or Q8a=3 or Q9a=1 or Q9a=2 or Q9a=3] based on the household scores.

$$Y(x) = \left\{ \begin{array}{l} 1 \text{ Food Secured} \\ 2 \text{ Mild Food Insecure} \\ 3 \text{ Moderately Food Insecure} \\ 4 \text{ severely food Insecure} \end{array} \right\}$$

The outcome variable is hierarchical definite order. Hence ordered logistic regression was applied to sort out associated factors that affect HFIAS.  $i = 1$  is defined as the minimum value of the variable,  $i = 2$  as the next ordered value, and so on, for the empirically determined  $k$  categories. Specification of the order logistic regression is given below;

$$y_i = 1 \text{ if } y_i^* \leq k_1$$

$$y_i = 2 \text{ if } k_1 \leq y_i^* \leq k_2$$

$$y_i = 3 \text{ if } k_2 \leq y_i^* \leq k_3$$

$$y_i = 4 \text{ if } k_3 \leq y_i^* \leq k_4$$

$z_i = \sum_{k=1}^k \beta_k x_k = E(y_i^*) \dots \dots \dots$  Eq (1) Note that, because of the random disturbance term, the unmeasured latent variable  $Y^*$  can be either higher or lower than  $Z$ . therefore,

$$z_i = \sum_{k=1}^k \beta_k x_k \dots \dots \dots \text{Eq (2) to simplify,}$$

$$(y = 1) = \frac{1}{1 + \exp(z_i - k_1)}$$

$$(y = 2) = \frac{1}{1 + \exp(z_i - k_2)} - \frac{1}{1 + \exp(z_i - k_1)}$$

$$((y = 3) = \frac{1}{1 + \exp(z_i - k_3)} - \frac{1}{1 + \exp(z_i - k_2)})$$

$$(y = 4) = 1 - \frac{1}{1 + \exp(z_i - k_3)} \quad (\text{Williams, 2021}).$$

Hence, using the estimated value of  $Z$  and the assumed logistic distribution of the disturbance term, the ordered logit model can be used to estimate the probability that the unobserved variable  $Y^*$  falls within the various threshold limits.

Lastly, a potpourri of FCS and HDDS were applied to measure the food utilization component of food security. These help to construct correlation with the other measurements and to recommend better indicator from the two measurements. FCS is dominantly used by WFP to measure food security at the country and household levels. The measurement addresses access to food and nutrient diversity of food (Jones *et al.*, 2013). Seven days recall period is used to estimate dietary diversity and food frequency (WFP, 2008). Households were asked about eight food groups (Staples, pulses, vegetables, fruit, meat and fish, dairy products, sugar, and oil) consumed in the last seven days ahead of the interviewing day (Jones *et al.*, 2013) (Appendix 1, A). By multiplying

the frequency of food groups eaten by the assigned weight for a specific food group results are summed up to get the FCS. Finally, the households are classified into food secure and insecure depending on the cutoffs. According to (Baumann *et al.*, 2013; WFP, 2008) if the consumption of sugar and oil is rare, the cutoffs are 0-21 for poor food consumption, 21.5-35 for borderline food consumption, and >35 for acceptable food consumption. If the consumption of sugar and oil is frequent in a community, cutoff values are 0-28 for poor food consumption, 28.5-42 for borderline food consumption, and > 42 for acceptable food consumption. And the household that lies in the poor and borderline food consumption is considered food insecure while those categorized in acceptable food consumption are food secure. In general, FCS is presented as follows;

$$FCS = a_{stable}x_{stable} + a_{pulse}x_{pulse} + a_{veg}x_{veg} + a_{fruit}x_{fruit} + a_{animal}x_{animal} + a_{sugar}x_{sugar} + a_{dairy}x_{dairy} + a_{oil}x_{oil}$$

Xi = frequency of food consumption and ai = weight of each food group,

$$Y(X) = \begin{cases} 1 \text{ poor food consumption} \\ 2 \text{ boarderline food consumption} \\ 3 \text{ accepatable food consumption} \end{cases}$$

Associated factors that affect FCS were analyzed using ordered logistic regression. HDDS measures the long-term effect of food quality in households or individuals. To measure HDDS, foods are grouped into 12 food groups (Swindale & Bilinsky, 2006) (Appendix 1, B). Households are asked the numbers of food items consumed in the last 24 hours and classified into low DDS (consume ≤3 number of food groups) optimal/adequate (consume 4-5 food groups ) high (consume ≥ 6 food groups) (Jones *et al.*, 2013). Associated factors were analyzed using ordered logistic regression.

Anthropometric measurements were used to measure child nutritional status. The commonly applied anthropometric indicators for children under five years are (Weight for Height/Length, Height for Age, and Weight for Age). Children below two years of age were weighed on a baby scale in the health service center while children above two years of age were weighed in the field using a Physician scale by a nurse. The height of infants was measured using a Length Board, locally made. Children from 6-59 months were considered for this study. Cogill (2003) set a z-

score cut-off for anthropometric measurements for children under five years. A healthy and well-nourished child is between -2 and +2 z-score unless he/she is wasted, stunted, and underweight.

### 4.2.3 Impact Assessment

PSM was applied to evaluate the impact of urban expansion on household food security. This method employed different socio-demographic and other variables to match individuals regardless of being displaced or not. The covariates, both in treated and control groups will have similar characteristics such that comparison on the outcome variable using a t-test could be possible using different algorithms. Since PSM uses a continuous outcome variable, HFBM was used to evaluate the impact of urban expansion on household food security. Because compared to the other measurements HFBM yields purely continuous output.

The sampled households are categorized as treatment and control groups, the treatment indicator  $D_i$  will assume 1 for those who are in the treated group (partially displaced from their land) and zero for the control group (non-displaced households). In such case, the outcome will be given as  $Y(D_i)$  for each individual  $i$ , where  $i = 1 \dots N$  and,  $N$  refers to the total population. Thus, the treatment effect for an individual  $i$  can be given as

$$T_i = Y_i(1) - Y_i(0) \text{ ----- Eq. (1)}$$

But, since we cannot see both the treatment and control outcomes for the same individual  $i$  the treatment effect described in Eq.(1) will not be possible for measuring the treatment effect of individual  $i$ , Thus, one has to concentrate on the population average treatment effects (*ATE*).

Among the average treatment effects, Average Treatment effect on the treated (*ATT*),

$$T_{ATT} = E(T/D = 1) = E[Y(1) | D = 1] - E[Y(0) | D = 1] \text{ ..... Eq. (2)}$$

Form the above equation Eq. (2) the counterfactual is  $E[Y(0) | D = 1]$  which is not observed for an individual  $i$  in the treatment group. Thus to estimate the intervention (*ATT*) one should have to substitute the counterfactual. Since components that determine project treatment decisions also determine the outcome variable of interest, using the mean outcome of the untreated individuals i.e.  $E[Y(0) | D = 0]$  does not yield a better estimate of the intervention's impact. The outcome of individuals in the treatment and control group will also be different even in the absence of the intervention leading to 'self-selection bias'. Thus the *ATT* will be given as

$$E[Y(1) | D = 1] - E[Y(0) | D = 0] = T_{ATT} + E[Y(0) | D = 1] - E[Y(0) | D = 0] \text{ .....Eq. (3)}$$

The difference between the left-hand side of the equation Eq. (3)) and  $\tau_{ATT}$  is called ‘self-selection bias’ and the true  $\tau_{ATT}$  is identified as;

$$E[Y(0) | D = 1] - E[Y(0) | D = 0] = 0 \dots \dots \dots \text{Eq. (4)}$$

To solve the selection problem, one has to invoke some assumptions, one among them is conditional independence; which assumes that given a set of observable covariates  $X$  which are not affected by treatment, and potential outcomes are independent of the treatment assignment.

$$\text{(Un-confoundedness)} \quad Y(0), Y(1) \perp\!\!\!\perp D | X, \forall X$$

This implies that selection is based on observable characteristics and all variables that influence treatment assignment and potential outcomes simultaneously are observed by the researcher. This is a strong assumption justified through data quality. It should also be clear that conditioning on all relevant covariates is limited in the case of a high dimensional vector  $X$ . For instance, if  $X$  contains  $s$  covariates which are all dichotomous, the number of possible matches will be  $2^s$ . To deal with this dimensionality problem, Rosenbaum and Rubin (1983) suggest using so-called balancing scores.

They show that if potential outcomes are independent of treatment conditional on covariates  $X$ , they are also independent of treatment conditional on a balancing score  $b(X)$ . The propensity score  $P(D = 1 | X) = P(X)$ , i.e. the probability for an individual to participate in treatment given his observed covariates  $X$ , is one possible balancing score. The conditional independence assumption (CIA) based on the propensity score (PS) can be written as:

$$\text{(Un-confoundedness gave the PS)} \quad Y(0), Y(1) \perp\!\!\!\perp D | X, \forall X$$

**Common Support:** A further requirement besides independence is a common support. It rules out the phenomenon of perfect predictability of  $D$  given  $X$ :

$$\text{(Overlap)} \quad 0 < P(D = 1 | X) < 1$$

It ensures that persons with the same  $X$  values have a positive probability of being both participants and non-participants (Heckman *et al.*, 1999).

**Estimation Strategy:** Given that CIA holds and assuming additionally that there is overlap between both groups (called ‘strong ignorability’ by Rosenbaum and Rubin (1983), the PSM estimator for ATT can be written in general as:

$$T_{ATT}^{PSM} = E\{P(X) | D = 1\} \{E[Y(1) | D = 1, P(X)] - E[Y(0) | D = 0, P(X)]\}$$

The PSM estimator is simply the mean difference in outcomes over the common support, appropriately weighted by the propensity score distribution of participants.

Table 4.1: Variables used in the binary, ordered, Poisson regression and impact assessment

variables	Description of variables	Expected sign
HFBM, HFIAS, FCS, and HDDS		
AccessCrdt	Access to credit (dummy) 0 = <i>no</i> , 1 = <i>yes</i>	+
AccessEx	Access to extension service (dummy) 0 = <i>no</i> , 1 = <i>yes</i>	+
AgeHH	Age of household head in number (continuous)	+/-
EDHH	Educational level of household head in number (continuous)	+
Farmingyear	Farming experience in years (continuous)	+
Fsize	Family size in number (continuous)	+/-
SexHH	Sex of household head (dummy) 0 = female, 1 = Male	+/-
Irrland	Irrigated land in hectare (continuous)	+
Landsize	Land size in hectare (continuous)	+
Marketdis	Market distance in kilometer (continuous)	-
Nfarmincome	Non-farm income in birr (continuous)	+
Remittance	Remittance in birr (continuous)	+
TLU	Tropical livestock unit in number (continuous)	+
Treatment	Treatment (dummy) 0 = non-displaced, 1 = displaced	-

## 4.3 Results and Discussions

### 4.3.1 Characteristics of Peri-Urban Households

Theoretical and empirical findings indicated that demographic and socio-economic characteristics of households are key to boon or barrier food security, poverty, production efficiency, and agricultural technology adoption. The descriptive result (Appendix II) indicated that the percentage of married and widow was higher both in non-displaced and displaced households. The occurrence of a higher percentage of widows is created due to the extended civil war in Ethiopia during the Derg regime and the border conflict between Ethiopia and Eritrea. In various aspects, married households are better off in food security status than widow and divorced households. For instance, Lee *et al.* (2020) found that married households were more food secured than widowed and divorced households. The descriptive result also revealed that non-displaced households had more children than displaced households. This is because non-displaced households are more or less have adequate land to produce enough food for the family compared to displaced farmers. Besides the focus group discussants stated that *displaced households are near to health institutions, frequently contact health extension and have a better understanding of family planning than non-displaced households.*

Furthermore, households were asked for what purpose did they use the compensation. The majority of the households use the money for more than two purposes (67.7%) followed by house construction (16.2%) and purchasing food items (11.1%). Shockingly, one household has wrongly used the money for usury to get higher interest than the legal interest rate. He stated that *the one who took the money denied me 38000ETB, now I am destitute.* A lower rate of migration was reported either they are displaced or non-displaced households though non-displaced households were migrated more. The drivers of migration were reported differently between displaced and non-displaced households. Displaced households were forced to migrate mainly due to a shortage of farming land, while non-displaced households migrated for searching better work and life. However, 56 years old male key-informant stated his fear that *gang ad vandalism was expanded in our tabia due to displacement. Members of the displaced households are engaged in vandalism like pillaging our goats, grains even they are killing people to loot their possession.*

Supplementing rain-fed agriculture with irrigation is one strategic plan in Ethiopia to move out of poverty and attain food security. However, few farmers are engaged in irrigation compared to the

potential of the *woreda*. Only 27.5% and 19.8% of non-displaced and displaced households, respectively, were engaged in irrigation. A larger percentage of non-displaced households participated in irrigation when compared to displaced households. Data collected from focus group discussant and key informants showed that *small landholding, price of irrigation inputs like fertilizer, modern seed, pumps, spare parts, and taking communal ponds to urban expansion are the roadblock to maximize irrigation in the study area*. The descriptive result also revealed that subsistence agriculture followed by two or more sources are the main income sources of households. Surprisingly, the percentage of displaced households who led their livelihood by farming was higher compared to non-displaced. The key informants explained that *regardless of the size of farmland, we invest much of our effort and time in agriculture because we do not have the required skill and competency level to compete with the urban community*. Financial accessibility is important to diversify income sources, improve production efficiency thereby reducing poverty and attaining food security of households. However, the descriptive result revealed that most of the respondents did not take loans from financial institutions. Compared to displaced households large percent of non-displaced households took credit. Data generated from the focus group discussant showed that *risk-taking, high-interest rates, and the availability of few financial institutions are the barrier to take credit*. On-farm research outputs proved that agricultural inputs boost agricultural production. However, the result showed that non-displaced households were better in the adoption of agricultural inputs than displaced households. Focus group discussants and key informants proved *mounting price, shortage of agricultural inputs, and timeliness bottleneck the adoption of agricultural inputs*. Similarly, the percentage of households who benefited from PSNP and have access to extension service were higher among non-displaced households than displaced households.

The descriptive result (Appendix III) showed that the average age of displaced households was higher than that of non-displaced households. The average age of non-displaced households is 50 years and the standard deviation of 12.9 years with a range of 27-87 years (Appendix III). While the mean age of displaced households is 61 years with a standard deviation of 13.3 years. This indicates that age variation is higher among displaced households than non-displaced households. This has implications to adopt agricultural technologies and attaining food security. Because the older household head, the lower tendency to adopt agricultural technologies and improve production efficiency. The mean educational level also showed non-displaced households

achieved higher educational levels than displaced households. The mean educational level of non-displaced and displaced households were grade three and two, respectively. Likewise, the standard deviation is also higher among non-displaced households than in displaced households. Therefore, the difference in the educational level was higher among on-displaced than displaced households. So the tendency of adopting agricultural technologies, nutritional knowledge, and production efficiency could be better among non-displaced households than displaced households.

However, the average family size of displaced households (6) was higher than non-displaced households (5). In general, the average family size of the study area is higher than the national average family size, which is 4.6 (EDHS, 2016). Data generated from the focus group discussant showed that *having many children consider a blessing and wealth*. Expectedly, the average farmland size of non-displaced households (0.67ha) was larger than displaced households (0.59ha). though the landholding of non-displaced households is large, it is below the regional average landholding, 0.75 (TSA, 2020). Because the *woreda* is densely populated compared to other parts of Tigray. The result showed that the average non-farm income was reported higher among displaced (8,512 birrs) than non-displaced households (5,429 birrs). Small landholding of displaced households creates an opportunity to participate in other income-generating activities. Amazingly, the average TLU was higher among displaced (3) than non-displaced households (2). The focus group discussants evidenced that *displaced households were engaged in modern livestock farming compared to non-displaced households*. Lastly, the mean market distance showed non-displaced households were far from the market center than displaced households. Therefore, displaced households had better access to agricultural inputs and outputs.

#### **4.3.2 T-test and Chi-Square Test Distribution by Treatment**

Inferential statistics were applied to show if there is a mean difference between non-displaced and displaced households. A t-test was used for continuous variables while a chi-square test was applied for dummy categorical variables. Table 4.2 shows, except for non-farm income and family size, the other explanatory variables had statistically significant mean differences. Farmland is invaluable productive asset of smallholder farmers, in most cases having large farmland translated to higher crop production. The result showed that there is a significant mean difference between non-displaced and displaced households. Non-displaced farmers have a larger land size than displaced households. Displaced households lost part of their farmland for development projects.

Similarly, a significant mean difference was reported between non-displaced and displaced farming experiences. The farming experience of displaced households was higher than non-displaced households. Data generated from focus group discussants and key informants indicated that *displaced farmers are and close to Axum town, and have practiced agriculture for centuries.*

Market distance between non-displaced and displaced had a statistically significant mean difference. This implies the average market distance of non-displaced households was longer than displaced households. This result is as expected since displaced households are very close to the urban areas. The finding also showed the educational level of non-displaced households was higher than displaced households. Displaced households might terminate schooling and be employed to generate income to meet household requirements. The result revealed that the average income generated from remittance was higher among displaced households than non-displaced households. The focus group discussant and key informants stated that *displaced households receive financial support from relatives to supplement the food produced from the remained plot of land. However, non-displaced households do not get support from relatives rather the relatives who live in urban areas expect more from the farmers.* Lastly, an unexpected result was found in the possession of TLU. Displaced households owned larger TLU than non-displaced households. Because displaced households are partially participating in livestock farming particularly; poultry, dairy, and beef farming.

Table 4.2: Statistical summary of t-test distribution by treatment

Explanatory variables	Mean values			P-values
	Non-displaced/control	Displaced/treated	Combined	
Family size	5.2	5.5	5.3	0.2275
Farmland size	0.7	0.6	0.6	0.0170**
Farming experience	27.5	37.7	30.5	0.0000***
Market distance	5.2	1.6	4.1	0.0000***
Educational level of HH	3.1	1.7	2.7	0.0005***
Nonfarm income	3063.8	3688.1	3248.7	0.4026
Remittance	687.5	2287.1	1161.3	0.0557*
TLU	2.4	2.8	2.5	0.0207**

\*\*\*, \*\* and \* indicates 1, 5, and 10% significance level, respectively, Source: Computed from own survey data (2019)

As presented in Table 4.3 the chi-square test result revealed no statistical correlation between displaced and non-displaced households for the stated variables.

Table 4.3: Statistical summary of chi square-test distribution by treatment

Explanatory variables	Categories	Sample percentage	Non-displaced %	Displaced %	Chi-square
Sex of household head	Female	28.2	70.8	29.2	0.909
	Male	71.8	70.2	29.8	
Access to credit	No	90.0	69.4	30.6	0.224
	Yes	10.0	79.4	20.6	
Access to irrigation	No	74.8	68.2	31.8	0.135
	Yes	25.2	76.7	23.3	
Access to extension service	No	77.1	71.1	28.9	0.224
	Yes	22.9	67.9	32.1	

Source: Computed from own survey data (2019)

### 4.3.3 Land Use/ Land Cover Dynamics in Axum Town

First, the overall accuracy assessment for the Lu/Lc 2020 classification in Axum town and surrounding was checked. The result indicated that the overall accuracy was 85.9 with a Kappa index of 0.83, which is in the category of strong accuracy degree of agreement (Appendix IV). As presented in Figure 4.2, and Table 4.4 shows dramatic changes in Lu/Lc from 1980-2020. The coverage of forest decreased by 1.1% from 1980 to 2000, and by 1.7% during 2000-2020. Grassland coverage decreased by 7.5% in the last six decades. In general, forest and grassland coverage declines continuously in the last six decades. This is might be because of the conversion of forest and grassland to agricultural land and rural settlement. Besides, in rural areas, they cut and utilize trees for firewood, construction, and agricultural equipment. Similarly, bare land coverage decreased by 8% during 1980-2000 and increased by 2.9% from 2000-2020. Increasing bare land in the last late two decades is due to overexploitation of grass and forest land, and the expansion of fenced areas not yet used for development projects.

In the last four decades from 1980 to 2000, cropland increased by 1.14% and decreased by 1.9% from 2000 to 2020 in the study area (Table 4.4). Because from 2000 to 2020 sizable cropland was changed to residential areas and other development projects. The rural settlement did not show significant changes from 1980 to 2000 but from 2000 to 2020 rural settlement increased by 1.55%. The influx of rural settlement from 2000 to 2020 was associated with the new legislation of rural residential areas that restricts households who have residence areas in rural areas to live in urban

areas. Households are forced to choose either rural or urban areas otherwise their land is taken and provided to those who did not have land.

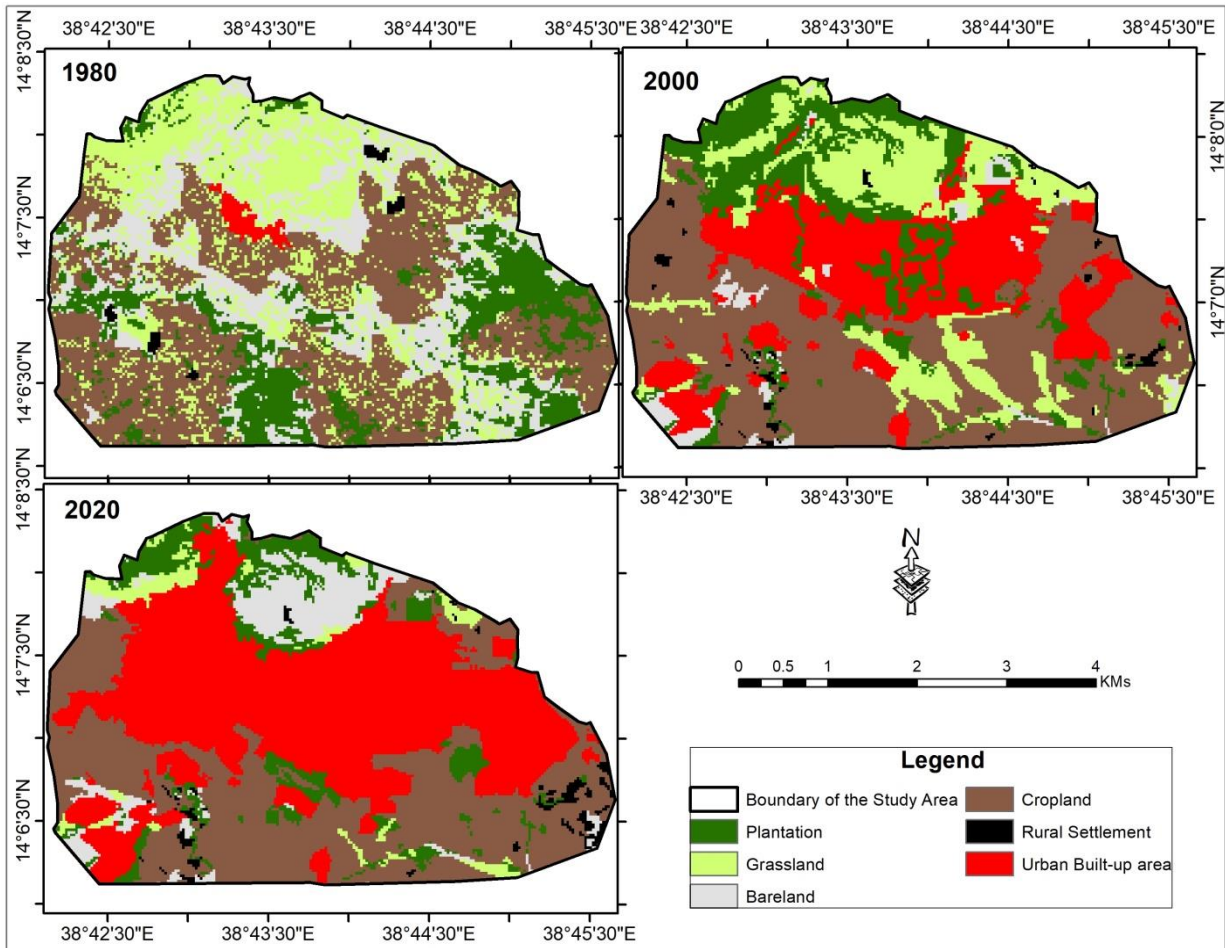


Figure 4.2: Lu/Lc of Axum city during 1980, 2000, and 2020  
 Source: Earthexplorer-USGS.Gov and Google Earth Pro

Table 4.4: Percentage of Lu/Lc in Axum town during 1980, 2000, and 2020

Lu/Lc type	1980		2000		2020	
	Hectare	Percentage	Hectare	percentage	Hectare	Percentage
Plantation	335.4	16.7	313.4	15.6	188.7	9.4
Grassland	489.3	24.4	329.9	16.5	64.9	3.2
Bare land	428.1	21.4	53.4	2.7	155.1	7.7
Cropland	719.6	35.9	823.6	41.1	694.5	34.6
Rural Settlement	12.0	0.6	18.2	0.9	27.9	1.4
Urban Built-up Area	20.7	1.0	466.6	23.3	874.0	43.6
Total	2,005.0	100.0	2005.0	100.0	2,005.0	100.0

Source: Computed from Landsat

Lastly, as presented in the graph and table, in the last six decades extended land was converted to urban build-ups. The result indicated that in the last six decades peri-urban land trespassed to urban built-ups continuously increases. It increased by 23.3% from 1980-2000, and 43.6% from 1980 to 2020. Figure 4.3 also shows, urban built-up increased by 30 ha from the delineated boundary of Axum town CSA (2007) from 2000 to 2020. Therefore, sizable farming land of peri-urban farmers was converted to urban built-up. Increasing natural population growth, and rural-urban migration are the possible forces that increase land used for build-ups.

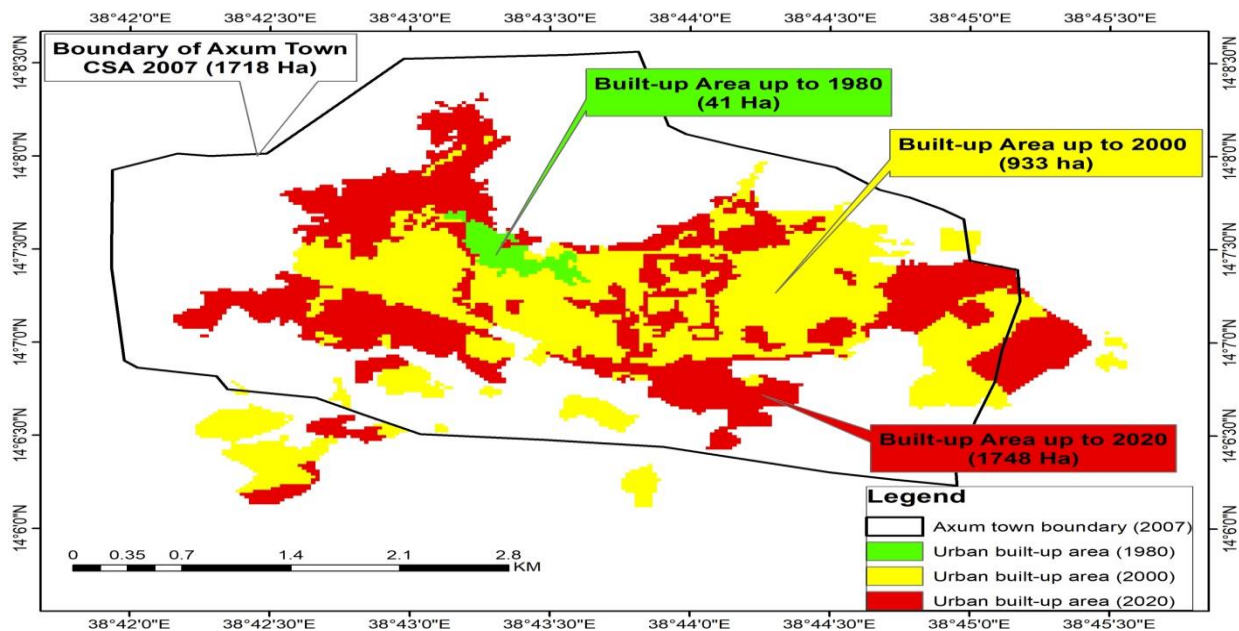


Figure 4.3: Expansion of built-up areas in Axum town during 1980-2020

Source: Source: Earthexplorer-USGS.Gov and Google Earth Pro

#### 4.3.4 Food Security Status of Households

To capture the different dimension of food security a combination of different measurements were applied. This topic has discussed each measurement independently.

**HFBM:** Normality test was conducted before proceeding to the subsequent steps. The data were normally distributed (Appendix V). The result revealed that the data are normally distributed with an average daily calorie intake of 2090.9 kcal (Table VI). Table 4.5 shows, food insecurity is unacceptable high both at *woreda* and treatment levels. At the *woreda* level, a significant mean difference was found between female and male-headed households. This implies food availability is higher among female-headed households than that of male-headed households. Data generated from the key informants and focus group discussants *showed that female-headed households invested every coin to improve food availability of households despite male-headed households, who spent money on Siwa and Beer alcoholic beverages. Besides, female-headed households get a chance of 50% to participate in PSNP, and women were empowered and exercised equal rights with men to access necessary assets to improve their living.* Therefore, PSNP might also significantly contribute to increasing household food availability. This result differs from the findings of Kahsay and Mulugeta (2014), who found that 77.3% of the population in Tigray was food insecure using the same indicator. About 35.8% and 28.7% of non-displaced and displaced households were food secured, respectively with no statistically significant difference between them.

Table 4.5: Percentage distribution of households to food availability

Groups	HFBM categories		Total	P-value
	Food secure	Food insecure		
Female	51 (53.1%)	45 (46.9%)	96 (100%)	0.0000***
Male	64 (26.1%)	181 (73.9%)	245 (100%)	
Total	115 (33.7%)	226 (66.3%)	341(100%)	
Non-displaced	86 (35.8%)	154 (64.2%)	240 (100%)	0.798
Displaced	29 (28.7%)	72 (71.3%)	101 (100%)	

\*\*\* indicates 1% significance level, Source: Computed from own survey data (2019)

In the farming communities' factors that are considered to be the most important variables to attain food security were identified and correlated with household food security status using a two-sample t-test. The result described that households with small family size, longer farming experience, smaller land size, and smaller TLU were found to be significantly more food secure

(Table 4.6). Practically speaking, in a farming community small farmland size and few TLU were translated to household food insecurity. However, a reverse relationship was found. The key informants and focus group discussants *proved that households with smaller farmland and TLU possess improved animal breeds and use modern inputs to increase crop productivity.*

Table 4.6: Mean comparisons of selected variables with food availability

Variable	Food security		Combined	P-value
	Food secure	Food insecure		
	Mean value	Mean value		
Family size	3.0	6.4	5.3	0.0000***
Farming experience	35.6	28.0	30.5	0.0000***
Land size in ha	0.59	0.67	0.64	0.0093***
TLU	1.8	2.9	2.5	0.0000***

\*\*\*, and \*, indicates a significant level at 1%, and 10%, respectively

Source: Computed from own survey data (2019)

**HFIAS:** Households were asked the nine generic occurrences and frequency of occurrence questions. Based on their responses, households were categorized into food secure, mildly food insecure, moderately food insecure, and severely food insecure (Appendix VII). The minimum and maximum HFIAS scores were 0 and 15 with an average value of 1.8. This indicated that most of the households were under the category of food secure. Of the total households, 49.3% of respondents were food secure whereas 29%, and 21.7% were mildly and moderately food insecure, respectively at 1% level of significance (Table 4.7). However, no households were reported under the category of severely food insecure. In general, the percentage of food secure male-headed households was higher than that of female-headed households. Maxwell *et al.* (2013) changed the categorical classification to binary classification of food secure and insecure. Households under the categories of food secure and mild food insecure are classified as food secure. Therefore, 78.3% of the population was food secure. This result was consistent with Moroda *et al.* (2018) conducted where 21.7% of the households in the Boset district of Ethiopia were found to be food insecure. But this result contradicts the finding of Mota *et al.* (2019) from the Wolaita zone, southern Ethiopia where 71.6% of the households were found to be food insecure.

Compared to displaced households, non-displaced households were more food secure. Of the sampled households, 50.8%, 29.6%, and 19.6% of non-displaced households and 45.6%, 27.7%, and 26.7% of displaced households were categorized under food secure, mild food insecure, and

moderately food insecure, respectively with no statistically significant relationship. Data collected from focus group discussants and key informants *showed that though the farmland size of displaced households is small, there are hardworking displaced farmers who effectively utilized the compensation to overcome food-related problems.* Thus the chi-square test result does not show a significant correlation between them.

Table 4.7: Percentage distributions of households access to food

Group	HFIAS			Total	P-value
	Food secure	Mild food insecure	Moderately food insecure		
Female	31 (18.5%)	18 (18.2%)	47 (63.5%)	96 (100%)	0.000***
Male	137 (81.5%)	81 (81.8%)	27 (36.5%)	245 (100%)	
Total	168 (49.3%)	99 (29%)	74 (21.7%)	341 (100%)	
Non-displaced	122 (50.8%)	71(29.6%)	47 (19.6%)	240 (100%)	0.339
Displaced	46 (45.6%)	28 (27.7%)	27 (26.7%)	101 (100%)	

\*\*\* indicates 1% significance level, Source: Computed from own survey data (2019)

Moreover, the ANOVA result showed that only farmland size and family size were found to be significant at 1% and 5% levels of significance, respectively (Table 4.8). Whereas, TLU and farming experience, found no statistical significance with HFIAS. The focus group discussant *reported that farmland size is an important factor to classify households as food secure and food insecure traditionally.* Therefore, the result showed that family size and farmland size affects household food security status positively or negatively.

Table 4.8: Result of one-way ANOVA

variables		Sum of squares	Degree of freedom	Mean of squares	F	Prob>F
Farmland size	Between groups	1.0	2	0.5	5.73	0.0036***
	Within groups	29.3	338	0.1		
	Total	30.3	340	0.1		
Family size	Between groups	39.8	2	19.9	3.96	0.0200**
	Within groups	1700.9	338	5.0		
	Total	1740.7	340	5.1		
TLU	Between groups	5.4	2	2.7	0.92	0.3992
	Within groups	994.5	338	2.9		
	total	999.9	340	2.9		
Farming experience	Between groups	183.4	2	91.7	0.48	0.6200
	Within groups	64749.6	338	191.6		
	total	64933.0	340	191.0		

\*\*\*, and \*\* indicate 1 and 5% significant level, respectively

Source: Computed from own survey data (2019)

**HDDS:** The result showed that the majority of the total households were in the optimum dietary diversity consumption category and statistically significant at 1% level of significance. Likewise, a significant number of displaced and non-displaced households were in the optimum dietary diversity consumption categories (Table 4.9). Surprisingly, male-headed households in the high dietary diversity consumption category were higher than that of female-headed households. This might be due to the economic discrepancies as male households were more engaged in farming particularly in irrigation and other non-farm activities that endure the economy of the households. Besides most male-headed households are with their partners, therefore, the wife cooks diversified foods to meet the requirement of her husband thereby her children. However, the percentage of food secure displaced households under the higher dietary diversity category were higher than non-displaced households with no significant differences.

Table 4.9: Percentage distribution of HDDS

Group	HDDS			Total	P-value
	Low DDS	Optimal/ Adequate DDS	High DDS		
Non-displaced	28 (11.7%)	138 (57.5%)	74 (30.8%)	240 (100%)	0.787
Displaced	11 (10.9%)	55 (54.5%)	35 (34.6%)	101 (100%)	
Total	39 (11.4%)	193 (56.6%)	109 (32%)	341 (100%)	
Male	28 (11.4%)	126 (51.4%)	91 (37.2%)	245 (100%)	0.003***
Female	11 (11.5%)	67 (69.8%)	18 (18.7%)	96 (100%)	
Total	39 (11.4%)	193(56.6%)	109 (32%)	341 (100%)	

\*\*\* indicates a 1% significant level, Source: Computed from own survey data (2019)

The ANOVA result showed that farmland size, family size, TLU, and farming experience had a significant correlation with household food security status measured using HDDS (Table 4.10).

Table 4.10: Result of one-way ANOVA

variable		Sum of squares	Degree of freedom	Mean of squares	F	Prob>F
Farmland size	Between groups	0.8	2	0.4	4.38	0.0132**
	Within groups	29.5	338	0.1		
	Total	30.3	340	0.1		
Family size	Between groups	40.9	2	20.5	4.07	0.0180**
	Within groups	1699.8	338	5.0		
	Total	1740.7	340	5.1		
TLU	Between groups	55.0	2	27.5	9.84	0.0001***
	Within groups	944.9	338	2.8		
	Total	999.9	340	2.9		
Farming experience	Between groups	980.9	2	490.4	2.59	0.0764*
	Within groups	63952.2	338	189.2		
	Total	64933.	340	191.0		

\*\*\*, \*\*, and \* indicates 1, 5, and 10% significant level respectively, Source: Computed from own survey data (2019)

**FCS:** The mean FCS of the sample households is 43.31 with a standard deviation of 7.2. The minimum and maximum scores of the households were 25 and 78, respectively (Table 4.11). On average the households were under the acceptable food consumption category. The correlation between the two cutoffs was 0.9051 which was statistically significant at 1%. The pairwise correlation analysis between each group and FCS showed that households who consumed sugar and oil were more correlated (0.7218) than households who do not consume sugar and oil (0.6677). Though all the correlations were statistically significant at 1%, consumption of sugar and oil is highly correlated. Therefore, 0 to 28 (poor), 28.5 to 42 (borderline), and >42 (acceptable) food consumption categories, respectively.

Table 4.11: Correlation of FCS and FCG

FCS	Obs	Mean	Std. dev.	Range
	341	43.6	7.2	25-78
Correlation b/n FCG1 and FCG2 = 0.9051***				
Correlation b/n FCS and FCG1 = 0.6677***				
Correlation b/n FCS and FCG2 = 0.7218***				

\*\*\*indicates a 1% significant level, Sources: Computed from own survey data (2019)

Table 4.12 shows, majority of the total sampled households were in the acceptable food consumption categories, respectively, with statistically significant at  $p < 0.001$ . The result also revealed that the percentage of food secure male-headed households was higher than that of female-headed households. Similarly, non-displaced households in the acceptable food consumption categories were higher than displaced households with no statistically significant correlation. Maxwell *et al.* (2013) changed the above categories to binary classification. Poor and borderline food consumption are categorized as food insecure. Based on this, 47.8% and 52.2% of the woreda respondents were food secure and food insecure, respectively with significant differences. Therefore, as above, male-headed households were more food secure than female-headed households. This result was different from the finding of Hailu *et al.* (2018) who found that, based on the FCS indicator, 40.3% of the households in Werie Leke *woreda*, Tigray were food secure. Similarly, 52.2% and 44.2% of displaced and non-displaced households were food secure, respectively with no significant differences between them.

Table 4.12: Percentage distribution of FCS

Group	FCG (with sugar and oil)			Total	P-value
	Poor Food consumption	Borderline food consumption	Acceptable food consumption		
Female	3 (3.1%)	61 (63.6%)	32 (33.3%)	96 (100%)	0.001***
Male	1 (0.4%)	113 (46.1%)	131 (53.5%)	245 (100%)	
Total	4 (1.2%)	174 (51%)	163 (47.8%)	341 (100%)	
Non-displaced	3 (1.2%)	131 (54.6%)	106 (44.2%)	240 (100%)	0.117
Displaced	1 (1%)	43 (42.6%)	57 (56.7%)	101 (100%)	
Total				341 (100%)	

\*\*\* indicates a 1% significant level, Sources: Computed from own survey data (2019)

Like HDDS, the ANOVA result showed that farmland size, family size, TLU, and farming experience had a significant correlation with household food security status measured using FCS (Table 4.13).

Table 4.13: Result of one-way ANOVA

variable		Sum of squares	Degree of freedom	Mean of squares	F	Prob>F
Farmland size	Between groups	1.0	2	0.5	5.86	0.0031***
	Within groups	29.3	338	0.1		
	Total	30.3	340	0.1		
Family size	Between groups	41.9	2	20.5	4.17	0.0163**
	Within groups	1698.8	338	5.0		
	Total	1740.7	340	5.1		
TLU	Between groups	68.8	2	34.4	12.48	0.0000***
	Within groups	931.2	338	2.8		
	Total	999.9	340	2.9		
Farming experience	Between groups	2014.5	2	1007.2	5.41	0.0049***
	Within groups	62918.6	338	186.2		
	Total	64933.0	340	191.0		

\*\*\*, and \*\*, indicates a significant level at 1%, and 5% respectively

Source: Computed from own survey data (2019)

#### 4.3.5 Correlation of Food Security Indicators

Household food security measured using different measurements yields dissimilar results. Therefore, continual use of diverse food security measurements are mandatory as far as a single holistic approach that captures all the dimensions is not functional. To examine correlation strength among indicators Pearson's r was applied. Except in HFIAS, a higher score indicates better food access. Hence the Pearson's r correlation showed HFIAS correlates negatively with HFBM, FCS,

and HDDS respectively. FCS positively with HDDS while HFBM is not correlated with FCS and HDDS. This finding agreed with Maxwell *et al.* (2013) conducted in Tigray where FCS was negatively correlated with HFIAS and positively correlated with HDDS. Thus the correlation is positive between FCS and HDDS than either of the above-listed food security indicators (Table 4.14). But of the indicators, HFIAS had a negative statistically significant correlation with total FCS and HDDS. Therefore, there is no possibility of utilizing one indicator over other indicators in the study area.

Table 4.14: Summary of Pearson's correlation of food security indicators

FS Indicators	HFBM	HFIAS	HDDS	FCS
HFBM	1.0000			
HFIAS	-0.1636*	1.000		
HDDS	-0.0118	-0.1642***	1.0000	
FCS	-0.0446	-0.1474***	0.4937***	1.000

\*\*\* indicates statistical significance at 1%, Sources: Computed from own survey data (2019)

#### 4.3.6 Anthropometric Measurements

To measure children under five ages, anthropometric measurements particularly; Weight for Height, Weight for Age, and Height for Age were applied. The detail of each measurement is discussed below;

**Thinness (Weight for Height/Length):** ‘This shows a child who is too thin for his or her height’ (WHO *et al.*, 2018, p. 2). A clinical sign of acute under nutrition, usually as a consequence of poor nutrient intake or a high outbreak of infectious diseases. Thinness impairs the proper function of the immune system increased the risk of death but treatment is possible (WHO, 2010). A child is wasted if the weight for height < -2 SD of the WHO Child Growth Standards median. The average z-score was -0.43 with a minimum and maximum z-score of -3.66 and 3.08, respectively. The chi-square test result showed that no statistically significant correlation was found at *woreda* and between displaced and non-displaced households (Table 4.15). However, the prevalence of thinness at the *woreda* level was a bit lower than the regional prevalence rate of thinness, which was 8.9% (TSA, 2019). Similarly, the prevalence of thinness across children from non-displaced and displaced households was lower by 0.2%, and 1.8% compared to the regional prevalence rate of thinness.

The result revealed that the prevalence rate of thinness was lower compared to the average prevalence rate of Ethiopia, which was 10% (NPC, 2018), and higher compared to Eastern Africa, which was 4% (WHO *et al.*, 2018), and the global average prevalence rate of thinness, which is 6.9% (FAO *et al.*, 2020). According to the classification of WHO (2010), children from the total sampled households, the prevalence rate of thinness was in the category of poor prevalence, which is set in the range of 5% to <10%. Besides the prevalence rate of thinness children from displaced and non-displaced households was in the category of poor prevalence. In general, high prevalence of thinness in the *woreda* compared to Eastern Africa and the global prevalence rate was, due to food and nutritional insecurity.

Table 4.15: Percentage distribution of thinness among children under five ages

Group	Not-wasting	wasting	Total	P-value
Female	44 (89.8%)	5 (10.2%)	52 (100%)	0.557
Male	53 (93%)	4 (7%)	54 (100%)	
Total	97 (91.5%)	9 (8.5%)	106 (100%)	
Non-displaced	84 (91.5%)	8 (8.7%)	92 (100%)	0.846
Displaced	13 (92.7%)	1 (7.1%)	14 (100%)	
Total	97 (91.5%)	9 (8.5%)	106 (100%)	

Sources: Computed from own survey data (2019)

**Stunting (Height for age):** This refers to a child who is very short for his or her age. Thus children are imposed to irreversible physical and mental retardation that accompanies stunted growth (WHO *et al.*, 2018). This hurts children's lifetime and even can pass to the next generation. A child wasted if height for age < -2 SD of the WHO Child Growth Standards median. The average z-score was -1.56 with a minimum and maximum z-score of -4.97 and 2.42, respectively. The chi-square test result showed that no statistically significant correlation was found at *woreda* and between displaced and non-displaced households (Table 4.16). However, the prevalence of stunting at the *woreda* level was lower than the regional prevalence rate of stunting, which was 40.9% (TSA, 2019). Similarly, the prevalence of stunting among children from non-displaced and displaced households was lower by half compared to the regional prevalence rate of stunting.

The result proved that the prevalence of stunting was lower compared to the average prevalence rate of Ethiopia, which was 38 % (NPC, 2018), Eastern Africa, which is 23.9% (WHO *et al.*, 2018), and the global stunting, which is 21.3% (FAO *et al.*, 2020). According to the classification of WHO (2010), the prevalence rate of children from the total sample and non-displaced

households were in the category of low prevalence, which is set to <20%. Besides the prevalence rate of stunting among children from displaced households was in the category of medium prevalence, which is set in the range of 20% to 29%.

In general, due to low vulnerability to drought, better health facilities, and potential for livestock and crop production reduces the prevalence of stunting in the study area. Data generated from focus group discussants showed that a lower stunting rate compared to the region was *due to low incidence of infectious diseases, better accessibility to school and non-farm income-generating activities, and productivity of the farmland compared to other parts of the Central zone.*

Table 4.16: Percentage distribution of stunting among children under five ages

Group	Not-stunting	stunting	Total	P-value
Female	40 (81.6%)	9 (18.4%)	49 (100%)	0.903
Male	46 (80.7%)	11 (19.3%)	57 (100%)	
Total	86 (81.1%)	20 (18.9%)	106 (100%)	
Non-displaced	75 (81.5%)	17 (18.5%)	92 (100%)	0.793
Displaced	11 (78.6%)	3 (21.4%)	14 (100%)	
Total	86 (81.1%)	20 (18.9%)	106 (100%)	

Source: Computed from own survey data (2019)

**Underweight (Weight for Age):** refers a child who is low weight for his or her age. This measurement shows the prevalence of acute and chronic malnourished children. A child is underweight if the weight for age < -2 SD of the WHO Child Growth Standards median. The average z-score was -1.20 with a minimum and maximum z-score of -3.47 and 1.58, respectively. The chi-square test result showed that no statistically significant correlation was found at *woreda* and between displaced and non-displaced households (Table 4.17). However, the prevalence of underweight at the *woreda* level was lowest compared to the regional prevalence rate of underweight, which was 21.2% (TSA, 2019). Similarly, the prevalence of underweight among children from non-displaced and displaced households was lower than the regional prevalence rate of underweight (21.2%).

The prevalence of underweight in the study area was lower compared to the average prevalence rate of Ethiopia, which was 24% (NPC, 2018), and higher than the global average prevalence of underweight, which is 5.6% (FAO *et al.*, 2020). According to the classification of WHO (2010), the prevalence rate of children from the total sample, non-displaced and displaced households were in the category of medium prevalence, which is set from 10% to 19%.

Table 4.17: Percentage distribution of underweight among children under five ages

Group	Not-underweight	underweight	Total	P-value
Female	42 (85.7.2%)	7 (14.3%)	49 (100%)	0.493
Male	46 (80.7%)	11 (19.3%)	54 (100%)	
Total	88 (83%)	18 (17%)	106 (100%)	
Non-displaced	76 (82.6%)	16 (17.4%)	92 (100%)	0.773
Displaced	12 (85.7%)	2 (14.3%)	14 (100%)	
Total	88 (83%)	18(17%)	106 (100%)	

Source: Computed from own survey data (2019)

To have a clear picture of undernourished children, whether they are stunted and/or wasted and/or underweight. A Composite Index of Anthropometric Failure (CIAF) was applied to what extent the children are malnourished. The result showed that 35.75% of children were suffering from one or more forms of under nutrition (Table 4.18).

Table 4.18: Result of composite index anthropometric failure

Anthropometric indicators	Percentage	CIAF
Group A (no failure)	64.15	35.75%
Group B(thinness only)	8.49	
Group C (thinness and underweight)	0.94	
Group D (thinness, stunting, and underweight)	0.94	
Group E (stunting and underweight)	5.66	
Group F (stunting only)	13.21	
Group Y (underweight only)	6.61	
$CIAF = \frac{1-A}{(A+B+C+D+E+F+y)}$		

Source: Computed from own survey data (2019)

#### 4.3.7 Determinants of Household Food Insecurity

The binary logistic regression result showed that family size, sex of household head, non-farm income, and TLU had a statistically significant association with household food security (Table 4.19). A multicollinearity test (VIF) was executed and no problem of multicollinearity was reported (Appendix VIII). Family size had a positive statistically significant effect on household food insecurity at 1% level of significance. Thus a unit increase in family size, increases the likelihood of food insecure households by 19.5%, keeping other variables constant. This happened most of the time if the household members are dominated by children and older people put pressure on household food availability or calorie consumption. Obayelu (2012), Kahsay and Mulugeta (2014), and Agidew and Singh (2018) found a negative statistically significant association between

food secure households and family size using the same indicator in Ethiopia. They evidenced that households with a larger dependency ratio and smaller economic active members are food insecure. Other empirical studies conducted by Mota *et al.* (2019) and Nata *et al.* (2014) found a neutral relationship between family size and household food security.

TLU is an important household asset to reduce the risk of food insecurity in agrarian countries. Households with larger TLU possession had a negative statistically significant effect on household food insecurity at 1% level of significance. A unit increase in the livestock possession of households increases the probability of food secure households by 4.3% keeping other factors constant. As livestock in rural households is a source of draught power, means of saving and expression of wealth, and protect households at the time of bad crop harvesting season. This result agrees with the findings of Beyene and Muche (2010), Geleta *et al.* (2018), and Kahsay and Mulugeta (2014) who found a positive statistically significant correlation between TLU and food secure households.

The sex of household head has a positive statistically significant effect on food secure households at 10% level of significance. A unit increase in the number of male-headed households increases the probability of households being food secure by 6.6% keeping other variables constant. Key informants and focus group discussants *evidenced that inherently, in rural areas, males are actively engaged in farming activities and other income-generating activities compared to females. Besides, the probability of getting extra land either by sharecropping or renting is higher in males than in females.* This result conforms with the finding of Jega *et al.* (2018) and Obayelu (2012) reported a positive relationship between male-headed and food secure households, who evidenced that historically the majority of activities like fishing, hunting, and farming are operated by a male that is why female-headed households make less productive and food insecure.

Lastly, it is clear in smallholder farmers income generated from agricultural production may not be sufficient to meet household requirements. Therefore, engaging in non-farm income-generating activities empowers smallholder farmers to adopt agricultural technologies thereby modernize the production system and attain food security. Apart from this, helps farmers to purchase food items in times of poor production. Non-farm income had a positive statistically significant influence on household food security at 10% level of significance. A unit increase in the amount of money

generated from non-farm income, increases households being food secure by 0.1%. This result is in line with the findings of Beyene and Muche (2010) who found a positive statistically significant association with food secure households. However, a reverse correlation was reported by (Agidew & Singh, 2018). They justified that the income generated from non-farm income is insignificant due to the lack of job opportunities in rural areas.

Table 4.19: Marginal effect of variables to household food security measured using HFBM

Variables	dy/dx	Std. Err.
Access to credit	0.056	0.119
Access to extension	0.004	0.056
Educational level of household head	0.002	0.007
Family size	-0.195***	0.040
Farming experience of household head	0.002	0.002
Sex of household head	0.066*	0.036
Irrigated land size	-0.177	0.306
Land size	0.093	0.090
Market distance	0.018	0.013
Non-farm income	0.001*	0.000
Remittance	0.000	0.000
TLU	0.043**	0.018
Treatment	-0.062	0.052

\*\*\*, \*\*, and \* indicate statistical significance at 1%, 5%, and at 10%, respectively.

Sources: Computed from own survey data (2019)

As presented in Table 4.20, the marginal effect of covariates on household food security categories varies. Farming experience, Family size, farmland size, sex of household head, remittance, and TLU possession had a statistically significant effect on household food security measured using HFIAS.

Farming experience underpins to enrich knowledge and skills of planting season, weeding and harvesting time, land preparation, and other agronomic practices as well. The result showed that farming experience had a positive statistically significant effect on the household in the category of mild food insecure. This indicates a unit increase in farm experience, decreases the probability of households being mild food insecure by 0.2%, keeping other variables unchanged. This result is consistent with the finding of Aboaba *et al.* (2020) who explained that farming experience decreases households in the categories of mild food insecure.

Family size had a statistically significant effect on food secure households at 1% level of significance. Households with larger family sizes were vulnerable to food insecurity. A unit increase in family size decreases the probability of households being food secure and increases the probability of households being mild and moderate food insecure by 11.3%, 4.6%, and 6.7%, respectively, keeping other variables constant. This result is in line with the findings of (Obayelu, 2012).

In rural areas farmland is a precious household asset and directly affects food production. The result revealed that farmland size and household food security had a statistically significant relationship. A unit increase in farmland size increases the probability of a household being food secure and decreases the probability of households in the category of mild and moderate food insecure households by 35%, 14.3%, and 20.6%, respectively, keeping other variables constant. This result is in line with the findings of Obayelu (2012), Moroda et al. (2018), and Mota *et al.* (2019) in Nigeria and Ethiopia found a positive statistically significant association between household food security and farmland size. As farmland size is considered a critical production factor that determines the type of crops to be grown and the quantity of agricultural food crops produced. Similarly, the sex of the household head had a statistically significant effect on household food security. A unit increase in male-headed households increases the probability of a household being food secure and decreases the probability of household in the category of mild and moderate food insecure by 46.2%, 6.4%, and 39.7% respectively, keeping other variables constant. This result is in line with the finding of (Obayelu, 2012).

Practically speaking, households who get remittance protect from selling their agricultural products and precious assets at a distressed price. The result showed remittance had a statistically significant association with household food security. A unit increase in the amount of money generated from remittance decreases the probability of a household being food secure by 0.1% and increases the probability of a household in the category of mild food insecure by 0.1%, keeping other variables constant. This might be the money generated from remittance is insignificant to change the food accessibility of households. In addition, remittance develops dependency syndrome and households may remain idle rather than actively engage in income-generating activities. This result differed from previous work (Abadi *et al.*, 2018). Who found a positive

statistically significant association between remittance and household food security status of household.

TLU is an important household asset that enhances household food security in agrarian countries. TLU possession had a statistically significant relationship with household food security. Households with larger TLU possession were more food secure than households with smaller TLU possession. A unit increase in TLU possession increases the probability of a household being food secure and decreases the likelihood of households being in the category of mild and moderate food insecure by 3.7%, 1.5%, and 2.2%, respectively, kept other variables constant. This is consistent with the findings of Abafita & Kim (2014) conducted in Ethiopia. They mentioned that livestock possession mitigates exposure of households to food insecurity in times of crop failure and other unexpected disasters. while Ibrahim *et al.* (2016) found a neutral connection between household food security and TLU possession in Nigeria.

Table 4.20: Marginal effect of variables on household food security measured using HFIAS

Variable	HFIAS indicator					
	Food secure		Mild food insecure		Moderate food insecure	
	dy/dx	Std. Err.	dy/dx	Std. Err.	dy/dx	Std. Err.
Access to credit	-0.123	0.082	-0.059	0.044	-0.064*	0.038
Access to extension	- 0.017	0.076	0.007	0.030	0.010	0.046
Educational level	-0.014	0.010	0.006	0.004	0.008	0.006
Family size	-0.113***	0.020	0.046***	0.012	0.067***	0.011
Farming experience	-0.004	0.003	0.002***	0.001	0.002	0.002
farmland size	0.350***	0.130	-0.143**	0.058	-0.206**	0.077
Sex of household	0.462***	0.052	-0.064**	0.032	-0.397***	0.067
Irrigated land size	0.218	0.279	-0.089	0.115	-0.129	0.165
Market distance	0.002	0.022	-0.001	0.009	-0.001	0.013
Non-farm income	0.001	0.000	0.000	0.000	0.000	0.000
Remittance	-0.001***	0.000	0.001**	0.000	0.000	0.000
TLU	0.037*	0.021	-0.015*	0.009	-0.022*	0.012
Treatment	0.016	0.110	-0.007	0.046	-0.009	0.064

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

Sources: Computed from own survey data (2019)

The marginal effect variables revealed that educational level, farming experience, irrigated land size, and TLU possession had a statistically significant effect on HDDS categories (Table 4.21). Education is an important social asset to boost household food security. The educational level of

the household head had a statistically significant association with household dietary diversity consumption. A unit increase in the educational level of household increases the probability of a household being in the category of high dietary diversity consumption and decreases the probability of a household being in the category of low and optimum dietary diversity consumption by 1.6%, 0.7%, and 1%, respectively, keeping other variables constant. Because increasing access to education improves the nutritional knowledge of households. This result is consistent with the findings of Iftikhar *et al.* (2020), Jebessa *et al.* (2019), Muhammad-Lawal *et al.* (2017), Ngema *et al.* (2018), and Taruvinga *et al.* (2013) found a positive relationship between education and household dietary diversity consumption. They suggested that more educated household heads have good knowledge and understanding of the health benefits of consuming a balanced diet.

Farming experience had a statistically significant effect on dietary diversity consumption of households. A unit increase in the farming experience of the household increases the probability of households in the category of high dietary diversity consumption and decreases the probability of households in the category of low and optimum dietary diversity by 0.7%, 0.3%, and 0.4%, respectively, holding other variables unchanged. Experienced farmers grow diversified crops to minimize the risk of crop failure. Besides increasing agricultural experience helps farmers to develop knowledge on sustainable land management and efficient utilization of limited resources to harvest more food crops. The result is consistent with the findings of (Huluka & Wondimagegnhu, 2019). They described farming experience increases the probability of farmers working in agriculture on a full-time basis.

Despite the existence of various rivers in Ethiopia, rain-fed agriculture is the dominant means of food production. Irrigation helps farmers to produce different agricultural products in the dry season to meet the food requirements of households. The result explored that irrigation has a statistically significant effect on household dietary diversity food consumption. A unit increase in irrigated land size decreases the likelihood of being in the category of low and optimum dietary diversity consumption and increases the likelihood of being in the category of high dietary diversity consumption by 29%, 39.6%, and 68.6%, respectively, holding other variables constant. Derso *et al.* (2020) found a similar result in the west Bale region, Ethiopia.

Furthermore, Households with larger TLU possession were food secure. A unit increase in TLU possession decreases the probability of households being in the category of low and optimum dietary diversity consumption and increases the probability of households in the category of high dietary diversity consumption by 1.9%, 2.6%, and 4.5%, respectively, keeping other variables constant. Taruvinga et al. (2013) proved that rural households with livestock ownership are more likely to move from a medium dietary diversity into a high dietary diversity consumption. Similarly, a recently published article proved that TLU improves household dietary diversity consumption (Derseo *et al.*, 2020; Iftikhar *et al.*, 2020; Jebessa *et al.*, 2019; Nkomoki *et al.*, 2019).

Table 4.21: Marginal effect of variables on household food security measured using HDDS

Variables	HDDS indicator					
	Optimum d. diversity		High dietary diversity		Low dietary diversity	
	dy/dx	Std. Err.	dy/dx	Std. Err.	dy/dx	Std. Err.
Access to credit	0.051	0.046	0.044	0.023	-0.095	0.067
Access to extension	0.007	0.027	0.008	0.034	-0.015	0.061
Educational level	-0.007**	0.004	-0.010**	0.005	0.016**	0.008
Family size	-0.002	0.006	-0.003	0.009	0.005	0.015
Farming experience	-0.003**	0.001	-0.004***	0.001	0.007***	0.002
farmland size	0.020	0.045	0.026	0.061	-0.046	0.106
Irrigated land size	-0.290**	0.124	-0.396**	0.166	0.686**	0.275
Market distance	-0.000	0.008	-0.000	0.012	0.001	0.018
Non-farm income	-0.000	0.000	-0.000	0.000	0.000	0.000
Remittance	-0.000	0.000	0.000	0.000	0.000	0.000
Sex of household	-0.022	0.029	-0.027	0.032	0.050	0.060
TLU	-0.019***	0.007	-0.026***	0.010	0.045***	0.016
Treatment	0.017	0.040	0.021	0.046	-0.037	0.086

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

Sources: Computed from own survey data (2019)

The marginal effect of variables showed that farming experience, sex of household head, irrigated land size, non-farm income, and TLU possession had a statistically significant effect on FCS categories (Table 4.22). A unit increase in the farming experience of households decreases the probability of households in the category of borderline food consumption and increases the probability of households in the categories of acceptable food consumption by 0.8% and 0.9%, respectively, given that all variables are constant. This result conforms with the finding of (Adeniyi & Dinbabo, 2019). Similarly, the sex of a household head had a statistically significant effect on

household food security. A unit increase in the number of male-headed households decreases households in the category of borderline food consumption and increases the probability of households in the category of acceptable food consumption by 18.4%, and 19.2%, respectively, keeping other variables constant. This result is consistent with the finding of (Phami *et al.*, 2020). They evidenced that most activities particularly farming, fishing, and hunting are normally done by men, which makes female-headed households less productive in these activities.

Irrigated land had a statistically significant effect on household food security. A unit increase in irrigated land size decreases the probability of households in the category of poor and borderline food consumption and increases the likelihood of households in the category of acceptable food consumption by 3.1%, 92.6%, and 95.7%, respectively kept other variables constant. Hailu et al. (2018) found a similar result in the Tigray region. They justified that irrigation increases the food production of households by producing more than once a year and complement rain-fed production. Similarly, non-farm income has a statistically significant effect on household food security. A unit increase in non-farm income decreases the probability of households in the category of poor and borderline food consumption and increases the probability of households in the category of acceptable food consumption by 0.1% each kept other variables constant. This result conforms with the finding of (Cholo *et al.*, 2018).

Lastly, TLU possession had a statistically significant effect on household food security. A unit increase in TLU possession decreases the probability of households being in the category of poor and borderline food consumption and increases the likelihood of households in the category of acceptable food consumption by 0.2%, 4.7%, and 4.9%, respectively, keeping other variables constant. Nkomoki *et al.* (2019) found a similar result TLU decreases households in the categories of poor and borderline food consumption and increases households in the category of acceptable food consumption.

Table 4.22: Marginal effect of variables on household food security measured using FCS

Variables	FCS measurement					
	Poor		borderline		acceptable	
	dy/dx	Std. Err.	dy/dx	Std. Err.	dy/dx	Std. Err.
Access to credit	0.002	0.004	0.064	0.087	-0.067	0.091
Access to extension	-0.001	0.002	-0.044	0.077	0.046	0.079
Educational level	0.000	0.000	0.004	0.011	-0.004	0.011
Family size	0.000	0.001	0.009	0.018	-0.009	0.018
Farming experience	-0.000	0.001	-0.008***	0.003	0.009***	0.003
farmland size	0.001	0.005	0.018	0.134	-0.019	0.139
Sex of household head	-0.008	0.005	-0.184**	0.073	0.192**	0.077
Irrigated land size	-0.031*	0.018	-0.926**	0.381	0.957**	0.392
Market distance	0.001	0.001	0.029	0.022	-0.030	0.023
Non-farm income	-0.001*	0.000	-0.001***	0.000	0.001***	0.001
Remittance	-0.000	0.000	-0.000	0.000	0.000	0.000
TLU	-0.002	0.001	-0.047**	0.022	0.049**	0.023
Treatment	0.003	0.004	0.088	0.102	-0.091	0.106

\*\*\*, \*\*, and \* indicates Statistical significance at 1%, 5%, and 10% probability levels, respectively. Source: Computed from own survey data (2019)

#### 4.3.8 Impact Assessment

HFBM was used as an outcome variable to estimate the impact of urban expansion on household food security. Households displaced from their farming land were assigned as treated otherwise a control group. Computing of this model demands variables that were not imposed by the treatment effect. Heckman *et al.* (1997) stated that including bulky variables and excluding important variables highly biases the result. Therefore, though food security is affected by several demographic and socio-economic factors, variables that only affect both participation decision and outcome variables were selected. The educational status of household head, access to credit, sex of household head, and family size were identified. A t and chi-square test were conducted to validate if mean differences existed between the treated and control group before matching. Table 4.23 shows, educational level of the household head had a statistically significant mean difference.

Table 4.23: Statistical summary of t-test distribution

Explanatory variables	Mean values			P-values
	Non-Displaced/control	Displaced/treated	Combined	
Family size	5.17	5.49	5.28	0.2275
Educational status	3.07	1.66	2.65	0.0005***

\*\*\* indicates 1% significant level, Source: Computed from own survey data (2019)

However, the chi-square test result showed the variables had not statistically significant relationship between displaced and non-displaced households (Table 4.24).

Table 4.24: Statistical summary of chi square-test distribution

Explanatory variables	Categories	Sample Percentage	Non-Displaced %	Displaced%	Chi-Square
Access to credit	No	90.0	69.4	30.6	0.224
	Yes	10.0	79.4	20.6	
Sex of household head	Female	96 (28.1)	28 (27.7)	68 (28.3)	0.909
	Male	245 (71.9)	73 (72.3)	172 (71.7)	

Source: Computed from own survey data (2019)

Generally, the educational level of the household head had a statistically significant mean difference, therefore, matching participates will be necessary to have a homogenous group to estimate the impact. A series and repeated tests were conducted to decide which variables to be included that satisfy the PSM assumptions. As indicated above two continuous and two categorical variables were selected based on the percentage of mean bias and  $\beta$  value. Because after matching the mean bias should be  $<5\%$  and  $\beta < 25\%$  (Caliendo & Kopeinig, 2005).

#### 4.3.8.1 Estimation of Propensity Score

The probit regression result shows that educational level household head and family size were statistically significant (Table 4.25). The pseudo- $R^2$  value is 4.5% which indicates the pseudo- $R^2$  explains the participation probability. Because a low  $R^2$  value minimizes the unique characteristics of treated households. This is an opportunity to match treated and controlled groups easily. Overall the estimated regression result is good and simplifies the matching process. Therefore, before estimating the ATT the covariates should be corrected.

Table 4.25: Probit regression of participation

Variables	Coef.	Std.Err.
Access to credit	-0.385	0.245
Gender	0.015	0.186
Educational status of HH	-0.091***	0.024
Family size	0.067*	0.368
_cons	-3.45	0.190
Log-likelihood	-197.79672	
Number of obs	341	
LR chi2(7)	18.79	
Prob > chi2	0.0009	
Pseudo R2	0.0453	

\*\*\*, and \*\*, indicates 1, and 5% significant levels, respectively,

Source: Computed from own survey data (2019)

#### 4.3.8.2 Matching Displaced and non-Displaced Households

The total mean propensity score of households is 0.294 with a minimum and maximum score of 0.048 and 0.485, respectively. The mean score of the treated and control group is 0.331 and 0.294, respectively. The minimum and maximum scores of the treated and control group were found between 0.122-0.485 and 0.048-0.485, respectively. Therefore, according to minima and maxima criteria the common support region lies between 0.122 and 0.485 (Table 4.26). Therefore, any household that was found out of this region was not included for matching. Luckily, no observation was found out of the common support region.

Table 4.26: Distribution of estimated propensity scores

Groups	Obs	Mean	Std. dev.	Min	Max
Total HH	341	0.294	0.105	0.048	0.485
Treated	101	0.331	0.086	0.122	0.485
Control	240	0.281	0.109	0.048	0.485

Source: Computed from own survey data (2019)

Graphically the pscore is presented in Figure 4.4. From this, the pscore is higher in treated on support than untreated on support.

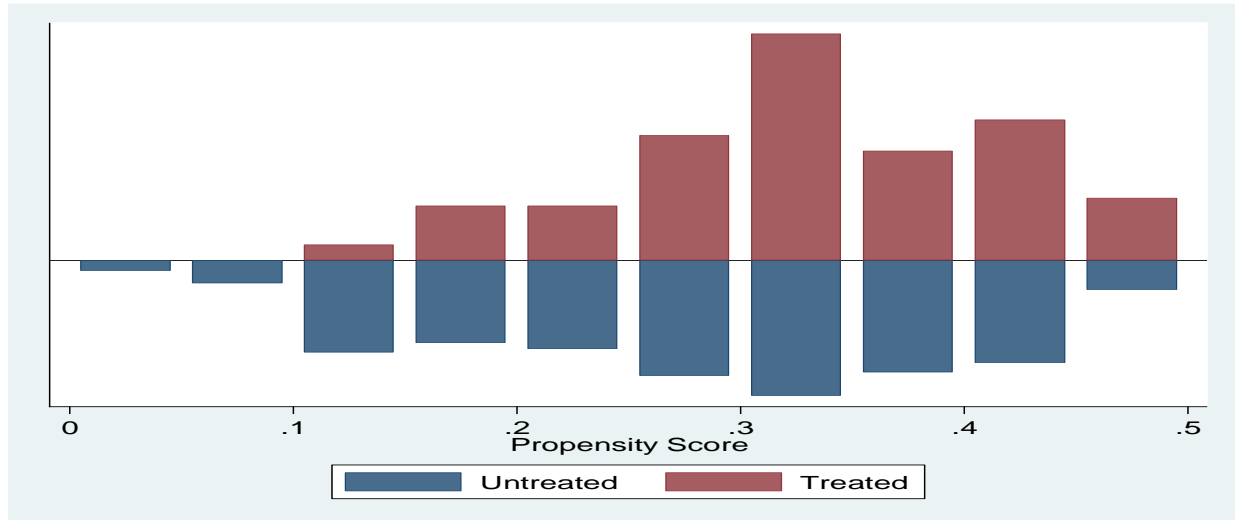


Figure 4.4: Distribution of propensity score,  
Source: Computed from own survey data (2019)

#### 4.3.8.3 Testing the Balance of Propensity Score and Covariates

After rigorous matching tests balancing property was achieved. Before matching the percentage of bias ranges from 1.4-44.1 but after matching it ranges from 2.2-4.7 which is far from the critical level cutoff point of 25% (Table 4.27). Besides educational level had a statistically significant mean difference before matching between the treated and control group but after matching no statistically significant correlation was found between the treated and control group.

Table 4.27: Propensity score and covariate matching

variables	Unmatched		Mean			
	Matched	Treated	Control	% bias	% reduction  bias	P> t
Access to credit	U	0.07	0.11	-15.0	.	0.225
	M	0.07	0.06	3.4	77.1	0.790
Sex of household head	U	0.72	0.72	1.4	.	0.909
	M	0.72	0.73	-2.2	-62.2	0.875
Educational status of household head	U	1.66	3.07	-44.1	.	0.001
	M	1.66	1.55	3.7	91.6	0.752
Family size	U	5.50	5.17	14.1	.	0.228
	M	5.50	5.39	4.7	66.4	0.748

Source: Computed from own survey data (2019)

Furthermore, fairly low pseudo-R2 and statistical insignificance after matching prove both groups have a similar distribution in covariates after matching (Table 4.28). Therefore, the matching

process exactly fits the requirement and balances the features in displaced and non-displaced households of the study area.

Table 4.28: Chi square-test for the joint significance of variables

Sample	Ps R2	LR chi2	p>chi2	MeanBias	MedBias	B	% var
Unmatched	0.045	18.790	0.000	18.600	14.5	53.2*	50
Matched	0.001	0.380	0.984	3.5	3.6	8.6	0

Source: Computed from own survey data (2019)

#### 4.3.8.4 Matching Algorithm

Caliendo *et al.* (2005) stated that there is no single and commonly used matching algorithm that dominates and applicable in all data collected to assess impact. However, for this study kernel matching was applied. Kernel matching matches observations that lay in the common support region only. The result showed that the average treatment effect on the treated (ATT) was a negative and statistically insignificant effect on displaced household food security (Table 4.29). Therefore, this implies that urban expansion did not affect household food availability.

Table 4.29: Result of average treatment effect on the treated (ATT)

Variable	sample	treated	controlled	differences	S.E	t-stat
Totcalorie	Unmatched	1974.79	2139.72	-164.92	154.04	-1.07
	ATT	1974.74	2120.76	-145.96	299.36	-0.49

Source: Computed from own survey data (2019)

## 4.4 Summary

This chapter has discussed the impact of urban expansion on peri-urban farmers' food security. Demographic characteristics of respondents revealed that the average age of displaced households was higher than non-displaced households with a mean average age of 61 and 50 years, respectively. The mean educational level of non-displaced and displaced households were grade three and two, respectively. Furthermore, the average family size of displaced households was higher than non-displaced households. In general, the average family size of the study area is higher than the national average family size, which is 4.6. The average farmland size is also higher among non-displaced households than displaced households though the landholding is below the regional average landholding which is 0.75 ha. The average non-farm income was higher among displaced than non-displaced households. Unexpectedly, the average TLU was higher among displaced than non-displaced households. The mean market distance also showed non-displaced

households were too far from the market than displaced households. Of the compensated 67.7%, 16.2%, and 11.1% had spent the money for more than two purposes, house construction, and purchasing food items, respectively. Migration was also reported higher among non-displaced households. The dominant driving forces to migrate in non-displaced households were searching for better life and work, while displaced households were due to a shortage of farming land. Participating in irrigation was found quite low with 27.5% and 19.8% of non-displaced and displaced households, respectively, where subsistence agriculture is the dominant means of income.

A t-test was conducted to validate if there is mean differences between non-displaced and displaced households. The t-test indicated that from the continuous variables a mean difference was reported in farmland size, family size, farming experiences, educational level, remittance, and TLU. While the chi-square test result revealed no statistically significant correlation across the dummy variables.

Food security status of the households varies depending on the type of food security measurement applied. All food security measurements yield a different result with no statistically significant correlation between displaced and non-displaced households. The percentage of food insecurity was higher among displaced households using HFBM and HFIAS. Of the respondents, 35.8% and 28.7%, of non-displaced and displaced households were food secure, respectively, using HFBM, and 50.8% and 45.6% were found food secure, respectively, using HFIAS. However, a reverse result was reported using FCS and HDDS. A significant correlation was reported between female-headed and male-headed household food security. The result showed that 30.8% and 34.6% of non-displaced and displaced using HDDS, and 44.2% and 56.7% of non-displaced and displaced using FCS were found food secure respectively. The nutritional status of children showed that no statistically significant correlation in wasting, stunting, and underweight between children from displaced and non-displaced households with a Composite Index of Anthropometric Failure (CIAF) value of 35.75%.

Family size, Farming experience, farmland size, and TLU covariates were selected and correlated with household food security using t-test and ANOVA. Of the four covariates, only family size and farmland size had a statistically significant effect on food security measured using HFIAS. While, all the covariates had a statistically significant correlation with food security measured

using HFBM, HDDS, and FCS. The correlation across food security indicators showed the HFIAS had a negative statistically significant correlation with HFBM, HDDS, and FCS.

The regression analysis result revealed urban expansion had an insignificant negative effect on household food availability of peri-urban household food security regardless of food security measurements. The determinants of food security/insecurity across different indicators indicated that HFIAS and FCS were affected by five demographic and socioeconomic factors while HFBM and HDDS were affected by four demographic and socio-economic factors. Lastly, to estimate the impact HFBM was used as an outcome variable computed using the selected explanatory variables. The ATT showed a negative 145.96kcal deficit with no statistical correlation between displaced and non-displaced households.

## **Chapter 5: Impact of Urban Expansion on Household Poverty in Axum, Tigray Region**

### **5.1 Introduction**

Poverty is a composite deprivation of poor access to education, lack of access to potable water within reach, living in a precarious area, poor nutrition, degraded health facilities, and lack of exercising democracy (Sen, 1999). Natural and human fabricated factors are limiting the eradication of poverty in all its forms, particularly in developing countries. Globally, development projects displace about 10 million people every year (Cernea, 2000). The development projects are launched to improve people's life however most displaced households were entrenched in poverty (Cao *et al.*, 2012). UNDP and OPHI (2019) reported that from 101 countries including Ethiopia, 23.1% of the population were multidimensional poor and half of this number were children. Globally, one out of six adults and one out of three children are multidimensionally poor. Of the multidimensional poor 57.5% were found in Sub-Saharan African countries. Unequal share of economic growth, instability, unplanned urban expansion, low educational level, weak institutions, heavy exploitation of natural resources, and vulnerability to natural disasters were among the predisposing conditions (World Bank, 2018). Similarly, World Bank (2019) reported lack of clean water, electricity, health facility, inaccessible education, lack of job opportunity, population growth, belittle females in development projects, climate changes, and policies in favor of elites are challenging the continent.

Though urban expansion is an inevitable phenomenon, major development induced not voluntary displacement was performed by government responsibility (Cernea, 1990). As a result, displacing peri-urban farmers will continue in developing countries. Terminski (2013) stated development induced displacement was outnumbered in Asia and Africa compared to other continents. Logically, an urban expansion made urban and rural areas much closer than they were ever before, and the exchange of goods and services including human flow becomes easy. Different perspective regarding the impact of urban expansion on household poverty was grown. Rural-urban linkage is one of the perspectives which focuses on the mutual benefits of urban and rural communities. The pro rural-urban linkage substantiates the exchange of goods and services among them creates a positive virtuous economic growth. As a result, displaced households improve their income sources and purchasing power thereby reduces impoverishment in peri-urban farmers (Christiaensen *et al.*, 2013). On the other hand, Cernea (1990) introduces the IRR model and argues

involuntary displacement marginalize and intensifies poverty and faced all-round impoverishment. Prenzel and Vanclay (2014) proved that people failed to respond and revive from the negative consequences and make people permanently poor and vulnerable to various shocks. Similarly, Adusah-karikari (2015) and Tsikata (2009) posited that denying farming people productive assets particularly farming land has an immediate and devastating impact on household poverty. Terminski (2013) also strictly argued that it is a matter of socioeconomic issue where loss of access to farming land and other common resources like grazing land, forests Water, and social integrations rises poverty in displaced households. Aboda *et al.* (2019) revealed that in developing countries displaced people are exposed to impoverishment than enriched.

Though urban expansion and its impact is a pressing issue, few studies have been conducted. A study conducted in Brazil by Randell (2016) reported that of the respondents 70% of displaced farmers registered better subjective well-being but smallholder farmers experienced severe poverty than before displaced. Other findings from India also showed 75% of development induced displaced smallholder farmers were found below the poverty line (Cernea, 2000). Previous and recent research findings from China proved that 60% of development induced displaced households were exposed to poverty (Robinson, 2003), and a significant negative ramification of displacement on employment, income level, and income resource, and overall well-being was reported (Huang *et al.*, 2018). Contrarily, a study conducted in Nigeria by Oruonye (2012) found 62% of displaced households were enriched than ever before. In sum, previous studies had left open whether urban expansion increases or decreases poverty.

Ethiopia hosts about 85.5 million (83.5%) multidimensional poor people and ranked in the last three countries followed by India and Nigeria. Ethiopia is home, to over half of the multidimensional poor households are malnourished and did not finish six years of schooling, 1/3<sup>rd</sup> of the population were multidimensional poor where their children did not attend school, 3/4<sup>th</sup> of the multidimensional poor have not electricity, and 80% of the multidimensional poor did not have sanitation facilities (UNDP & OPHI, 2019). The report also showed that 27.3% of the population was poor on a monetary basis.

Majority of the studies conducted on determinants of poverty were in rural areas using the unidimensional poverty measurement but limited researches were done on determinants of multidimensional poverty. A study conducted in Ethiopia showed that family size, sex of

households, dependency ratio, and livestock ownership are the most important determinants of rural poverty (Ermiyas *et al.*, 2019). They verified that livestock ownership and sex of households were negatively related to poverty while family size and dependency ratios were positively affect household poverty. Similarly, Afera, (2015) and Bogale *et al.* (2005) found total family size and dependency ratio have a positive association with poverty of households and statistically significant. Whereas, farmland size, livestock owned (TLU), educational status of the household head, access to credit, and access to off-farm income were negatively related to household poverty and statistically significant. Generally, in countries like Ethiopia where their means of livelihood is subsistence agriculture, households who owned substantial agricultural land were more likely to exit from poverty (Deressa & Sharma, 2014). Besides female-headed households, large family size, and high dependency ratio households were vulnerable to poverty as well.

In Tigray, where the study was conducted development induced displacement is commonly practiced. Like other countries and other parts of Ethiopia, prime agricultural land is taken for the construction of residential houses. This is creating pressure on peri-urban farmers' livelihood as there are no industries to host ample labor created due to displacement. In other countries, farmers were displaced from their farmland and being displaced mainly to establish large processing plants or dams that have a trickle-down effect on the community. In general, the effect of development induced displacement was observed in the study area. So far, studies conducted on poverty were either in urban or rural areas. Previous researches, for instance, Gebrekidan (2019), and Haile (2018) conducted on poverty were done at the household level and little emphasis was provided on child poverty. The poverty status of the study area was not assessed using a multidimensional poverty index. Besides urban expansion and its impact on peri-urban smallholder farmers were barely studied. Lastly, the determinant of multidimensional poverty of peri-urban farmers is not studied so far in the study area. Therefore, this study addresses the aforementioned lacuna and will have strong policy implications.

## **5.2 Methodology**

### **5.2.1 Poverty Measurement Validity**

Quantification of poverty based on the minimum consumption requirement per day is commonly practiced. Due to this, many kinds of literature boldly criticize the monetary or household consumption base measurement of poverty though it has its own strengths and weakness as measurement (Batana, 2013; Santos, 2013; Yu, 2013). For instance, Spicker, Leguizamon, and Gordon (2007) claimed that the income-based definition is not inclusive as different people have their own definition and concept of poverty. Others also mentioned monetary approach does not qualitatively and inclusively measure the wellbeing of people (Akindola, 2009). He also stated that no attention is given to use microdata to measure household poverty rather it depends on macro data which ignores individual variation as well as the feeling of the poor.

Considering these all, oxford poverty and human development initiatives in collaboration with the United Nations Development Program introduced a new inclusive poverty measurement called multi-dimensional poverty index (MPI) because poverty is multiple deprivations (Alkire & Santos, 2010; Klugman, 2011). The human development index verified that economic growth can be an important tool to reduce poverty though its impact is not automatic. Practically, people must be educated and free from diseases to contribute and benefited from economic growth. Because countries like Argentina, Honduras, the United Kingdom, and the United States America had scored higher economic growth and yet the prevalence of poverty is there. As a result, HDI includes education and health in addition to income to measure the human development index. Therefore ranking countries should be based on these three parameters (Hopkins, 1991). Then later UNDP added another important indicator to capture important human development dimensions which are crucial to monitor poverty, inequality, and gender issues. These are the Multidimensional Poverty Index (MPI), the Inequality-adjusted Human Development Index (IHDI), and the Gender Inequality Index (GII). Therefore, currently applying MPI to measure poverty is becoming prominent. The thesis of this poverty measurement is poverty alleviation should consider the diversified problems of the poor inclusively. Ameliorating economic and social well-being, the poor should access to education, hospitals and clinics, potable water, all-season roads, loans and communication, and able to participate in decision making which directly has consequences in resource allocation determinant to poverty alleviation (UNDP, 1997).

In sum, MPI uses microdata at the household level to measure poverty. According to Alkire et al. (2015), three dimensions and ten indicators based on these a weighted deprivation score is set. A study conducted in 104 countries showed that people classified as poor by the MPI are not equivalent to those classified as poor people using the poverty line set internationally. A clear variation is observed particularly in the poorest countries. So this shows the monetary measurement should at least complement with multidimensional poverty index to reduce measurement errors (Alkire & Santos, 2010). Similarly, a study conducted in Indonesia showed a significant variation in measuring the prevalence of poverty (Hanandita & Tampubolon, 2016).

In conclusion, despite its longtime application of income/consumption-based measurement, it lacks addressing the feeling and real situation of the poor. It only addresses the material need of the human being. Currently, child poverty is a pressing issue compared to adult poverty so monetary approach measurement has not the power to show poverty variation across and within households. Therefore, MPI uses microdata from households and better portrays the situation of poverty. It also strongly addresses poverty distribution and variation at the household level including child poverty.

### **5.2.2 Multidimensional Poverty Index (MPI)**

Alkire Foster method was applied to measure poverty using the MPI. Multidimensional poverty provides a better picture than the traditional unidimensional indices like income-based measures. The Alkire Foster method “used to create global and national poverty measures with context-specific dimensions and indicators” (Alkire, 2011, p. 1). This method has three dimensions with equal weight and ten indicators, indicators within the same dimension have equal weight and households were classified as poor and non-poor based on the number of deprivations cutoffs (Alkire & Foster, 2011). This approach has several steps, the first and most important is identifying dimensions and indicators and setting the deprivation cutoffs. For this study, the commonly used dimensions and indicators were applied as presented in Table 5.1. If a household is deprived recorded as 1(yes), otherwise 0 (no).

Table 5.1: Dimensions, indicators, weights of indicators

Dimension	Indicator	Weight	Deprivation cutoff
Education	schooling	1/6	No household member has completed five years of schooling
	Attendance	1/6	Any school-aged child in the household is not attending school up to class 8
Health	Nutrition	1/6	Any adult or child in the household with nutritional information is undernourished
	Mortality	1/6	Any child has passed away in the household
Standard of living	Electricity	1/18	The household has no electricity
	sanitation	1/18	The household's sanitation facility is not improved or it is shared with other households
	Water	1/18	The household does not have access to safe drinking water or safe water is more than a 30-minute walk (round trip)
	Floor	1/18	The household has a dirt, sand, or dung floor
	Cooking fuel	1/18	The household cooks with dung, wood, or charcoal
	Asset	1/18	The household does not own more than one radio, telephone, TV, bike, or cart, and does not own a car or truck

Source: Adopted from Alkire et al. (2011)

Deprivations experienced by each household were summed. the score lies between 0 and 1, with 1 the highest deprivation and 0 no deprivation. Deprivation increases from 0 to 1 (Alkire & Santos, 2010).  $C_i = W_1I_1 + W_1I_1 + W_dI_d$ , where  $I_i = 1$  if the household is deprived in indicator  $i$  and  $I_i = 0$  otherwise, and  $W_i$  the weight attached to indicator  $i$  with  $\sum_{i=1}^d w_i = 1$ . Therefore, a person's deprivation must be at least a third of the (weighted) considered indicators to be considered MPI poor.

### 5.2.3 MPI Aggregation

The incidence and intensity of poverty are key to estimating MPI. Thus the incidence and intensity of deprivation was determined using the formula,  $H = \frac{q}{n}$  Where H, multidimensional poverty headcount ratio, q represents the number of multidimensional poor households, n total sampled households. And intensity or breadth of multidimensional poverty (A) is estimated using the formula,  $A = \frac{\sum_{i=1}^n ci(K)}{q}$  Where  $ci(K)$  is the censored deprivation score of households  $i$  and  $q$  is the number of households who are multi-dimensional poor (Alkire et al., 2015).  $MPI = H \times A$

The unique characteristic of the MPI is that it can be split into population sub-groups such as *woreda*, *tabia*, regions, or ethnic groups, depending on the aim of the research. MPI is breakdown into dimensions and indicators. To decompose by indicators, first, the censored headcount ratio is estimated for each indicator. The censored headcount ratio for a particular indicator is obtained by adding up the number of poor people who are deprived in that indicator and dividing it by the total population (Alkire *et al.*, 2011). Once all the censored headcount ratios have been computed, it can be verified that the weighted sum of the censored headcount ratios also generates the *woreda*'s MPI. So the MPI is constructed from all ten indicators:

$MPI_{woreda} = W_1CH_1 + W_2CH_2 + \dots + W_{10}CH_{10}$  ,  $W_1$  is the weight of indicator 1 and  $CH_2$  is the censored headcount ratio of indicator 1. Similarly, the percentage contribution of each indicator to overall poverty is computed as follows:

$$\text{Contribution of indicator } i \text{ to MPI} = \frac{W_iCH_i}{MPI_{woreda}} * 100,$$

Therefore, if the contribution to the poverty of a certain indicator higher than its weight, this suggests that there is a relatively high deprivation in this indicator in the *woreda*. The poor are more deprived in this indicator than in others.

The same procedure was followed to analyze the MPI of children under five age. The calculation of the deprivation headcount ratio uses the formula below:

$h_{j,r} = \frac{q_{j,r}}{n_r}$  ,  $q_{j,r} = \sum_{i=1}^{n_r} y_i$  ,  $h_{j,r}$  is headcount ratio of children deprived in dimension  $j$  of the reference population  $r$ ,  $q_j$ , is the number of deprived children in dimension  $j$  of the reference population  $r$ ,  $n_r$ , total number of children in the reference population  $r$ ;  $y_j$  deprivation status of child  $i$  in dimension  $j$ , with  $y_{j=1}$  if  $x_j < z_j$  (deprivation) and  $y_j = 0$  if  $x_j \geq z_j$  (no deprivation);  $x_j$  value of dimension  $j$  for child  $i$ ;  $z_j$  a threshold of the dimension  $j$ . Whereas, the deprivation count is presented as,

$$D_j = \sum_{i=1}^d y_j$$

$D_j$  is the total number of dimensions each child  $i$  is deprived in; with  $y_i = 1$  if child  $i$  is deprived in the dimension  $j$ ;  $y_j = 0$  if child  $i$  is not deprived in dimension  $j$ . whereas, the multidimensional child deprivation headcount is

$H = \frac{q_k}{n_a}$  ,  $q_k = \sum_{i=1}^n y_k$ , where, H-multidimensional child deprivation headcount ratio according to cut-off point  $K$  in age group  $a$ ;  $q_k$  - number of children affected by at least  $K$  deprivations in the

age group  $a$ ;  $n_a$  - total number of children in the age group  $a$ ;  $y_k$  - deprivation status of a child  $i$  depending on the cut-off point  $K$ ;

While the average intensity of deprivation was calculated using the following formula:

$$A = \frac{\sum_1^{q_k} c_k}{q_k * d}$$

$A$  - Average intensity of multidimensional deprivation according to the cut-off point  $K$  for the age group  $a$ ;  $q_k$  - number of children affected by at least  $K$  deprivations in the age group  $a$ ;

$d$  - total number of dimensions considered per child within the relevant age group  $a$ ;  $c_k$  - number of deprivations each multidimensionally deprived child  $i$  experiences, with  $c_k = d_i^* y_k$

The multidimensional child deprivation headcount ratio is:

$M_o = H * A$ ,  $M_o$  - adjusted multidimensional child deprivation headcount ratio. Generally, six dimensions and 14 indicators were taken to estimate the MPI of children under five years (Table 5.2).

Table 5.2: Dimensions, indicators, definition, and threshold of the children MPI

Dimensions	Indicator	Indicator definition and thresholds
Nutrition	Underweight	Deprived if children are two standard deviations below the median of the reference population
	Wasting	Deprived if children are two standard deviations below the median of the reference population
	Stunting	Deprived if children are two standard deviations below the median of the reference population
	Number of meals per day	Deprived if the child has eaten less than three times in a day
	Number of food items consumed per day	Deprived if the child has consumed less than three food items per day
	Infant and Young Child Feeding	Child age of under 2 years currently never breastfeeding
Health	Skilled birth attendant	Deprived if the child was not born with a skilled birth attendant
	Measles vaccination	Deprived if the child has not taken this vaccination
	BCG vaccination	Deprived if the child has not taken this vaccination
Information	Access to information	Deprived if the child does not have access to one of these items – radio, television, phone, or a computer
Shelter/housing	Overcrowding	Deprived if living with more than four household members per room
	Roof and floor material	Deprived if unsustainable roof and floor material such as mud and thatch
Water	Access to an improved water source	Deprived if no access to protected water
sanitation	Access to toilet	A child has access to unimproved sanitation facilities such as pit latrine without slab/open pit, bucket or has no facility i.e. bush/field

Source: Adapted from Woldehanna et al. (2017)

Associated factors that affect household poverty were analyzed using binary logistic regression. The detailed specification of the model refers (see chapter four under methodology).

Table 5.3: Explanatory variables used in the binary logistic

variables	Description of variables	Expected sign
Multidimensional poverty	Dummy 0= multidimensionally poor, 1= not-multidimensionally poor	
AccessCrdt	Access to credit (dummy) 0 = <i>no</i> , 1 = <i>yes</i>	-
AccessEx	Access to extension service (dummy) 0 = <i>no</i> , 1 = <i>yes</i>	-
EDHH	Educational level of household head in number (continuous)	-
Farmingyear	Farming experience in years (continuous)	-
Fsize	Family size in number (continuous)	+/-
Irrland	Irrigated land in hectare (continuous)	+
lsize	Farming Land size in hectare (continuous)	-
MarketDis	Market distance in kilometer (continuous)	-
Nfarmincome	Non-farm income in birr (continuous)	-
Remittance	Remittance in birr (continuous)	+/-
SexHH	Sex of household head (dummy) 0 = Female, 1 = Male	+/-
TLU	Tropical livestock unit in number (continuous)	-
Treatment	Treatment (dummy) 0 = non-displaced, 1 = displaced	+

Source: Author (2019)

## 5.3 Results and Discussion

### 5.3.1 Chi-Square Test and Percentage Distribution of Unidimensional Headcount Ratio

Table 5.4 shows, the percentage of household members who did not complete five years of schooling was a bit higher among displaced households with no statistical significance. Similarly, School-aged children who did not attend school up to grade 8 were higher in displaced households than non-displaced households with a statistically significant correlation at 5% level. In general, the prevalence of child mortality was higher in the study area. Besides the prevalence of childhood mortality were higher among children from non-displaced households than children from displaced households with a significant correlation at 1% level of significance. Malnutrition was reported fewer, only 6.2% and 5.9% of malnourished children from non-displaced and displaced households were found, respectively, with no statistically significant correlation.

The result also revealed majority of the households did not have access to electricity 97.1%. Access to electricity was higher among displaced households than non-displaced households with statistical significance at 1% level of significance. A similar result was also found in access to sanitation. Displaced households had better access to sanitation with statistical significance association at 5% level of significance. Contrarily the percentage of access to improved drinking water was higher among non-displaced than displaced households with no statistical significance. This is because non-displaced households have water pumps not more than 30' round trip but displaced households have not with this radius. The result showed that the percentage of non-displaced households with dirty or dung floors was higher than the percentage of displaced households with statistical significance at 5% level of significance.

Lastly, households who cook using wood, dung, and charcoal were higher among non-displaced than displaced households with a statistically significant at 1% level of significance. Asset owned both by non-displaced and displaced households was small. Of the sampled households only 0.4% of non-displaced, and 3% of displaced households had either radio, TV, telephone, bike, and motorcycle with statistical significance at 5% level of significance. This is because displaced households are close to urban areas and their living is relatively modernized than no-displaced households.

Table 5.4: Statistical summary of chi-square test distribution of MPI indicators by treatment

Indicators		Non-displaced	Displaced	P-Value
No household member has completed five years of schooling	No	231(96.3%)	97 (96%).	0.926
	Yes	9 (3.7%)	4 (4%)	
Is there any school-aged child who is not attending school up to class 8	No	187 (77.9%)	68 (67.3%)	0.040**
	Yes	53 (22.1%)	33 (32.7%)	
Is there any child who died in the family?	No	162 (67.5%)	45 (44.6%)	0.000***
	Yes	78 (32.5%)	56 (55.4%)	
Is there any adult or child who is malnourished?	No	225 (93.8%)	95 (94.1%)	0.914
	Yes	15 (6.2%)	6 (5.9%)	
The household has no electricity	No	7 (2.9%)	17 (16.8%)	0.000***
	Yes	233 (97.1%)	84 (83.2%)	
The households sanitation facility is not improved (according to MDG guidelines)	No	10 (4.2%)	10 (9.9%)	0.040**
	Yes	230 (95.8%)	91 (90.1%)	
The household does not have access to improved drinking water(according to MDG)	No	197 (82.1%)	74 (73.3%)	0.66
	Yes	43 (17.9%)	27 (26.7%)	
The household has dirt, sand, or dung floor	No	40 (16.7%)	27 (26.7%)	0.033**
	Yes	200 (83.3%)	74 (73.3%)	
The household cooks with dung, wood, or charcoal	No	1 (0.4%)	5 (4.9%)	0.004***
	Yes	239 (99.6%)	96 (95.1%)	
The household does not own more than one radio, TV, computer, telephone, bike, motorcycle	No	1 (0.4%)	3 (3%)	0.046**
	Yes	239 (99.6%)	98 (97%)	

\*\*\*, and \*\* indicates 1 and 5% significance level, Source: Computed from own survey data (2019)

### 5.3.2 Analysis of Incidence, Intensity, and Adjusted MPI of Adults

Households' indices of multidimensional poverty were constructed using the three commonly used dimensions and 10 indicators of deprivation. Because including other dimensions like wealth is not give a better picture of the *woreda* as displaced households do not have a proportional land size and TLU with non-displaced households. Table 5.5 shows that 62%, 69%, and 59% of total sampled, displaced, and non-displaced households were multidimensionally poor. They have deprived at least in all indicators of close to 2/3 dimensions or a combination of indicators across dimensions. This result is lower than the prevalence rate of poverty incidence and intensity in Tigray, which was 81.7% and 55%, respectively (OPHI, 2018). Similarly, on average total sampled, displaced and non-displaced households are deprived in 47%, 49%, and 47% of the weighted indicators, respectively. This implies that on average majority of the households were poor. The percentage of multidimensional headcount ratio or incidence of poverty was higher among

displaced households than non-displaced households. The intensity of poverty was higher among displaced households than non-displaced households. Cogently, the multidimensional headcount ratio does not fulfill the dimensional monotonicity of poverty. Because those households with a poverty incidence of 69% or 59% may or may not be all equally poor. So, MPI represents the share of the population that is multidimensional poor adjusted by the intensity of the deprivation suffered. Therefore, the percentage of poor displaced households were higher than non-displaced households. At the *woreda* level, the prevalence of multidimensionally poor households was lower than the prevalence rate of the Tigray region, which was 45% (OPHI, 2018). However, the result is higher than the average Ethiopian multidimensionally poor people, which was 23.1% (UNDP & OPHI, 2019).

Table 5.5: Result of incidence, intensity and Adjusted MPI ( $k \geq 3$ )

MPI measurement	Total households	Displaced	Non-displaced
Incidence (H)	0.62	0.69	0.59
Intensity (A)	0.47	0.49	0.47
Adjusted MPI	0.29	0.34	0.27

Source: Computed from own survey data (2019)

The deprivation score was disaggregated into vulnerable to poverty and severe poverty to observe to what extent variation exists between displaced and non-displaced households. The chi-square test result showed that there is a statistically significant difference between displaced and non-displaced households in the number of people under the category of vulnerable to poverty and severe poverty at 1% level of significance (Table 5.6). Accordingly, 40.4% and 68.8% of displaced and non-displaced households were vulnerable to poverty. Moreover, 59.6% and 31.2% of the displaced and non-displaced households were exposed to severe poverty. Therefore, the severity of poverty was higher among displaced households compared to non-displaced households. The overall picture also showed that the households vulnerable to poverty were higher compared to households under severe poverty categories at the *woreda* level. Therefore, if the livelihood of the household is not endured, the probability of the household moved to severe poverty will be upswing. This result was higher than the Tigray prevalence rate vulnerable to poverty and lower than the Tigray severe poverty prevalence rate, which was 9.5% and 54.6%, respectively (OPHI, 2018).

Table 5.6: Distribution of poverty severity across households

Group	Vulnerable to poverty 20 % ≤ Ci < 33 %	Severe Poverty ≥ 50 %	P-value
Displaced	40.4%	59.6%	0.000***
Non-displaced	68.8%	31.2%	
Total	59.9%	40.1%	

Source: Computed from own survey data (2019)

A t-test was also conducted to prove if there is a mean difference across the groups (Table 5.7). The result showed that displaced and non-displaced households had a statistically significant correlation at 1% level of significance. This implies the prevalence of multidimensionality poverty was higher among displaced households than non-displaced households. Several empirical studies proved that rural poverty was deeply rooted among female-headed households than their counterpart in male-headed households. However, a statistically insignificant correlation was reported between female and male-headed households.

Table 5.7: Result of two-sample t-test

Group	Observation	Mean	Std. Err.	Std. Dev.	Pr ( T  >  t )
Female	96	0.395	0.012	0.124	0.9294
Male	245	0.394	0.009	0.139	
Combined	341	0.394	0.007	0.135	
Difference		0.001	0.016		
Displaced	101	0.424	0.016	0.162	0.0089***
Non-displaced	240	0.382	0.008	0.119	
Combined	341	0.394	0.007	0.135	
Difference		0.042	0.016		

\*\*\* indicates statistically significant at 1%, source: Computed from own survey data (2019)

### 5.3.3 Contribution of Dimensions and Indicators to Overall Multidimensional Poverty

The result showed that from the education dimension, the contribution of school attendance to overall poverty was higher compared to years of schooling. Similarly, the percentage contribution of displaced households' school attendance to overall poverty was higher compared to non-displaced households. The health dimension also shows the percentage contribution of displaced household child mortality to overall poverty was larger than non-displaced households though the percentage contribution of malnutrition to overall poverty was higher among non-displaced households.

Lastly, the percentage contribution of living standard indicators to overall poverty was higher among non-displaced households than displaced households. A strong effort is required to reduce the child mortality rate through proper nutrition and improving health facilities in the study area.

Table 5.8: Contribution of each indicator to overall multidimensional poverty

		Education		Health		Living standard					
		Sch	Atte	Mort	Nutr	Elec	Sani	water	Floor	Fuel	Asset
Displaced	Censored headcount ratio	0.03	0.28	0.52	0.05	0.61	0.67	0.25	0.52	0.66	0.66
	Percentage of contribution	1.3	14.1	26.2	2.6	10.1	11.1	4.2	8.6	10.9	10.9
Non-displaced	Censored headcount ratio	0.03	0.22	0.31	0.09	0.57	0.56	0.15	0.53	0.59	0.59
	Percentage of contribution	1.6	13.3	19.3	5.3	11.6	11.3	3	10.8	11.9	11.9
Total household	Censored headcount ratio	0.03	0.24	0.38	0.08	0.58	0.59	0.18	0.52	0.61	0.61
	Percentage of contribution	1.6	13.5	21.7	4.3	11.1	11.2	3.4	9.9	11.6	11.6

Sch (schooling), Atte (Attendance), Mort (Mortality), Elec (Electricity), Sani (Sanitation),  
Source: Computed from own survey data (2019)

The contribution of each dimension to overall poverty showed that the contribution of living standard to overall poverty was higher followed by health and education, respectively (Figure 5.1). The percentage contribution of education, health, and living standard to the overall poverty of displaced households was higher than non-displaced households except in living standards. At the *woreda* level, the percentage contribution of education, health, and living standard to overall poverty was 15%, 26%, and 59%, respectively. Therefore, much effort is expected to improve the living standard of the community to minimize the prevalence of multidimensionally poor households. The contribution of education, health, and living standard to overall poverty was higher compared to a study conducted in Degu'a Temben, which was 13%, 24.6%, and 60.5%, respectively (Gebrekidan, 2019).

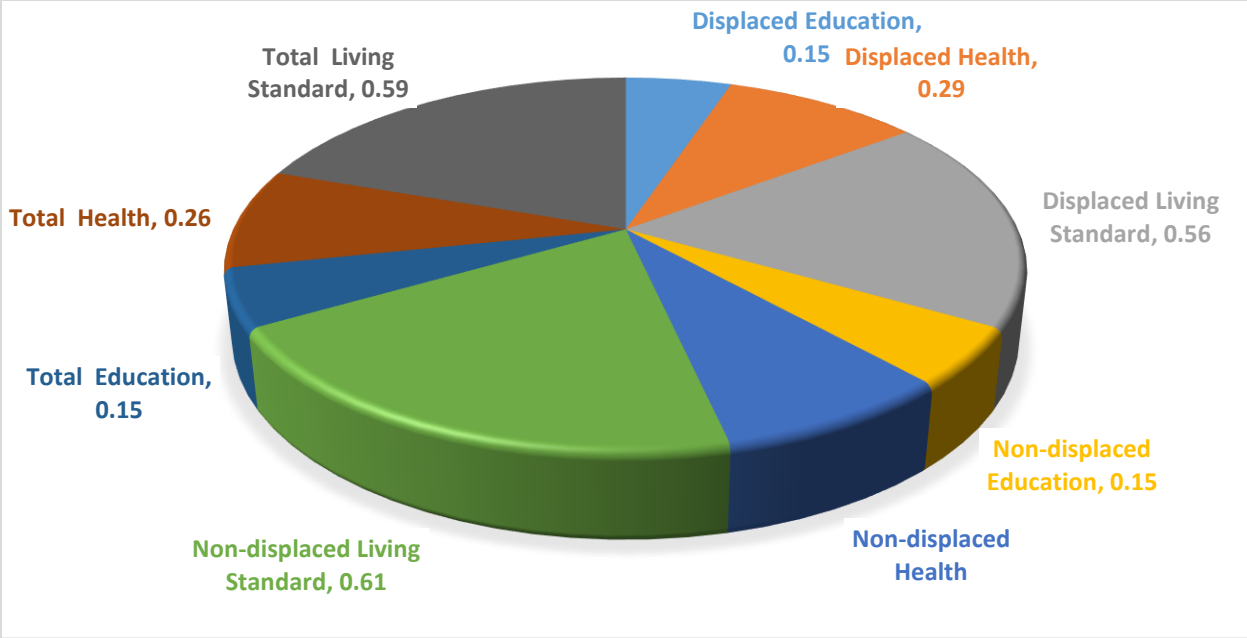


Figure 5.1: Contribution of dimensions to overall poverty  
 Source: Computed from own survey data (2019)

**5.3.4 Children Multidimensional Poverty Index**

Among the different sustainable development goals, eliminate poverty in all its forms is one. Therefore, addressing child poverty is mandatory. The result showed that children from displaced households were highly deprived in stunting (21.4%), underweight (14.3%), the number of food items consumed per day (10.4%), roof and floor materials (9.4%), and access to a toilet (13.2%). On other hand, children from non-displaced households were highly deprived in stunting (18.5%), underweight (17.4%), number of food items consumed per day (65.1%), skilled birth attendant (12.3%), access to information (21.7%), overcrowding (21.7%), roof and floor materials (80.2%), access to improved water (12.3%), and access to a toilet (79.2%) (Table 5.9). Therefore, the proportion of children deprived of stunting, wasted, underweight, and skilled attendant during delivery was found lower than the national report, which was 37.9%, 9.9%, 23.8%, and 38.9% of children under five years of age were deprived in height for age, weight for height, weight for age, and skilled birth attendant, respectively (CSA & UNICEF, 2018). Therefore, children are eating less than three food items per day, mothers give birth at home without skilled health attendants, denied information, children live more than four in a single room, have not accessed to protected and clean water supply, and children use unimproved toilet facilities. In general, though both children from displaced and non-displaced households were mainly deprived in the above-listed

indicators, they are also deprived in other indicators hardly. However, the chi-square test result confirmed that except, in the roof and floor material, and access to an improved water source no significant correlation was reported between children from displaced and non-displaced households across the indicators. This implies, the percentage of children from displaced households had better access to clean roof and floor materials, and access to improved water than children from non-displaced households. This might be displaced households are close to urban areas and accustomed to urban livings as compared to non-displaced households. Data generated from key informants and focus group discussants showed that *some displaced households used the compensation for house construction as a result they have quality houses compared to non-displaced households.*

Table 5.9: Chi-square test result of multidimensional Child deprivation Indicators

Indicators		Non-displaced	Displaced	P-Value
Wasting	No	84 (91.3%)	12 (85.7%)	0.505
	Yes	8 (8.7%)	2 (14.3%)	
Stunting	No	75 (81.5%)	11 (78.6%)	0.793
	Yes	17 (18.5%)	3 (21.4%)	
underweight	No	76 (82.6%)	12 (85.7%)	0.773
	Yes	16 (17.4%)	2 (14.3%)	
Number of meals per day	No	91 (98.9%)	0 (0%)	0.695
	Yes	1 (1.09%)	6 (5.9%)	
Number of food items consumed per day	No	23 (25%)	3 (21.4%)	0.772
	Yes	69 (75%)	11 (78.6%)	
Infant and Young Child Feeding	No	88 (95.6%)	13 (92.9%)	0.646
	Yes	4 (4.4%)	1 (7.1%)	
Skilled birth attendant	No	79 (85.9%)	14 (100%)	0.133
	Yes	13 (14.1%)	0 (0%)	
Measles vaccination	No	92 (100%)	14 (100%)	-
	Yes	0 (0%)	0 (0%)	
BCG vaccination	No	87 (94.6%)	14 (100%)	0.372
	Yes	5 (5.4%)	0 (0%)	
Access to information	No	69 (75%)	12 (85.7%)	0.0379
	Yes	23 (25%)	2 (14.3%)	
Overcrowding	No	77 (83.7%)	10 (71.4%)	0.265
	Yes	15 (16.3%)	4 (28.6%)	
Roof and floor material	No	7 (7.6%)	10 (71.4%)	0.017**
	Yes	85 (92.4%)	4 (28.6%)	
Access to an improved water source	No	79 (85.9%)	9 (64.3%)	0.045**
	Yes	13 (14.1%)	5 (35.7%)	
Access to toilet	No	8 (8.7%)	0 (0%)	0.251
	Yes	84 (91.3%)	14 (100%)	

Source: Computed from own survey data (2019)

Deprivation was analyzed across the dimensions. Figure 5.2 shows, children from displaced households were 100% deprived of sanitation, 92.9% in nutrition, and 71.4% in housing. As portrayed in the figure they are also deprived in other dimensions but sanitation, nutrition, and housing dimensions account for more than 70% each. Similarly, children from non-displaced households were devastatingly affected by sanitation, housing, and nutrition with 91.3%, 93.5%, and 85.9% respectively. The percentage of deprivation was also higher in health, access to information, and housing dimensions in non-displaced children than displaced children. However, the proportion of deprivation in sanitation, access to water, and nutrition was higher among children from displaced households compared to children from displaced households. Regardless of the deprivation magnitude across each dimension still the deprivation was a bit higher in children from non-displaced households.

At the *woreda* level, the highest deprivation rate by dimensions was reported in nutrition, housing, and sanitation. These dimensions were registered more than 80% of deprivation each. Generally, the prevalence of deprivation across the dimensions was devastating, particularly in the above-listed three dimensions. Therefore, much effort and strong commitment are solicited by concerned bodies to avert the prevailing deprivations. Compared to the CSA and UNICEF (2018), the report revealed 89.8%, 90.1%, and 76.4% of children were deprived of housing, sanitation, and nutrition which is lower than the percentage of children deprived in housing, sanitation, and nutrition of this study. Contrarily, the proportion of children deprived of water and health service were 59.2% and 83.7%, respectively which is by far higher than the percentage of children deprived of water and health in this study.

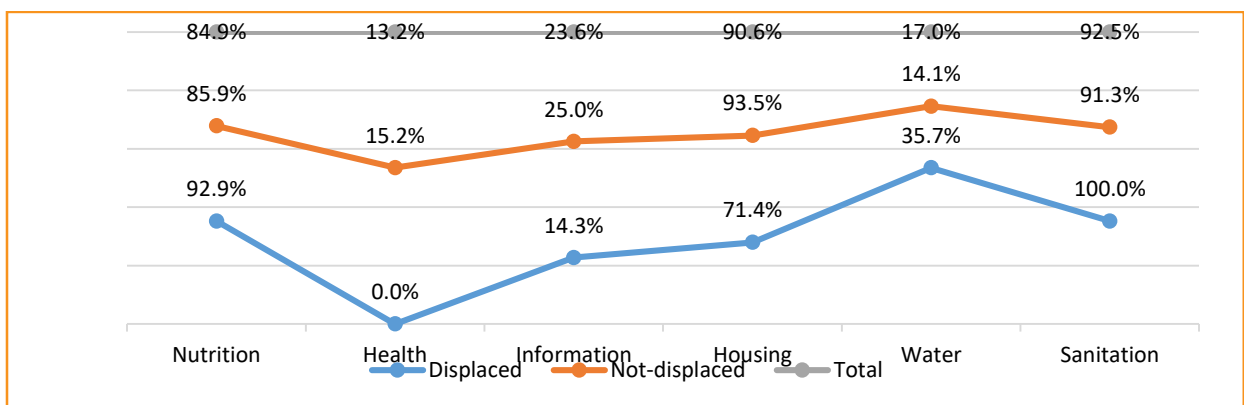


Figure 5.2: Percentage distribution of deprivations by dimensions  
Source: Computed from own survey data (2019)

Lastly, multidimensional child poverty and the contribution of each dimension to the overall adjusted deprivation headcount ratio were calculated. Since there are no clear cutoffs to determine who is poor or not using the multidimensional child poverty index, a k value of 3 was used. Therefore, children where their Di score  $\leq 3$  were not deprived otherwise deprived. Accordingly, the multidimensional child deprivation rate (H) children from displaced households were 35.6% poor. Similarly, 37% and 36.8% of children from non-displaced and total children were found poor, respectively. The intensity of poverty among children also showed that 70%, 70.6%, and 70% of children from displaced, non-displaced, and total households were deprived in the weighted indicators, respectively (Table 5.10). In general, the adjusted MCD index shows 25%, 26.1%, and 25.8% of children from displaced, non-displaced, and total sampled households were found poor, respectively. This indicates 25%, 26.1%, and 25.8% of children are deprived in four or more dimensions. This result was lower than the empirical analysis from Metadata conducted in Ethiopia, which was 39% of children under five years of age were multidimensionally poor in Tigray (Birhanu *et al.*, 2017).

Table 5.10: Result of multidimensional child deprivation rate, intensity, and adjusted MCD index

k>3	displaced	Non-displaced	Total sample
Multidimensional child deprivation rate (H)	0.357	0.37	0.368
Average deprivation intensity among the deprived (A)	0.70	0.706	0.70
Adjusted MCD index (M <sub>0</sub> )	0.25	0.261	0.258

Source: Computed from own survey data (2019)

T-test was conducted to check whether there is a significant mean difference between children from displaced and non-displaced households. No statistically significant correlation was found between female and male children. Similarly, the mean difference between children from displaced and not-displaced households was not statistically significant (Table 5.11).

Table 5.11: Statistical summary of two-sample t-test across the group

Group	Observation	Mean	Std. Err.	Std. Dev.	Pr ( T  >  t )
Female	52	3.250	0.145	1.046	0.7262
Male	54	3.185	0.116	0.848	
Combined	106	3.217	0.092	0.946	0.7547
Displaced	14	3.143	0.275	1.027	
Non-displaced	92	3.228	0.098	0.939	
Combined	106	3.217	0.092	0.946	

Source: Computed from own survey data (2019)

Additionally, the contribution of each dimension to overall multidimensional child poverty was estimated. The decomposition of multidimensional deprivation, nutrition, sanitation, and housing contributes largely to overall child poverty both in children from non-displaced and displaced households even at the *woreda* level. In all the categories, regardless of the magnitude, the three dimensions largely contribute to the overall multidimensional poverty of children in the study area. From this, to eradicate poverty in all its forms and to realize sustainable development goals, exhaustive and viable works should be done in nutrition, sanitation facilities, and housing facilities in the study area.

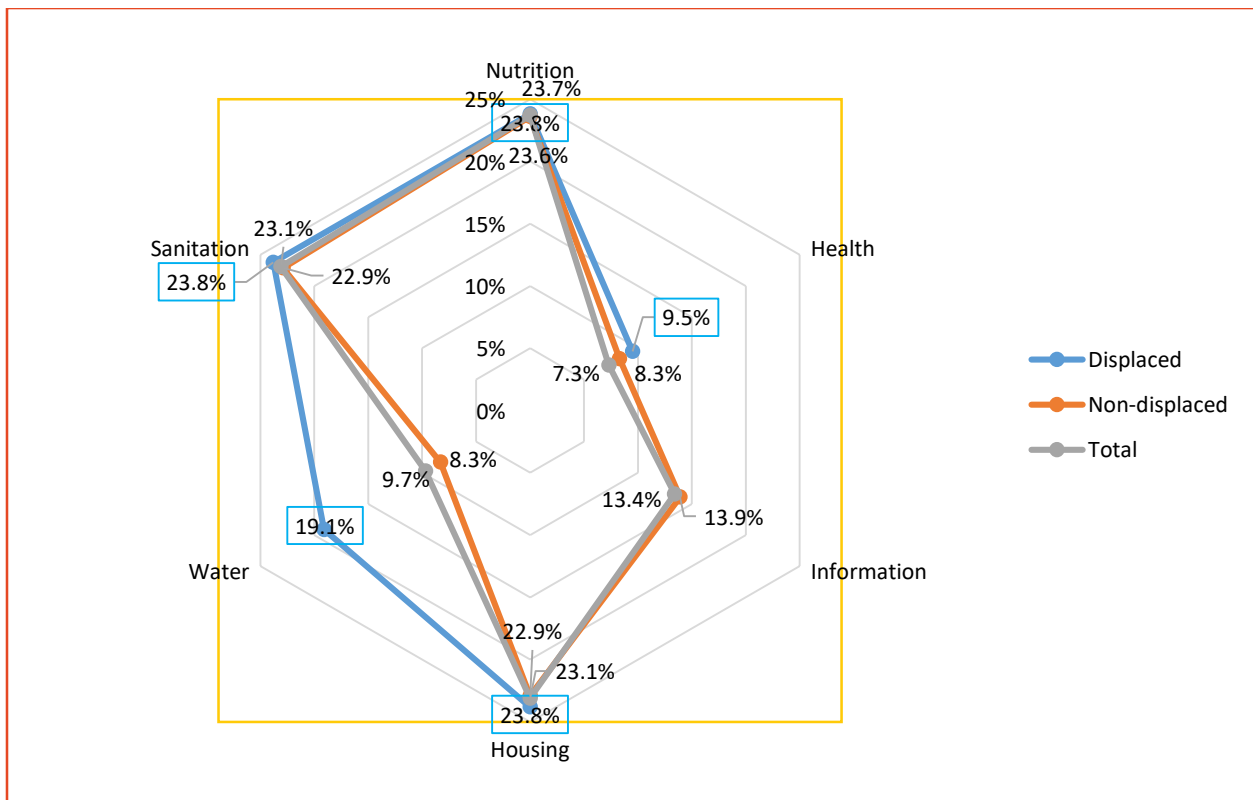


Figure 5.3: Percentage contribution of dimension to overall child poverty ( $M_0$ )

Source: Computed from own survey data (2019)

### 5.3.5 Determinants of Household Multidimensional Poverty

The binary logistic regression result showed that the Educational level of household head, irrigated land size, and treatment effect had a statistically significant effect on household multidimensional poverty at different levels of significance (Table 5.12).

Households with higher educational levels were less vulnerable to multidimensional poverty. A unit increase in the educational level of the household head decreases the probability of the

household being multidimensionally poor by 1.7%, hold other variables constant. This conforms with the findings of (Adepoju, 2020; Birhanu *et al.*, 2017; Gebrekidan, 2019). They evidenced that educated households can decide reasonably and easily access information relevant to their livelihood. Apart from this, secular education creates enabling environment to get different job opportunities that can ultimately lead to households transitioning from poor to non-poor status.

It is crystal clear, the livelihood of smallholder farmers in Ethiopia relies on conventional farming. Households with larger irrigated farmland entry into multidimensional poverty were less likely. A unit increase in the size of irrigated land increases the probability of a household being not multidimensionally poor by 71.8%, holding other variables constant. Irrigation supplements the rain-fed agriculture during the dry season and helps to generate more income to exit from poverty. This result is consistent with the finding of (Hussain, 2004) who suggested that irrigation reduces poverty significantly by making additional income. Haile (2018) stated that an actual reduction in headcount ratio, multidimensional poverty index, and poverty intensity of irrigation users was observed in Ethiopia.

Lastly, displaced households had a positive statistically significant association with household multidimensional poverty. The descriptive statistics result indicated that displaced households had a low educational level and larger family size than non-displaced households. Lower educational level linked with a larger family size of displaced households challenge to employ in better payable work and households dominated by children and old people contribute less additional labor to increase return, is low. This agrees with the theoretical assumption of (Cernea, 2000), displacement impoverishes people. Besides (Mezgebo (2014) also reported urban expansion had an adverse effect on consumption expenditure that could be translated to household poverty later.

Table 5.12: Logistic regression result of determinants of multidimensional poverty

Variables	dy/dx	Std. Err.
Access credit	0.067	0.096
Access extension	-0.049	0.068
Educational status of household head	0 .018**	0.009
Family size	0 .023	0.016
Farming experience of household head	0.002	0.003
Farmland size	0.007	0.020
Irrigated land size	0 .692**	0.300
Market distance	-0.025	0.023
Non-farm income	0.001	0.000
Remittance	0.001	0.000
Sex of household head	0.035	0.070
TLU	0.017	0.021
Treatment	-0.172**	0.084

\*\* indicate significant at 5% level of significance. Source: Computed from own survey data (2019)

## 5.4 Summary

This study aimed to examine the impact of urban expansion on household multidimensional poverty and the associated factors that affect multidimensional poverty. The indicators showed that except for household members who did not finish grade five, adult or child malnutrition, and households who do not have access to improved drinking water the rest indicators had a statistically significant correlation between non-displaced and displaced households. The percentage of children who terminate school before attending grade eight, the mortality of children, and lack of access to clean drinking water were higher among displaced households than non-displaced households. Whereas, access to electrical power, lack of access to a latrine, lack of access to cemented floor, cooking using dung and firewood, not owing one or more either radio, television, telephone, cart, bike, or motorcycle, were higher among non-displaced households than displaced households.

At the household level, the incidence of poverty was higher among displaced households with a prevalence rate of 69% while the incidence of poverty among non-displaced households was 59%. The prevalence rate of poverty incidence was 62% at the *woreda* level. The intensity of poverty was reported 49%, 47%, and 47% among displaced, non-displaced, and total households, respectively. Generally, 34%, 27%, and 29% of displaced, non-displaced, and total households

were multidimensionally poor. The Percentage contribution living standard, education, and health dimensions to overall poverty was 58.9%, 15.4%, and 28.8%, respectively, at the *woreda* level. Similarly, the percentage contribution of living standards, education, and health dimensions were 58.9%, 15.1%, and 26%, respectively, among displaced households, and 60.5%, 14.9%, and 24.6% among non-displaced households.

Children from displaced households were highly deprived in the number of food items consumed per day (10.4%), living in a poorly constructed house (roof and floor materials) (9.4%), and access to a toilet (13.2%). On the other hand, children from non-displaced households were highly deprived in stunting (21.7%), the number of food items consumed per day (65.1%), skilled birth attendant (12.3%), access to information (21.7%), overcrowding (21.7%), roof and floor materials (80.2%), access to improved water (12.3%), and access to a toilet (79.2%). At *woreda* level, children were also deprived in stunting (23.6%), the number of meals per day (90%), the number of food items consumed per day (75.5%), skilled birth attendant (12.3%), access to information (23.6%), overcrowding (17.9%), roof and floor material (89.6%), access to an improved water source (17%), and access to a toilet (92.5%). Overall, the children were extremely deprived of the number of food items consumed per day, roof and floor materials, and access to the toilet in both categories compared to other indicators.

The percentage deprivation of dimensions showed that children were 100% deprived in sanitation, 92.9% in nutrition, and 71.4% in housing, respectively. They are also deprived in other dimensions but sanitation, nutrition, and housing dimensions account for more than 70% each. Similarly, children from non-displaced households were devastatingly affected by sanitation, housing, and nutrition with 91.3%, 93.5%, and 85.9%, respectively. The percentage of deprivation was higher in health, access to information, and housing dimensions in non-displaced children than displaced children. However, the proportion of deprivation in sanitation, access to water, and nutrition was higher among children from displaced households than children from displaced households. Regardless of the deprivation magnitude across each dimension still the deprivation was a bit higher in children from non-displaced households. But unlike adult poverty, the incidence, intensity, and adjusted poverty were higher among children from non-displaced households than displaced households. The severity of poverty was also outnumbered among displaced households. The t-test result proved that there was a mean difference in poverty and a statistically significant

correlation between displaced and non-displaced households. Lastly, the binary regression result showed being displaced had a positive statistically significant effect, and educational level and irrigated land size had a negative statistically significant effect on peri-urban farmers' multidimensional poverty.

## **Chapter 6: Urban Expansion and Its Effect on Production Efficiency in Axum Tigray Region**

### **6.1 Introduction**

Quantifying production efficiency with best frontier output date back to the 1950s (Sena, 2003). Production efficiency is the capacity of a producer producing a maximum output either using a possible combination of existing resources or at minimum cost (Greene, 2008). Agriculture is vital to transform Ethiopia's economy, into middle-income countries through feeding raw materials to industries (ATA, 2016). This sector has remained the backbone of the economy and mainstreamed in the development plan of Ethiopia. Due to this, several works have been done to boost agricultural productivity and reduce poverty and food insecurity (FDRE, 2016). The same report revealed that irrespective of the quantity of crop collected annually, crop production contributes much to the economy of Ethiopia. At the end of GTP I, the share of the crop to the agriculture sector was 27.4%. Out of the staple food crops, sorghum, barley, wheat, maize, and tef<sup>4</sup> are the main food items widely grown, traded, processed, and consumed in Ethiopia. Gray and Tefera (2014) stated that cereals employed 60% of rural employment and cover 80% of total farming land. Thus increasing the agricultural production efficiency of cereals is crucial to meet food self-sufficiency and endure the economy (Sena, 2003).

The academic literature reveals that enhancing crop efficiency is possible to the frontier output. However, due to low capital, population density, and small and fragmented agricultural land agricultural productivity remains stagnant in Ethiopia (Gray & Tefera, 2014). Unless agricultural efficiency is enhanced, eradicating poverty and food insecurity will remain ambitious (World Bank, 2008). Increasing crop efficiency of smallholder farmers is basic to solve poverty and food insecurity as 98% of cereals are produced by smallholder farmers (Gray & Tefera, 2014). The production and productivity of tef would be enhanced using modern agricultural inputs or improving the efficiency of producers using existing resources or a combination of both (Wassie, 2014). Limited capital in most developing countries particularly in Ethiopia, increasing the efficiency of tef helps producers to produce maximum output using the existing resources (Bravo-Ureta & Pinheiro, 1997).

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<sup>4</sup> Is one among the most important staple crops of Ethiopia mainly used to make Injera.

Regardless of the size of farm plots they owned, most Ethiopian farmers grow tef and served as meals almost in everyday consumption. Its gluten-free make tef mostly demanded food crops globally and intensively working to increase tef productivity. Fikadu *et al.* (2019) evidenced that the yield gap of tef between the potential and the actual tef yield was 4 quintals/hectare. Generally, though agriculture has remained the backbone of Ethiopia's economy, its productivity is low (Wassie, 2014). However, limited researches have been done on tef efficiency. Weldegebriel (2014), and Dessale and Tegegne (2018) studied the technical efficiency of tef in the Central Zone of Tigray and Jamma in the South Zone of Wollo. They said nothing on the allocative and economic efficiency of tef. There are also various researches done on the technical efficiency of various crops in Africa however production efficiency of tef was left to Ethiopians and limited work was done in tef efficiency.

Besides, the majority of researches conducted in Ethiopia on tef efficiency were generated from secondary data and few researches were done from primary data. Studies conducted so far mainly focused on the technical efficiency of tef but allocative/price and economic efficiency of tef were ignored. So far no studies have been conducted on the effect of urban expansion on tef efficiency of smallholder farmers.

This study fills the gap and opens a new insight to the knowledge domain of development-induced displacement with the aim of; estimating the technical, allocative, and economic efficiency of displaced and non-displaced, identifying associated factors that hinder the efficiency of tef production between displaced and non-displaced peri-urban smallholder farmers.

## 6.2 Model Specification

Despite different crops are grown, tef is dominantly grown crop in the study area. Thus tef is selected to estimate agricultural production efficiency. Increasing tef productivity helps farmers to produce marketable surplus and increase the purchasing power of farmers to diversify their dishes to achieve food security. This study uses a parametric production efficiency estimation approach, particularly stochastic frontier analysis (SFA). The deterministic stochastic production function is specified;

$$y_i = f(x_i; \beta) \dots\dots\dots (1).$$

Where,  $y_i$  maximum output  $x_i$  a vector of non-stochastic agricultural inputs and  $\beta$  is the parameter to be calculated. Aigner *et al.* (1977) expand the equation by including the stochastic part or error term component of the stochastic production function.

$$y_i = (x_i; \beta) + \varepsilon_i, i \dots N, \dots \dots \dots (2).$$

Where  $i = 1, 2, \dots, n$ , and  $\varepsilon_i = v_i - u_i$ , where  $v_i$  = random error of statistical noise,  $u_i$  = error of technical inefficiency. After this, a best fit stochastic production function model was selected using the Akaike information criterion (AIC). Accordingly, a model with a smaller AIC value (translog production function) was selected. Greene (2008) describes the translog production function model for one output and k inputs;

$$\ln y_k = \beta_0 + \sum_{k=1}^k \beta_k \ln x_k + \frac{1}{2} \sum_{k=1}^k \sum_{m=1}^k \beta_{km} \ln x_k \ln x_m + u$$

kth= respondents (tef producer),  $y_k$  = tef output in kg,  $x$ = input variable,  $\beta_0$ , a coefficient to be determined. Therefore, the model specification for this study is;

$$\begin{aligned} \ln \text{teef output} = & \beta_0 + \beta_1 \ln x_1 + \beta_2 \ln x_2 + \beta_3 \ln x_3 + \beta_4 \ln x_4 + \beta_5 \ln x_6 + \beta_6 \ln x_6 + \frac{1}{2} \beta_7 \ln x_1^2 + \\ & \beta_8 \ln x_2^2 + \beta_9 \ln x_3^2 + \beta_{710} \ln x_4^2 + \beta_{11} \ln x_5^2 + 12 \ln x_6^2 + \beta_{13} \ln x_1 \ln x_2 + \beta_{14} \ln x_1 \ln x_3 + \\ & \beta_{15} \ln x_1 \ln x_4 + \beta_{16} \ln x_1 \ln x_5 + \beta_{17} \ln x_1 \ln x_6 + \beta_{18} \ln x_2 \ln x_3 + \beta_{19} \ln x_2 \ln x_4 + \beta_{20} \ln x_2 \ln x_5 + \\ & \beta_{21} \ln x_2 \ln x_6 + \beta_{22} \ln x_3 \ln x_4 + \beta_{23} \ln x_3 \ln x_5 + \beta_{24} \ln x_3 \ln x_6 + \beta_{25} \ln x_4 \ln x_5 + \beta_{26} \ln x_4 \ln x_6 + \\ & \beta_{27} \ln x_5 \ln x_6. \end{aligned}$$

For the  $x_1, x_2, x_3, x_4, x_5$  and  $x_6$  variables (refer Table 6.1).

Farrel (1957) specified the technical efficiency for a single output;

$$TE_i = \frac{Y_i}{Y_i^*}, \text{ where } Y_i^* = f(x_i; \beta) \dots \dots \dots (3).$$

The TE of the  $i$ th farmers is expressed by the ratio of the observed production output to the potential output (frontier output).

$$TE_i = \text{Exp}(-u_i) = \frac{Y_i}{Y_i^*} = \frac{f(x_i; \beta) \exp v_i - u_i}{f(x_i; \beta) \exp v_i} \dots \dots \dots (4)$$

Therefore Technical inefficiency is  $1 - TE \dots \dots \dots (5)$ , the score lies between 0 and 1, 1 refers to the highest tef technical efficiency and zero otherwise. The total variance or the discrepancy error term is estimated as,  $\sigma^2 = \sigma_v^2 + \sigma_u^2$ ,  $\gamma = \sigma_u^2 / \sigma^2$ ,  $\gamma$  refers to what extent the technical inefficiency describes the model. Whereas the specification of allocative efficiency is the same the difference is in allocative efficiency variables are expressed in cost.

Table 6.1: Variables in the stochastic production frontier model for technical efficiency

<b>Variables</b>	<b>Measurement units</b>	<b>Expected sign</b>
Tef output quantity	Kg/hectare	
Farm size under tef cultivation	hectare	+
Labor (family and hired)	Man-days/hectare	+/-
Seed quantity	Kg/hectare	+
Chemical fertilizer	Kg/hectare	+
Herbicide quantity	Litre/hectare	+
Plow quantity	Number of plow/hectare	+

Table 6.2: Variables in the stochastic production frontier model for price efficiency

<b>Variables</b>	<b>Measurement units</b>	<b>Expected sign</b>
Allocative/price efficiency		
Labor wage	Birr	-
Seed cost	Birr	-
Fertilizer cost	Birr	-
Herbicides cost	Birr	-
Plowing cost	Birr	-

Tobit model was applied to estimate the determinants of technical efficiency, allocative, and economic efficiency. Tobit model is defined;

$$y_i^* = x_i\beta + \varepsilon_i \dots \dots n, \text{ with } \varepsilon_i|x \sim N(0; \delta^2), \text{ with } y = y^* \text{ if } y^* > 0, \text{ and } y=0 \text{ otherwise} \dots \dots (1).$$

Where  $y_i^*$  is the latent variable for the  $i^{\text{th}}$  tef producers representing efficiency scores,  $x_i$  represents independent variables hypothesized to influence technical, allocative, and economic efficiencies,  $\beta$  represents the unknown parameters, and  $\varepsilon_i$  is the error term. Empirically the Tobit model is presented;

$$y_i^* = \beta_0 + \sum_{n=1}^{14} \beta_n x_i + \varepsilon_i \dots \dots \dots (2). \text{ Where } y_i^* \text{ tef efficiency score, } \beta_0 \text{ the unknown parameters, and } x_i \text{ represents the determinants of technical, allocative, and economic efficiencies.}$$

Table 6.3: Variables used in the Tobit model

<b>variables</b>	<b>Description of variables</b>	<b>Expected sign</b>
Tef TE, AE, EE	%	
AccessCrdt	Access to credit (dummy) 0 = <i>no</i> , 1 = <i>yes</i>	+
AccessEx	Access to extension service (dummy) 0 = <i>no</i> , 1 = <i>yes</i>	+
AgeHH	Age of household head in number (continuous)	+/-
EDHH	Educational level of household head in number (continuous)	+
Farmingyear	Farming experience in years (continuous)	+
Fsize	Family size in number (continuous)	+/-
SexHH	Sex of household head (dummy) 0 = Female 1 = Male	+/-
Irrland	Irrigated land in hectare (continuous)	+
Landsize	Fam land size in hectare (continuous)	+
Marketdis	Market distance in kilometer (continuous)	-
Nfarmincome	Non-farm income in birr (continuous)	+
Remittance	Remittance in birr (continuous)	+
TLU	Tropical livestock unit in number (continuous)	+
Treatment	Treatment (dummy) 0 = non-displaced, 1 = displaced	-

## 6.3 Results and Discussion

### 6.3.1 Selecting Production Function Model

The study carried out two phases of post-estimation of statistical analyses. To determine an appropriate stochastic production function, a hypothesis was tested using AIC to use either using Cobb-Douglas or Translog production function. Findings of the study reveal that AIC was lower in translog production function than in Cobb-Douglas production function (Table 6.4). So, the translog production function was selected because the lower the AIC score is the best the functional model.

The second hypothesis test was checked for its appropriateness by calculating the total variance or discrepancy ratio of the model. The discrepancy ratio  $y$  statistics value assures to what extent the technical inefficiency explains variation in the model. Results verify that at the *woreda* level, 75.4% variations of tef technical efficiency from the frontier are attributed to farmers' technical inefficiency. Whereas the rest variation in tef output is due to other uncontrolled factors or statistical noises. The result also reveals the variation in tef output from the frontier accredited to farmers' technical inefficiency was higher among non-displaced households. This implies that though there is wider room for rising crop production in the study area by improving the efficiency of inefficient farmers and additional investment in modern agricultural technology is vital to boost overall tef productivity, particularly among displaced households.

Table 6.4: Summary result of Akaike's information criterion (AIC)

Models	AIC
Cobb-Douglas production function	156.2
Translog production function	95.1
$y$ non-displaced households	0.886
$y$ displaced households	0.751
$y$ total	0.754

Source: Computed from own survey data (2019)

### 6.3.2 Technical efficiency

The result shows the average technical efficiency of the study area was 78.6% and ranges from 25.8% and 95.9% (Table 6.5). Avoiding factors that reduce tef technical inefficiencies, there is a probability of increasing tef output by 18%, to perform on the *woreda*'s best frontier of 95.5% TE. This result agrees with Dessale and Tegegne (2018), and Abera (2019) conducted in Ethiopia who

found 78% and 79% of tef technical efficiency, respectively. Another study conducted by Wassie (2014) in Ethiopia also revealed that 63.5% of tef technical efficiency. Compared to non-displaced households, displaced households were technically inefficient with a statistically mean significant difference at 1% level of significance. Controlling all factors that minimize tef output coming from technical inefficiencies, there is a room to boost tef output by 16% and 22.3% among non-displaced and displaced households, respectively. Application of small quantity of fertilizer and large quantity of herbicides, poor combination of chemical fertilizer and herbicides, improved tef seed and herbicides, and herbicides and number of plowing, and number of plowing and labor were the causes of low technical efficiency among displaced households (Appendix IX). However, statistically insignificant correlation was found between female and male-headed households on tef technical efficiency. Generally, the variation in technical efficiency among households in the study area implies resources are utilized inefficiently.

Table 6.5: Summary of tef technical efficiency and t-test

	<b>Obs</b>	<b>Mean</b>	<b>Std.Dev.</b>	<b>Min</b>	<b>max</b>
Technical efficiency of non-displaced	240	0.806	0.143	0.275	0.959
Technical efficiency of displaced	101	0.739	0.167	0.258	0.951
Total technical efficiency	341	0.786	0.154	0.258	0.959
	<b>Obs</b>	<b>Mean</b>	<b>Std. Err.</b>	<b>Std. Dev.</b>	<b>P-value</b>
Non-displaced	240	0.806	0.009	0.149	0.0002
Displaced	101	0.739	0.017	0.167	
Combined	341	0.786	0.008	0.154	
Female	96	0.790	0.017	0.166	0.7624
Male	245	0.785	0.009	0.149	
Combined	341	0.786	0.008	0.154	

Source: Computed from own survey data (2019).

### 6.3.3 Allocative/Price Efficiency

A similar procedure like that of technical efficiency was followed, first best stochastic production function was identified using the Akaike Information Criterion (AIC) (Table 6.6). Next total variance or discrepancy ratio of the model was estimated. The result indicated that at the *woreda* level, 71% variations of tef price efficiency from the frontier attributed to farmers' price inefficiency. Whereas the rest variation in tef price efficiency is due to other uncontrolled factors or statistical noises. The result also reveals the variation in tef output from the frontier accredited to farmers' price inefficiency was similar between non-displaced and displaced households. This

shows though there is more room for increasing tef price efficiency in the study area by improving the efficiency of inefficient farmers and additional investment in modern agricultural technology with possible prices is mandatory to boost overall tef price efficiency.

Table 6.6: Result of Akaike's information criterion and allocative/price efficiency

Models	AIC
Cobb-Douglas production function	288.9
Translog production function	152.6
y non-displaced households	0.737
y displaced households	0.736
y total	0.710

Source: Computed from own survey data (2019).

At the *woreda* level, the average price efficiency was found 78.8% and ranges from 25.7% to 95.6% (Table 6.7). There is a chance of increasing the allocative efficiency by 17.6%. Attaining frontier price efficiency of tef using the existing production factors can save a cost of 17.6%. Similarly, displaced households lag behind the frontier price efficiency than non-displaced households. Controlling price inefficiency, attaining frontier price efficiency could save a cost of 16% and 21.3% among non-displaced and displaced households, respectively. The t-test showed that a statistically significant mean difference was found between displaced and non-displaced households at 1% level of significance (Table 6.7). The result shows non-displaced households were more price efficient than displaced households. Non-displaced households effectively utilize every coin, and better at selecting least-cost input combinations than displaced households. Therefore, displaced households spent more expenses on improved tef seed, herbicides, a combination of labor wage and fertilizer, and a combination of fertilizer and improved tef seed (Appendix IX). However, no statistically significant correlation was found in the allocative efficiency of tef between female and male-headed households.

Table 6.7: Summary of allocative/price efficiency and t-test

	<b>Obs</b>	<b>Mean</b>	<b>Std.Dev.</b>	<b>Min</b>	<b>max</b>
Allocative efficiency of non-displaced	240	0.803	0.133	0.299	0.956
Allocative efficiency of displaced	101	0.753	0.159	0.257	0.951
Total allocative/price efficiency	341	0.788	0.143	0.257	0.956
	<b>Obs</b>	<b>Mean</b>	<b>Std. Err.</b>	<b>Std. Dev.</b>	<b>P-value</b>
Non-displaced	240	0.803	0.009	0.133	0.0026
Displaced	101	0.753	0.016	0.159	
combined	341	0.788	0.008	0.143	
Female	96	0.793	0.016	0.157	0.6849
Male	245	0.786	0.009	0.137	
Combined	341	0.788	0.008	0.143	

Source: Computed from own survey data (2019)

### 6.3.4 Economic Efficiency

Table 6.8 shows, the average economic efficiency of the *woreda* was 64%. Controlling the technical inefficiency and allocative inefficiency there is a probability of increasing the economic efficiency of the households by 29.8%. Similarly, kept control technical and allocative inefficiency, economic efficiency of non-displaced and displaced households can be upswing by 27% and 35.6%, respectively. The t-test result indicated that a statistically significant mean difference was found between non-displaced and displaced households at 1% level of significance. Therefore, non-displaced households were economically effective than displaced households. Proper management, improving quality of inputs, and equating the ratio of input prices to their marginal cost of tef is essential to improve the economic efficiency of tef

Table 6.8: Summary of economic efficiency and t-test

<b>Variable</b>	<b>Obs</b>	<b>Mean</b>	<b>Std.Dev.</b>	<b>Min</b>	<b>max</b>
Economic efficiency of non-displaced	240	0.665	0.191	0.083	0.911
Economic efficiency of displaced	101	0.581	0.216	0.066	0.902
Total economic efficiency	341	0.640	0.202	0.066	0.911
<b>Group</b>	<b>Obs</b>	<b>Mean</b>	<b>Std. Err.</b>	<b>Std. Dev.</b>	<b>P-value</b>
Non-displaced	240	0.665	0.012	0.191	0.0004
Displaced	101	0.581	0.021	0.215	
combined	341	0.640	0.011	0.202	
Female	96	0.651	0.022	0.213	0.5381
Male	245	0.634	0.013	0.198	
Combined	341	640	0.011	0.202	

Source: Computed from own survey data (2019)

### 6.3.5 Determinants of Technical, Allocative, and Economic Efficiency

The result reveals access to credit, access to extension, farming experience, TLU, and displacement had a statistically significant effect on tef technical, allocative, and economic efficiency of smallholder farmers (Table 6.9). Access to credit, access to extension service, and being displaced had a positive statistically significant, and farming experience and TLU had a negative statistically significant effect on tef technical, allocative, and economic inefficiency.

Households who have access to credit were lower in TE, AE, and EE. A unit increase in access to credit increases the probability of households being technical, price, and economic inefficient by 5.9%, 4.3%, and 6.6%, respectively, keeping other variables constant. Access to credit helps smallholder farmers to solve short period money liquidity, to adopt modern agricultural inputs thereby increasing production. However, in this study, a reverse relationship was found between tef technical, allocative, and economic efficiency and access to credit. This might be due to production-deficit farmers might use the loan to purchase food items than purchasing agricultural inputs. Data generated from focus group discussants *indicated that the loan we receive from lending institutions is small with a higher interest rate. As a result, farmers shift the money to other activities that have fast return instead of utilizing to adopt agricultural technologies.* Abate *et al.* (2019) researched on red paper in Ethiopia and get a similar result. He explained the loan might be used for home consumption and other purposes rather than adopting agricultural inputs. This result also contradicts Ahmed *et al.* (2014), Dessale *et al.* (2018), and Weldegebriel (2014) who found a positive statistically significant association with the technical, allocative, and economic efficiency of tef output. They stated that access to credit increases farmers' efficiency as it solves the interim shortage of money during the crop growing season. Studies conducted by Gela *et al.* (2019), and Kassa *et al.* (2019) reported a neutral relationship with the technical, allocative, economic efficiency.

The result implies access to extension services decreases the technical, price, and economic efficiency of households. A unit increase in access to extension service decreases the probability of households being technical, allocative, and economic efficient by 7.9%, 7.1%, and 9.5%, respectively, holding other variables unchanged. Access to extension services increases farmers' awareness to the adoption and utilization of modern agricultural inputs. However, a reverse association was reported between access to extension service, and TE, AE, and EE. Data generated

from key informants and focus group discussants *underpinned that the development agents do not train us technical skills rather they spent almost all their time on political-related activities, poor competency level of agricultural experts, and the frequency of training is not adequate and the training provided is below our natural wisdom.* This result is in line with the finding of Wassie (2014) who suggested that the selection problem and the quality of the training delivered to farmers caused to have a positive effect on technical inefficiency of tef. Contrarily, this result is inconsistent with the findings of Kassa *et al.* (2019), Sisay *et al.* (2015), and Berhan (2015) found a positive statistically significant association with the technical efficiency of tef. They stated that extension agents supply information on improved livestock and crop production technologies and market integration. Hence farmers who have access to extension services were more likely to adopt improved agricultural technologies thereby increases their production efficiencies. Another empirical study conducted by Dessale *et al.* (2018) found a neutral relationship.

Farming experience had a positive statistically significant effect on technical, price, and economic efficiency. It was hypothesized to have a positive effect on efficiency. A unit increase in farming experience increases the probability of households being technical, price, and allocative efficient by 0.1%, 0.1%, and 0.2%, respectively, given that all variables are constant. Practically speaking, as professional works, farming experience demands cumulative knowledge, skill, and practices to enhance the agricultural productivity of farmers. Apart from this, experienced farmers have technical skills in infestation control, the type of seed to use, and the quantity of different inputs. This conforms to the finding of (Asefa, 2011). He verified that experience increases knowledge on efficient resource utilization of farmers.

TLU is another variable that has a positive statistically significant effect on the technical, price, and allocative efficiency of tef. A unit increase in TLU possession increases the probability of households being technical, price, and economic efficient by 2%, 1.6%, and 2.4%, respectively, keeping other variables constant. In smallholder farmers, having a large TLU guaranty household during crop failure, helps farmers to get draught power and to purchase modern agricultural inputs by selling livestock. This result agrees with the finding of Asefa, (2011) and Sisay *et al.* (2015) who stated that crop production is mainly supported and supplemented by animal husbandry. It has a direct effect on the technical, allocative, and economic efficiency of crops, farmers who

owned more number of TLU will have more money to purchase agricultural inputs and has again the chance to get oxen for draught power.

Lastly, being displaced had a negative statistically significant effect on technical, price, and economic efficiency and meets the prior hypothesis. A unit increase in the number of displaced households increases the probability of displaced households being technical, price, and economic inefficient by 8.3%, 6.8%, and 10.1%, respectively, keeping other variables constant. Displaced households have less productive assets compared to non-displaced households, this challenges displaced households to purchase and utilize a combination of modern agricultural inputs to enhance production. Data generated from key informant interviews and focus group discussions revealed *we are idle and we did not use our energy to generate other income than farming due to the lack of a large processing plant to employ us*. This implies effective utilization of labor was poor in the study area that is translated to low efficiency.

Table 6.9: Tobit regression result of factors affect technical, price, and economic efficiency

Variables	TE		AE		EE	
	Dy/Dx	Std. Err.	Dy/Dx	Std. Err.	Dy/Dx	Std. Err.
Access to credit	-0.059**	0.027	-0.043*	0.025	-0.066*	0.035
Access to extension	-0.079***	0.021	-0.071***	0.020	-0.095***	0.028
Educational level	0.003	0.003	0.001	0.003	0.002	0.004
Family size	-0.001	0.005	-0.000	0.005	-0.001	0.001
Farming experience	0.001*	0.001	0.001*	0.001	0.002*	0.00
Irrigated land size	0.071	0.089	0.112	0.084	0.005	0.118
Farmland size	-0.003	0.034	0.015	0.032	0.114	0.046
Market distance	0.001	0.006	0.001	0.006	0.003	0.008
Non-farm income	0.000	0.000	0.000	0.000	0.000	0.000
Remittance	0.000	0.000	-0.000	0.000	0.000	0.000
Sex of household head	-0.021	0.021	-0.016	0.020	-0.034	0.027
TLU	0.020***	0.006	0.016***	0.006	0.024***	0.008
Treatment	-0.083***	0.028	-0.068***	0.026	-0.101***	0.037

\*\*\*, \*\* and \* indicate significance at 1%, 5%, and 10%, respectively

Source: Computed from own survey data (2019)

## 6.4 Summary

This chapter focuses on urban expansion and its effect on the production efficiency of smallholder peri-urban farmers. Translog production function was applied to analyze production efficiency particularly, technical, allocative, and economic efficiency using frontier software. Technical efficiency in the *woreda*, displaced, and non-displaced households were 75.4%, 75.1%, and 88.6%, respectively. The effect of technical inefficiency of tef production was higher than the statistical noises. Particularly, the effect of statistical noise was higher among the total and displaced households. The average technical efficiency of the non-displaced, displaced, total sample was 80.6%, 73.9%, and 78.6%, respectively. Controlling factors of tef technical inefficiency, the efficiency of tef can be increased by 16%, 22.3%, and, 18%, respectively among the non-displaced, displaced, and the total sample. The t-test result shows a statistically significant mean difference in technical efficiency between non-displaced and displaced households at 1% level of significance.

The discrepancy  $\gamma$  statistics of allocative efficiency was small than the technical efficiency. 73.7%, 73.6%, and 70.1% of the variation in price efficiency among non-displaced displaced, and the total households was coming from price inefficiency. At the *woreda* level, the average price efficiency was 78.8%. Avoiding factors of price inefficiency attaining frontier price efficiency minimizes a cost of 17.6%. The result revealed tef price inefficiency was higher among displaced households than non-displaced households with a mean value of 75.3% and 80.3%, respectively. There is a possibility of increasing tef price efficiency of displaced and non-displaced households by 22.3% and 16%, respectively controlling effects rises from price inefficiency of tef. The t-test result also shows there is a statistically significant mean difference in allocative efficiency between non-displaced and displaced households at 1% level of significance.

At the *woreda* level, average economic efficiency was found 64% with a possibility of increasing economic efficiency by 29.8%. Non-displaced households were economically efficient than displaced households with a value of 66.6% and 58.1%, respectively. Therefore, there is a possibility of increasing the economic efficiency of non-displaced and displaced households by 27% and 35.6% each. Similarly, there is a statistically significant mean difference in economic efficiency between non-displaced and displaced households at 1% level of significance.

Lastly, across technical, allocative, and economic efficiency, access to credit, access to extension service, farming experience, TLU, and treatment effect was statistically significant at a different level of significance. Except for farming experience, and TLU, the rest three variables negatively affect the technical, allocative, and economic efficiency of tef in the study area.

## **Chapter 7: Urban Expansion and Its Effect on Technology Adoption in Axum, Tigray Region**

### **7.1 Introduction**

Enhancing agricultural productivity is a basic and precondition to transform agriculture in developing countries (Janvry *et al.*, 2016). To do so, applying relevant agricultural technologies to modernize subsistence production is informed to be a genuine approach to meet the food requirements of the ever-growing human population (Abdullahi & Sherif, 2015). They also strengthened in the rapidly growing world, where farming land is shrinking due to horizontal urban expansion and development-induced projects, agricultural productivity should grow by 70% to meet food requirements. In several developing countries, not exceptional to Ethiopia, subsistence agriculture has a significant contribution to the national economic growth applying their natural wisdom (CIMMYT, 1993). This fetters the growth of the agricultural sector and poor performance of agricultural growth have been registered continuously in Sub-Saharan Africa (World Bank, 2008). Therefore, an achievable shift could be made on the agricultural productivity of smallholder farmers through disseminating agricultural technology (Janvry *et al.*, 2016). Investing in agricultural technologies reduces poverty and improves food security through boosting food production and supplying surplus products to the market (Gill, 2002; Mekonnen, 2009). In sum, in areas where farming land is converted to residential areas, modernizing agriculture to increase productivity/unit area and profitability is unquestionable to tackle poverty in rural households (World Bank, 2008).

Boserup's theory and others describe the long-term process of land use intensifications driven by population pressure and land scarcity, which endogenously induce technological and institutional innovations to raise agricultural output from a given land. Under the pressure of population growth, a shift from extensive to relatively intensive systems of land use has been witnessed in almost every part of the world (Boserup, 1965). As people shift out of agriculture to more remunerative activities off the farm and outside the rural areas, a positive virtuous economic dynamic is set in motion, with new opportunities being generated, by attracting poor rural workers who gain directly, and by positively affecting the rural areas indirectly, through remittances and increased demand for their goods, fostering economic growth and reducing poverty (Christiaensen *et al.*, 2013).

Empirical studies of rural to urban migration focus largely on cash remittances from urban to rural areas, with migration generally considered to have a positive effect on rural household incomes. Studies on the direct linkages between cash remittances and farm investments are less common. Tiffen (2003) notes the importance of cash remittances for making investments in improved technology among smallholders in West Africa. The share of remittances in rural cash incomes is generally small in Sub-Saharan Africa, however, and tied to historical patterns of mobility. Cash remittances, therefore, do not constitute a likely source of capital for the general upgrading of smallholder technology. Unlikely, Case studies show farmers have invested and adopted new technologies but the transition to an urbanized economy has been hindered by poor policies (Tiffen, 2003).

The achievement of the green revolution in Asia gave a lesson to African countries to utilize and adopt modern agricultural inputs particularly improved crop varieties to improve agricultural productivity (Awotide et al., 2016). A study conducted in Shanghai stated peri-urban agricultural land is converted to residential and other development works as a result high technology like hydroponic, indoor horticulture, and vertical agriculture is widely practiced around the cities (Hosseinifarhangi *et al.*, 2019). Gwan and Kimengsi (2020) confirmed that urban expansion forced farmers to agricultural intensification and adopting high-value crops as coping strategies in Bamenda city, Cameroon. Another study conducted in Ethiopia displaced farmers get better access to improved dairy farms, animal fodder, and poultry farming (Mengistu, 2016). Urban development increases off-farm employments, which will enhance the opportunity costs of more intensive farming (Uchida *et al.*, 2009)

In developing countries, limited access to credit, inaccessible information, small farm plot, low educational performance, lack of suitable farm equipment, lack of accessory materials, and poor infrastructure facilities are a few among the factors that hinder agricultural adoption (Meinzen-dick *et al.*, 2004). A study conducted in China revealed that farmers' experience, training, and positive attitude to technology adoption are limiting factors to adopt agricultural packages (Li *et al.*, 2020). A panel data collected from 25 counties in Africa reported policy-related tools like access to information, access to credit, and wealth-related factors like land size, livestock possession, and off farm-income are positively related to the adoption of agricultural technologies (Arslan *et al.*, 2020)



of as consisting of those unobservable factors which explain the marginal probability of making a type  $j$  claim. Each  $\epsilon_j$  is drawn from a  $J$ -variate Normal distribution with zero conditional mean and variance normalized to unity (for reasons of parameter identifiability), where  $\epsilon \sim N(0, \Sigma)$ , and the covariance matrix  $\Sigma$  is given by

$$\Sigma = \begin{bmatrix} 1 & \dots & p_{12} & \dots & p_j \\ p_{21} & \dots & 1 & \dots & p_{2j} \\ \vdots & & & & \\ \vdots & & & & \\ p_{j1} & \dots & p_{j2} & \dots & 1 \end{bmatrix} \dots \dots \dots (2)$$

Note that in this formulation of the MVP model, we can derive marginal probabilities directly. For instance, the marginal probability of observing the  $j^4$  type of claim can be expressed as

$$pr(I_j = 1) = \phi(x' \beta_i), \text{ for } j = 1, \dots, J \dots \dots \dots (3)$$

Where  $\phi(\cdot)$  denotes the cumulative distribution function of the standard normal. Moreover, the joint probability of observing all possible types of claim comes from a  $J$ -variate standard normal distribution

$$pr(I_1 = 1, \dots, J) = \phi_j(x' \beta_1, \dots, x' \beta_j; \Sigma) \dots \dots \dots (4) \text{ (Young et al., 2009).}$$

Where  $\Sigma$  is the covariance matrix

Table 7.1: Explanatory variables used in the multivariate probit model

variables	Description of variables	Expected sign
HFBM, HFIAS, FCS, and HDDS		
AccessCrdt	Access to credit (dummy) 0 = no, 1 = yes	+
AccessEx	Access to extension service (dummy) 0 = no, 1 = yes	+
AgeHH	Age of household head in number (continuous)	+/-
EDHH	Educational level of household head in number (continuous)	+
Farmingyear	Farming experience in years (continuous)	+
Fsize	Family size in number (continuous)	+/-
SexHH	Sex of household head (dummy) 0 = female, 1 = Male	+/-
Irrland	Irrigated land in hectare (continuous)	+
Landsize	Land size in hectare (continuous)	+
Marketdis	Market distance in kilometer (continuous)	-
Nfarmincome	Non-farm income in birr (continuous)	+
Remittance	Remittance in birr (continuous)	+
TLU	Tropical livestock unit in number (continuous)	+
Treatment	Treatment (dummy) 0 = non-displaced, 1 = displaced	-

Source: Literature and Author (2019)

## 7.3 Result and Discussion

### 7.3.1 Selecting Agricultural Technologies

The assumption made in this study is, displaced and non-displaced households' tendencies to adopt agricultural packages vary. Achieving this hypothesis demands a selection of relevant agricultural technologies practiced and disseminated by the bureau of agriculture in the region. As presented in table 7.2, out of the different technologies used in the study area four agricultural technologies were selected. Due to its long-years extension works both displaced and non-displaced households have not a problem of adopting other agricultural technologies and practices like fertilizer, modern seed, animal fodder, and water harvesting technologies, etc. Therefore, to evaluate agricultural adoption difference between displaced and non-displaced households row sawing, modern hive, generator, and practicing irrigation were chosen as agricultural packages. As stated close above adopting fertilizer, animal fodder, modern seed, and water harvesting technologies is not such a problem between displaced and non-displaced farmers. Therefore, including such variables to see variation between displaced and non-displaced households does not give sense consequently those agricultural technologies were excluded from the multivariate probit model.

Table 7.2: Frequency distribution of selected agricultural technology adoption

Type of Technology	Treatment	Adopter	Non-adopter	Total
Row sawing	Control (non-displaced)	64	176	240
	Treated (displaced)	30	71	101
	Total			341
Modern hive	Control (non-displaced)	11	229	240
	Treated (displaced)	9	92	101
	Total			341
Irrigation	Control (non-displaced)	66	174	240
	Treated (displaced)	20	81	101
	Total			341
Generators	Control (non-displaced)	28	212	240
	Treated (displaced)	5	96	101
	Total			341

Source: Computed from own survey data (2019)

### 7.3.2 Determinants of Agricultural Technology Adoption

Theoretical and empirical literature described, adoption of agricultural packages required adequate farmland. If they do not have land, they are not willing to invest in agricultural technologies. The result underpins the apriori hypothesis. Displaced households had a negative statistically

significant effect on adopting a generator and participating in irrigation. This implies displaced households were less likely to purchase a generator and actively participate in irrigation activities. A unit increase in the number of displaced households decreases the probability of households engaged in irrigation and purchasing generators by 53.7% and 96.7%, respectively, keeping other variables unchanged. Displaced households have a small plot of land and a lower educational level. Hence displaced farmers are not interested to engage in irrigation and buy a generator to produce food crops using irrigation. Rather they search for other non-farm income-generating activities to meet the food requirement of the household. Surprisingly, adopting a modern hive found a negative neutral relationship with displaced households. Whereas row sawing positively and not significantly correlated to displaced households.

An inverse relationship was reported between the age of the household head and participating in irrigation. One year increase in the age of household head decreases the probability of households participating in irrigation by 6.2%, keeping other factors constant. The result revealed younger households participated better in irrigation than older household heads. Irrigation is labor-intensive and demands a variety of agricultural packages. Therefore, young farmers comparably have enough physical fitness to effectively manage irrigation. A consistent result was found by (Chuchird *et al.*, 2017; Deksisia & Bayissa, 2020; Sharaunga & Mudhara, 2018). They reported that as the household head age increases the tendency to participate in irrigation decreases. A similar result was also found by (Sisay, 2018). He explained that elders are reluctant, not risk-takers, and incapable to work much time.

Households with larger family sizes were more likely to participate in irrigation schemes. Compared to other agricultural activities irrigation demands much labor. A unit increase in the family size of households increases the likelihood of participating in irrigation by 10.9% keeping other variables constant. Households with large family sizes were actively engaged in irrigation than households with small family sizes. This finding agrees with (Deksisia & Bayissa, 2020). They suggested that household who has large size engaged in the agricultural labor force has better chance to use irrigation water

Farming experience is another covariate that had a positive statistically significant effect on households participating in irrigation. Experienced farmers have a deep understanding of agronomics practices and the know-how to allocate available resources. Therefore, as farmers'

experience increases the tendency of households' participation in irrigation increases in the study area. A unit increase in the farming experience of household head increases the likelihood of engaging in irrigation by 5.9%, remaining other variables constant. This contradicts Regassa (2015) who stated that the probability of changing means of livelihood to other non-farm activities is higher among experienced farmers.

Households with a large number of livestock possession were intensively involved in irrigation than households with a small number of livestock. Increasing TLU by one unit increases households' participation in irrigation by 14.9% keeping other factors fixed. In rural areas, livestock is an important asset. Majority of farmers with a large number of livestock participate in irrigation to produce green animal feeds to increase the productivity of milk and beef. This result is in line with (Urgessa *et al.*, 2021). Households with large livestock owners have better access to finance by selling of livestock which helps them to invest in irrigation aggressively.

Tigray region is known for its diversified colors and quality of honey. Compared to other livestock farming honey bee production needs a small plot of land. This motivates farmers to engage in honey bee production. The multivariate probit estimation result showed that the household head sex positively and significantly correlated with the adoption of modern hive. A unit increase in the number of male-headed households increases the probability of adopting modern beehives by 74.9% keeping other factors constant. This implies male-headed households were more likely to adopt modern hives than female-headed households. Female-headed households are swamped with caring for and preparing foods. This competes their time and fails to properly manage honey bee production. Besides honey bee is aggressive so this puts pressure on female-headed households and limits their participation. This result agrees with (Chemwok *et al.*, 2016). They justified that female-headed households were less likely to participate in beekeeping compared to male-headed households. Contrarily, Fetenssa (2018) reported a negative and not significant correlation with the sex of household heads.

Education improves technology adoption of farmers and is a key to transform the livelihood of households. Increasing the educational level of households enhances the tendency to invest in the modern hive. Households with higher educational levels had a better capacity to adopt modern hive than households with lower educational levels. A unit increase in the educational level of the household heads increases the probability of adopting modern beehives by 6.5% holding other

variables unchanged. Theoretical and empirical literature suggested education helps farmers to manage agronomic practices scientifically and adopt relevant agricultural packages to improve productivity. This result is parallel with the work of (Abebe *et al.*, 2008; Amanuel, 2018). They explained that exposure to education is generally supposed to increase a farmer's ability to obtain, process, and use information relevant to the adoption of improved agricultural technologies.

Remittance plays important role in solving liquidity problems and supplements agricultural production in Ethiopia. It is expected result, remittance improves the adoption of the modern beehive. Households who get higher remittances were a higher tendency to purchase modern beehives than households who get lower remittances. A unit increase in the amount of birr collected from remittance increases the likelihood of adopting modern beehive by 0.1% keeping other variables constant. It is important to note that modern agricultural technologies solicit a higher budget. So money generated from remittance increases the adoption of modern beehive. This agrees with the finding of Happy *et al.* (2019) who stated remittance played a great role to adopt and use agricultural technology in the farm household.

Livestock possession enhances modern beehive adoption. This meets the apriori hypothesis where increasing livestock possession ascends the adoption of modern agricultural packages. The result revealed households with larger TLU to have superior capacity to purchase modern beehives than households with smaller TLU. A unit increase in TLU increases the probability of households adopting modern beehives by 18.8% keeping other factors constant. As stated above, livestock possession is an important community-based wealthy assessment. Therefore, farmers with large livestock possession were considered wealthier and actively participate in honey production. This finding agrees with (Jebesa, 2017). But another study conducted by (Fetenssa, 2018) reported a negative and insignificant correlation.

Generator among the irrigation technologies disseminated to enhance irrigation scheme productivity. Adopting generator positively and significantly correlated with sex of household head. Male-headed households had a better affinity to purchase generators than female-headed households. A unit increase in the number of male-headed households increases the probability of households purchasing a generator by 14.6% keeping other variables constant. This is because in Ethiopia female farmers are poor and poorly participate in non-farm activities to generate additional income. Besides, generators demand physical fitness to operate. This finding is in line

with the work of (Getacher *et al.*, 2013). They justified that liquidity is a major constraint for adoption as a result female-headed households are often poorer and have less affinity to adopt a generator.

Surprisingly, non-farm income negatively and significantly correlated to the adoption of a generator. Increasing the amount of money generated from non-farm income reduces the propensity of farmers to purchase a generator and engaging in irrigation in the study area. A unit increase in non-farm income decrease the probability of households purchasing generator by 0.1%, keeping other variables constant. Because the amount of income might be insignificant to purchase generators or farmers getting better non-farm income to shift their livelihood to non-farm activities and involve in petty trading and other activities. TLU has a positive and significantly associated with adopting generators. As repeatedly stated above increasing livestock possession enhances the purchasing power of farmers. This contradicts Happy *et al.* (2019) research conducted in Bangladesh.

In Ethiopia, agricultural extension workers are assigned up to *Kushet* and *Tabia* level. And limited achievements were recognized compared to years spent and experts deployed. However, the result confirmed access to extension service positively and significantly correlated with adopting a generator. Households who get access to extension services increase the purchasing power of generators compared to those who did not get extension services. A unit increase in access to extension increases the probability of households purchasing generators by 53.7% keeping other variables constant. The possible justification is the get better awareness on the advantage of utilizing agricultural technologies. This result is consistent with (Adeoti, 2009), who stated that households who get frequent extension services were better at introducing irrigation inputs.

Lastly, the recently introduced row sowing was discussed. Age of household head inversely correlated with row sowing of tef. A unit increase in the age of the household head decreases the probability of tef row sowing by 3.3% kept other factors constant. Elder households were less likely to practice tef row sowing than younger households. The possible explanation is, row sowing is labor-intensive compared to conventional sowing. Therefore, younger farmers are actively practicing row sowing even younger farmers engage in non-farm income-generating activities. This income helps them to hire daily laborers. This result is in line with the finding of (Abebe *et*

*al.*, 2008). They clarified that elders have not an interest in row sawing because it is laborious. However, another study conducted by Tamirat (2020) found a negative and neutral correlation.

Agricultural practice requires experience spent in farming. Farming experience positively and significantly associated with row sawing. A unit increase in farming experience resulted in increasing the probability of households' row sawing by 4.1% keeping other factors constant. Farmers with higher years of farming experience are better in row sawing than farmers with fewer years of farming experience in the study area. Access to credit solves money liquidity of farmers to adopt agricultural packages for short time. Access to credit positively and significantly associated with tef row sawing in the study area. A unit increase in the amount of credit increases the likelihood of households' tef row sawing by 50.5% keeping other variables constant. Households who got loans from the financial institution were better in row sawing compared to those who did not get a loan. Row sawing demands higher labor compared to conventional sawing so getting a loan helps farmers to hire laborers to implement row sawing.

Lastly, the rho (correlation) showed that except for participating in irrigation and adopting generators there is no correlation among the technological packages used. This shows that participating in irrigation and purchasing generators are complementary. Therefore, these two technologies go simultaneously. Whereas, the other technologies can adopt separately they had no complementary relationship.

Table 7.3: Multivariate probit result

Covariates	Irrigation status		Modern hive adoption		Generator		Row sewing	
	Coef.	Std. err	Coef.	Std. err.	Coef.	Std. err.	Coef.	Std. err
AccessCrdt	-0.025	0.257	0.192	0.327	0.063	0.313	0.505**	0.236
AccessEx	0.189	0.194	0.335	0.307	0.537**	0.234	-0.236	0.196
AgeHH	-0.062***	0.022	0.062	0.041	-0.056	0.054	-0.033*	0.018
EDHH	-0.009	0.029	0.064*	0.035	0.015	0.035	-0.005	0.026
Farmingyear	0.059***	0.022	-0.053	0.039	0.053	0.052	0.041**	0.017
Fsize	0.109**	0.049	0.129	0.087	0.047	0.059	-0.004	0.048
lsize	0.190	0.363	-0.786	0.534	0.363	0.415	-0.226	0.334
MarketDis	-0.062	0.060	-0.053	0.108	-0.108	0.077	0.042	0.057
Nfarmincome	-0.000	0.000	-0.000	0.000	-0.001*	0.001	0.000	0.001
Remittance	0.000	0.000	0.000***	0.000	-0.000	0.000	0.000	0.000
SexHH	0.167	0.238	1.749**	0.867	5.146***	1.702	0.100	0.203
TLU	0.149**	0.063	0.188**	0.095	0.208***	0.077	-0.013	0.056
Treatment	-0.536*	0.302	-0.097	0.521	-0.967**	0.394	0.168	0.268
_cons	-0.010	0.671	-5.860	1.725	-5.526	0.870	-0.238	0.616
/atrho21	0.075	0.148						
/atrho31	1.211***	0.171						
/atrho41	0.073	0.098						
/atrho32	0.246	0.186						
/atrho42	-0.186	0.132						
/atrho43	0.002	0.110						

Source: Computed from own survey data (2019)

Table 7.4: Estimated marginal effect of technology adoption

Variables	Irrigation Practice		Adoption modern beehive		Adoption of generator		Adoption of tef row sawing	
	dy/xx	Std. Err.	dy/xx	Std. Err.	dy/xx	Std. Err.	dy/xx	Std. Err.
AccessCrdt	-0.025	0.257	0.192	0.327	0.063	0.313	0.505**	0.236
AccessEx	0.189	0.194	0.335	0.307	0.537**	0.234	-0.236	0.196
AgeHH	-0.062***	0.022	0.062	0.041	-0.056	0.054	-0.033*	0.018
EDHH	-0.009	0.030	0.065*	0.035	0.015	0.035	-0.005	0.026
Farmingyear	0.059***	0.022	-0.053	0.039	0.053	0.052	0.041**	0.017
Fsize	0.109**	0.049	0.128	0.087	0.047	0.059	-0.004	0.048
lsize	0.190	0.363	-0.786	0.534	0.363	0.416	-0.226	0.334
MarketDis	-0.062	0.060	-0.053	0.108	-0.107	0.077	0.042	0.056
Nfarmincome	-0.000	0.000	-0.000	0.000	-0.001*	0.000	0.000	0.000
Remittance	0.001	0.000	0.001***	0.000	-0.000	0.000	0.000	0.000
SexHH	0.167	0.238	0.749**	0.867	0.146***	0.702	0.100	0.203
TLU	0.149**	0.063	0.188**	0.095	0.208***	0.077	-0.011	0.058
Treatment	-0.537*	0.302	-0.097	0.521	-0.969**	0.394	0.168	0.268

Source: Computed from own survey data (2019)

#### 7.4 Summary

The overall objective of this chapter is to assess the effect of urban expansion on agricultural technology adoption of peri-urban farmers. A multivariate probit model was employed to investigate variations in agricultural technology adoption. Four agricultural technologies were found a significant correlation with covariates. There is no problem of adopting fertilizer and modern seed in the study area.

The result showed that age of household head, family size, farming experiences, TLU, and treatment group were found a significant effect on participating in irrigation. Displaced households poorly participated in irrigation. In sum, the age of the household head and treatment group has a significant negative correlation with households participating in irrigation. Whereas, Family size, farming experiences, and TLU had a significant positive correlation to household participation in irrigation. However, the treatment group had an insignificant negative correlation with a household adopting a modern beehive. The sex of household head, remittance, educational level, and TLU had a significant positive correlation with the adoption of a modern beehive.

Displaced households were a significant negative correlation with adopting generators. While, sex of household head, TLU, and access to extension service had a positive statistically significant

correlation with adopting generator. Only non-farm income had a significant negative correlation with generator adoption. Lastly, the treatment effect had an insignificant positive correlation with adopting tef row sawing. Farming experience and access to credit had a significant positive correlation with tef row sawing. Only the age of household head had a negative statistically significant correlation with tef row sawing.

## Chapter 8: Conclusion and Recommendations

### 8.1 Conclusion

The focus of this study is, to investigate the impact of urban expansion on household food insecurity, poverty, agricultural production efficiency, and agricultural technology adoption in Axum, Tigray Region, Ethiopia. The different food security measurements yield unlike results of household food security status. Prevalence of food insecurity was higher in displaced, non-displaced, and in general at the *woreda* level. This converges with the finding of previous work where displaced households did not feed their households for more than 7 months (Addisu, 2015). However, even though the percentage of food insecurity was higher in displaced households, no statistically significant mean difference was reported between displaced and non-displaced households. This divergence with the theories of food insecurity and displacement. Because the theory of food insecurity indicates households who have not adequate productive assets are suffering from food insecurity. Similarly, displacement theory shows households dispossessed from their agricultural land were food insecure. Food insecurity was also prevalent among male-headed households measured using HFBM measurement. Currently, most development plans favor and provide special merit to female-headed households regardless of its practical implementation. Besides they are employed in paid domestic activities and female-headed households spent the money for home expenditure which increases the calorie requirement of households. The t-test result of HFBM using selected covariates showed households with small family size, and higher farm experience was food secure. However, larger farmland size and larger TLU possession had a reverse correlation with food security. Larger farmland size and larger TLU might not be directly translated to better production and productivity but the quality of the farmland and livestock also matters.

Unlike HFBM, there is a statistically significant mean difference between female and male-headed households' food security status measured using HFIAS. This measurement captures detailed issues beyond the availability of calories of foods, therefore, consumption of a single calorie-rich food meets the calorie requirement of the household and households become food secure. Whereas, HFIAS assesses the feeling of households, the kinds of food items consumed, the variety of food items, size of the food, interest, and number of meals consumed per/day. So limited access to assets, low educational level, and limited financial access to purchase required food items are among the

factors that hinder attaining female-headed household food security. The t-test showed that households with larger family sizes and farmland sizes had better food security status measured using HFIAS. Larger farmland size helps farmers to increase food production, similarly, households with larger family sizes have higher economic active members who support the household either working on the farm or non-farm income-generating activities.

The hypothesis test showed that no statistically significant mean difference was found between displaced and non-displaced households measured using FCS and HDDS. However, the prevalence of food utilization problems was higher among female-headed households. Economic discrepancies are the driving causes as male-headed households are more engaged in farming particularly in irrigation and other non-farm activities which enhances the economy of the household. Besides most male-headed households are with their partners, therefore, the wife cooks diversified food items to meet the nutritional requirement of the households. Households with larger family sizes, farmland sizes, TLU, and higher farming experiences were food secured.

So far, no one composite food security measurement was developed and the indicators gave different results. So, the correlation test was carried out and the result revealed except between HDDS and FCS, no positive correlation was found among food security indicators. The correlation was very low, therefore, utilizing either the indicators instead gives a bad and misrepresentation of the result. Maxwell *et al.* (2013) found a divergence result in the Eastern Zone of Tigray where FCS highly correlated with calorie consumption and HDDS.

The impact assessment results show no statistically significant mean difference between displaced and displaced households. Therefore, this result disproves the assumption of displacement theory, as the thesis of displacement theory is displaced households are exposed to food insecurity. Similarly, the nutritional status of children shows that no statistically significant mean difference between children from displaced and non-displaced households even between female and male children in the study area.

Poverty is a persistence and a daily feature of Ethiopia. The chi-square test result of MPI showed the majority of the indicators have a significant correlation between displaced and non-displaced households. A statistically significant mean difference was found between non-displaced and displaced multidimensionally poor households. Similarly, the prevalence of severe poverty was higher among displaced households. This is mainly associated with low educational level and

possession of a small plot of irrigated land. Besides children are getting out of education to support their families and the family is entrenched in a vicious circle of poverty. Therefore, urban expansion intensifies poverty in the study area. Therefore, the result converges with the concept and theories of poverty and displacement. However, no statistically significant mean difference was found between children from non-displaced and displaced households.

The translog production function revealed a statistically significant mean difference in technical, allocative, and economic efficiency between displaced and non-displaced households. This is associated with non-displaced households were better in educational level and have a large land size which helps them to utilize a combination of inputs at a reasonable cost. Regardless of being displaced or not displaced the production gap was mainly due to production inefficiency. Access to credit, access to extension service, farming experience, TLU possession, and displacement are the cause of production inefficiency in the area.

Lastly, the multivariate probit result shows that displaced households had less tendency to participate in irrigation and adopting generators. However, displacement had a neutral statistically insignificant effect on the modern beehive and row sawing. Age of household head, TLU, and displacement had a negative statistically significant effect, and family size and farming experience had a positive statistically significant effect on households' affinity to participate in irrigation. Sex of the household head, educational level, remittance, and TLU were identified as determinants of modern beehive adoption. Similarly, age of household head, farming experience, and access to credit affects households to practice row sawing adoption in the study area. Lastly, the adoption of a generator was determined by age of household head, non-farm income, sex of household head, TLU possession, and displacement.

Generally, urban expansion negatively intensifies poverty which is consistent with the previous works conducted in Addis Ababa and Tigray, respectively, by Leulseged *et al.* (2012), and Mezgebo (2014) evidenced that poverty was prevalent among displaced households. Besides, displaced peri-urban households were inefficient in tef production and had less tendency to adopt agricultural technologies. Unlikely, urban expansion had not a statistically significant effect on food security status of peri-urban households.

## 8.2 Recommendation

Food security was measured by applying diversified indicators to capture the multidimensional nature and to get a better picture of household food security status. The different food security measurements yield unlike results and the correlation among the measurements was low. Therefore, the researcher recommends depending on the context of the study area all necessary dimensions should be measured using a specific measurement as per the dimension of food security. In addition, researchers and food security practitioners should work aggressively to develop a matrix/a holistic measurement that captures the four dimensions of food security together.

The prevalence of food insecurity in the study area was unacceptably high. Therefore, tangible and practical training should be provided on family planning, empowering female-headed households, and supplying improved animal breed to enhance the agricultural productivity of smallholder farmers in the study area. Food insecurity reduction programs like PSNP and HABP should properly be implemented to bring sustainable changes and endure the livelihood of the community.

The determinants of food security/insecurity across the four indicators are differently affected by demographic and socioeconomic factors. Therefore, the researcher recommends the traditional identification of food security determinants in general regardless of the indicators should be avoided. Rather potential organizations that work in ameliorating food insecurity challenges should employ indicator-based determinants of food insecurity to bring actual changes in food security.

Thinness, stunting, and underweight, and the composite index anthropometric failure of children under five ages were prevalent. Therefore, health and agricultural experts should provide training on the nutritional requirement and care of children, cultivating different vegetables, implementing nutrition-sensitive agriculture that serves as a source of children's food. The government structure from kebele to federal should aggressively work to establish furnished health institutions and push agricultural technologies to increase agricultural productivity in the study area.

The prevalence of multidimensional poverty was higher at the *woreda* level, particularly among displaced households. Living standard and health dimensions were the major contributors to the overall poverty of the study area. Therefore, a strong linkage between health practitioners and development agents is badly demanded to provide regular training and visits to improve the living

standard of the household particularly, how they keep their hygiene and advise them to have clean toilet and prepare hand-washing equipment, and agricultural productivity to enhance households' access to a balanced diet. Besides, the regional bureau of water resources should identify hotspots with a critical shortage of water to serve clean water. As stated multidimensional poverty is higher among displaced households. Therefore, from Kushet to ministry offices should acknowledge the consequences of urban expansion on household poverty. Stages should be arranged for farmers to get adequate and relevant information on why are they displaced? and how do they get the compensation with its proper cost breakdown. And farmers should get relevant and repeated training on how to utilize the money, in what types of income-generating activities they will participate and how to improve the agricultural productivity per/unit area. A strong monitoring and evaluation system should be set to follow the livelihood status of displaced farmers.

Technical, allocative, economic efficiency was lower among displaced households. Therefore, policymakers and implementers should address the problem of efficient resource utilization than simply disseminating agricultural technologies or the introduction of agricultural technologies should link with farmers' efficiency to tackle food insecurity and poverty of the study area. The agricultural inputs notably the quantity of chemical fertilizer and pesticides had a statistically significant elasticity on tef efficiency. Therefore increasing the quantity of chemical fertilizer has a positive effect and pesticides have a negative effect on tef efficiency. So, policymakers should focus and strengthen financial institutions to solve the money liquidity of smallholder farmers, and repeated capacity building training for developmental agents and farmers is mandatory. The federal government should also reasonably share agricultural inputs timely and the regional bureau as well. *Woreda* experts should demonstrate practically on farmer training center under close supervision, how different combinations of inputs yield a different result of technical efficiency and provide sufficient market information on agricultural inputs. Besides research institutions of the region should work in collaboration with the *woreda* agriculture and rural development office to improve the production efficiency of smallholder farmers.

Furthermore, farming experience and TLU possession improve the production efficiency of the *woreda*. So, development agents should motivate farmers to demonstrate their wisdom and provide capacity building to increase livestock productivity. However, access to credit, access to extension service, and being displaced had an adverse effect on tef efficiency. Therefore, developmental

agents should train farmers on technical issues to improve productivity instead of making themselves swamped with political activities. Similarly, the Tigray region should facilitate adequate loans and decrease the interest rate of the loan to smallholder peri-urban farmers.

Agricultural technology adoption was reported higher among non-displaced households. Therefore, Agricultural experts of the woreda should be courageous enough to give special support to displaced farmers to adopt agricultural technologies thereby increasing productivity per unit area. Additionally, the regional government should give them special attention including exempting the price of some irrigation inputs to thrive the economy of displaced households.

To this end, urban expansion had negative consequences on production efficacy, agricultural technology adoption, and poverty reduction. This needs special attention, therefore, concerned bodies should:

- Establish a legitimate separate institution from federal to *woreda* which merely follows issues related to development-induced displacement and a clear urban expansion plan should be developed that considers the real problem of the nation.
- Develop one and holistic land tenure system that addresses urban, peri-urban, and rural areas together
- The municipal of the town should act legally on land taken from peri-urban farmers, yet not used to the intended program

### **8.3 Future Research Directions**

- Impact assessment would be better if base data is available unfortunately lack of data and money forces the researcher to use cross-sectional data. Therefore, researchers who want to study in this area will be better to use longitudinal data.
- Further study should be done using a combination of poverty measurements
- The production efficiency of other major crops of the study area should be studied as this study, focuses only on tef production efficiency.

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## 8.4 Appendices

### Appendix I: Household survey questionnaire

Addis Ababa University  
College of development studies  
Center for food security studies  
Ph.D. Program in Food Security and Development

#### Household Survey Questionnaire

##### Dear Respondents,

I am a Ph.D student at Addis Ababa University, College of Development Studies, Center for Food Security Studies. This questionnaire is prepared to collect primary data for my Ph.D dissertation research entitled, **“Urban Expansion and Its Effects on Food Insecurity And Poverty: Evidence from Peri-Urban Farmers in Axum, Tigray Region, Northern Ethiopia”**. Your genuine contribution during the interview session will have paramount importance to the completion of the study with the required quality and time. Your privacy and confidential information will be kept utmost and will not pass to the third party that may hurt, discriminates, or disadvantages you.

Thank you in advance for your cooperation.

**Name of Interviewer:** \_\_\_\_\_

**Interview Date:** \_\_\_\_\_

**Household code:** \_\_\_\_\_

**Tabia:** \_\_\_\_\_

### Personal information and household characteristics

No.	Questions	Response Alternatives	Code
	What is your sex?	1 = male, 0 = female	[ ]
	What is your age in years as of the interview date?		
	Your education level completed in year's	1 = illiterate 2 = traditional/religious 3 = primary incomplete 4 = primary complete 5 = secondary incomplete 6 = secondary complete 7 = technical/vocational 8 = diploma graduate 9 = degree graduate	[ ]
	What is your religion?	1 = Tewahido orthodox 2 = Muslim 3 = other	[ ]
	What is your marital status?	1 = married 2 = single 3 = divorced 4 = widowed 5 = widower	[ ]
	Are you the head of the household?	1 = yes, 0 = no	[ ]
	What is the size of your household?	0-1 ___ 1-2 ___ 2-3 ___ 3-5 ___ 5-7 ___ 7-10 ___ 10-12 ___ 12-14 ___ 14-16, ___ 16-18 ___ 18-30 ___ 30-60 ___ >60 ___ 1. 0-14 years _____ 2. 15-64 years _____ 3. >64 years _____	
	Do you have under five years old children?	1 = yes(skip to 8a) 0 = no	[ ]
8a	Child 1      Child 2 age in years _____ Age in Years _____ height in meter _____ Height in meter _____ weight in kg _____ Weight in Kg _____		
	Employment status of Household head	1 = employed 2 = not employed 3 = pensioner	[ ]

### Household productive asset ownership

No.	Questions	Response Alternatives	Code
	Do you have farming land?	1 = yes (skip to 1a), 0 = no(skip to 1b)	[ ]

1a	What is the farm size you have in Tsimdi?		
1b	How do you obtain the land you cultivate?	1 = rent 2 = crop sharing 3 = from relatives, friends/neighbourhood 4 = others	[ ]
	Is your land is taken by the government for development works?	1= yes(skip to 2a) 0 = no	[ ]
2a	How much in Tsimdi?		
	Have you get a compensation?	1=yes (skip to 3a, 3b, 3c) 0=no	[ ]
3a	How much do you get?		
3b	For what purpose do you use it?	1 = purchasing food items 2 = purchasing agricultural inputs 3 = opening business 4 = house construction 5 = treatment 6 = ceremonies 7 = usuary 8 = animal feed 9 = two or more	[ ]
3c	Did you get any official guidance how to use the money?	1=yes 0 = no	[ ]
	Compared to the land needs of your household, how do you rate your present landholding	1= more than enough 2,= enough, 3 = too small(skip to 4a)	[ ]
4a	How do you fulfill the land requirement of Your household?	1= share cropping 2 = renting 3 = gift 4 = two or more 5=others (specify)	[ ]
	Did any member of the household migrate?	1 = yes (skip to 5a) 0 = no	[ ]
5a	What was the reason for moving?	1= shortage of land 2 = searching better work 3 = searching better life 4 = others (list)_____	
	Do you have irrigated land?	1 = Yes(skip to 6a), 2 = No	[ ]
6a	How much in Tsimdi do you irrigate?		
	What type of irrigation technology do you use?	1= pond, 2 = Dam 3 = river diversion, 4 = others	[ ]
	What type of farming system you employ?	1 = Crop 2 = Livestock 3 = Mixed	[ ]

	What are the income sources of your household?	1 = farming 2 = business 3 = temporary employment, 4 = remittance 5 = two or more 6 = others	[ ]
	How many years of experience do you have in the work you engaged?		
	Do you have or any household member get employment outside and further from your farm	1= yes (skip to 9a), 0 = no	[ ]
9a	What is the average amount of non-farm income you generate per year?		

1. Do you own livestock? 1 = Yes (skip to the next table) , 0 = No

livestock	Quantity	value	Sold (in value)	
Ox				
Cow				
Heifer				
Bull				
Calf				
Sheep				
Goat				
Donkey				
Horse				
Mule				
Camel				
Chicken				
Modern hive				
Traditional hive				
Total				

### Physical factors

No.	Questions	Response alternatives	Code
1	What is the distance to the nearest market in km?		
2	Do you get market information	1=Yes (skip to 2a) 2= No	[ ]

2a	How do you get market information	1= calling to partners in the market center 2 = via cooperative members 3 = via relatives, friends and neighbors 4 = via national or r regional radio 5 = walking to the market 6 = extension workers 7 = two or more of these 8 = others	[ ]
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### Social capital factors

No	Questions	Response alternatives	code
	Are you a member to farmer cooperative?	1=yes(skip to 1a) 0=No	[ ]
1a	What services do you get from the cooperative?	1= market information 2= low-cost credit 3= output markets 4=access to affordable input 5=access to better output market 6= storage facility 7= low-cost transport 8=two or more of these 9= all these services	
	Do you have contact with development agents?	1=yes (skip to 3a) 0 = no	[ ]
3a	How frequently do you get from DA?	1= more than one in a week 2 = once per week 3 = never in a week 4 = minimum one in a week 5 = never in a month	[ ]
	What support do you get from DA?	1= market information 2 = metrological information 3 = techniques of farming and harvesting 4 = two or more of these 5 = all of these	[ ]

### Access to Livelihood services

No.	questions	Response alternatives	Code
1	Do you get training services?	1= yes (skip to 1a, 1b, 1c) 0 = no	[ ]
1a	How many times a year?	1= once 2 = twice 3 = more than two	[ ]
1b	On what skills?	1= market skills	[ ]

		2 = business skills 3 = production skills 4 = livestock raising skills 5 = two or more of these skills 6 = all of these	
1c	Was the training helpful?	1= yes 0 = no	[ ]
2	Do you have access to extension services?	1= yes (skip to 2a, 2b) 0 = no	[ ]
2a	On what issues?	1= input use 2 = production efficiency 3 = postharvest handling 4 = market activities 5 = networking 6 = two or more of these issues 7 = all of these	[ ]
2b	Are these services helpful	1= yes 0 = no	[ ]
3	Do you get access to credit services/	1= yes (skip to 3a, 3b, 3c, 3d) 0 = no	[ ]
3a	What are the sources of credit?	1= farmer cooperatives 2 = local MFI (debit) 3 = commercial bank 4 = informal sources 5 = world bank 6=two or more of these source	[ ]
3b	For what purpose do you spend the money	1 = input purchase 2 = to purchase food 3 = celebration 4 = fattening or dairy farming 5 = to send children to school 6 = to purchase oxen for farming 7 = two or more of the above 8 = other purposes	[ ]
3c	Is the cost of credit affordable to you?	1= yes 0 = no	[ ]
3d	Was the credit helpful to you?	1= yes 0 = no	[ ]
4	Do you have access to productive inputs?	1= yes (skip to 4a, 4b, 4c) 0 = no	[ ]
4a	What type of inputs?	1= fertilizer 2 = row sawing 3 = improved seeds 4 = pest and weed control 5 = improved animal breed 6 = modern hive	[ ]

		7 = irrigation pumps 8 = two or more of these 9 = all of these	
4b	Are the inputs affordable to you?	1= yes 0 = no	[ ]
4c	Are the inputs helpful to you?	1= yes 0 = no	[ ]
5	Are you beneficiary of PSNP?	1= yes 0 = no	[ ]
5a	What source of power do you use?	1= charcoal 2 = animal dung 3 = wood 4 = kerosene/gas 5 = two or more of these 6 = all of these	[ ]
6	Do you get organizational support?	1= yes (skip to 6a, 6b) 0 = no	[ ]
6a	What type of organization	1= farmer cooperative 2 = government organization 3 = NGO 4 = private business 5 = two or more of these organizations	[ ]
6b	What type of support do you get?	1= input use 2 = production technology 3 = marketing activities 4 = business activities 5 = market and price information 6 = two or more of these	[ ]

## 2. Data to for production efficiency of tef

No.	Agricultural in puts	amount	Price per litre/kg	Total prices
1	Chemical fertilizers			
2	Herbicides/pesticides			
3	Improved seed			
4	Water pump/generator			
5	Ploughing oxen			
6	Family labour			
7	Hired labour			
8	Size of land for cereals			
9	Irrigated land			
10	Production			

### Measuring Household poverty: MPI questionnaire

Dimensions	Questions and indicators	Response alternative	Code
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Education	1a) years of schooling No household member has completed five years of schooling	1= yes (skip to 2a) 0 = no	[ ]
	2a) What is the reason?	1= no access to school 2 = lack of money for schooling 3 = do not want/ no interest 4 = to help family 5 = others	[ ]
	1b) child school attendance Is there any school-aged child who is not attending school up to class 8?	1= yes (skip to 2b) 0 = no	[ ]
	2b) What is the reason?	1= no access to school 2 = lack of money for schooling 3 = do not want/ no interest 4 = to help family 5 = others	[ ]
Health	2a) Child mortality Is there any child died in the family?	1= yes 0 = no	[ ]
	2b) Nutrition Is there any adult or child who is malnourished?	1= yes 0 = no	[ ]
	3a) Electricity The household has no electricity	1= yes 0 = no	
Living standard	3b) improved sanitation The households sanitation facility is not improved(according to MDG guidelines) or it is improved but shared with other households	1= yes 0 = no	[ ]
	3c) Improved drinking water The households does not have access to improved drinking water(according to MDG guidelines) safe drinking water is more than a 30 minute walk from home, roundtrip	1= yes 0 = no	[ ]
	3d) flooring The household has dirt, sand or dung floor	1= yes 0 = no	[ ]
	3e) cooking fuel The households cooks with dung, wood or charcoal	1= yes 0 = no	[ ]

	3f) asset ownership The household does not own more than one radio, TV, computer, telephone, bike, motorbike or refrigerator, and does not own a car or truck	1= yes 0 = no	[ ]
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Household asset	quantity	Value
Radio		
television		
bicycle, motorcycle or vehicle		
generator		
water pump		
refrigerator		
animal cart		
Car or truck		
Eucalyptus tree		
Modern beehive		
land size		
Irrigated land		
Milking HF cow		
Plowing oxen		
>25 modern breed chicken		

### Child MPI

Dimensions	Indicator	Indicator definition and thresholds	Response alternatives
Nutrition	Underweight	Deprived if children are two standard deviations below the median of the reference population	1= yes 0 = no
	Wasting	Deprived if children are two standard deviations below the median of the reference population	1= yes 0 = no
	Number of meals per day	Deprived if the child has eaten less than three times in a day	1= yes 0 = no
	Number of food items consumed per day	Deprived if the child has consumed less than three food items per day	1= yes 0 = no
	Infant and Young Child Feeding	Child age under 2 years currently never breastfeeding	1= yes 0 = no

Health	Skilled birth attendant	Deprived if the child was not born with a skilled birth attendant	1= yes 0 = no
	Measles vaccination	Deprived if the child has not taken this vaccination	1= yes 0 = no
	BCG vaccination	Deprived if the child has not taken this vaccination	1= yes 0 = no
Education	School enrolment	Deprived if the child is not enrolled in school	1= yes 0 = no
	Primary school	Deprived if older than 14-years-old but has not finished primary school	1= yes 0 = no
Information	Access to information	Deprived if the child does not have access to one of these items – radio, television, phone or a computer	1= yes 0 = no
Shelter	Overcrowding	Deprived if living with more than four household members per room	1= yes 0 = no
	Roof and floor material	Deprived if unsustainable roof and floor material such as mud and thatch	1= yes 0 = no
Water and sanitation	Access to an improved water source	Deprived if no access to protected water	1= yes 0 = no
	Access to toilet	A child has access to unimproved sanitation facilities such as pit latrine without slab/open pit, bucket or has no facility i.e. bush/field	1= yes 0 = no

### A, measuring household food security: FCS

Question: I would like to ask about all the different foods that your household members have eaten in the last 7days. Could you please tell me how many days in the past week your household has eaten the following foods? (For each food, what was the primary source of each food item eaten that week was, as well as the second main sources of food, if any)

	Food item/Group	Days eaten in the past week(0-7days )		Source of food (use Code)	
		1=not eaten, 1=1 day 2=2 days 3=3 days	4=4 days 5=5 days 6=6 days 7= 7 days	Primary	Secondary
a	Enjera				
b	Sorghum				

c	Other cereals				
d	Groundnuts, legumes				
e	Meat/chicken				
f	Cooking oil				
g	Vegetables				
h	fruits				
i	Milk, yogurt, cheese, etc.				
j	Eggs				
k	Sugar				
l	Wild foods(including leaves)				
m	Miscellaneous(tea, soft drinks, bread, biscuits, fast foods)				
Food source codes Purchase =1, Own production = 2, purchased, barter =3 , Borrowed =4, received as gift = 5, food aid = 6 others (specify					

### **B, Household Dietary Diversity Score (HDDS)**

Now I would like to ask you about the types of foods that you or anyone else in your household ate yesterday during the day and at night. Read the list of foods and place a one in the box if anyone in the household ate the food in the last 24 hours, place a zero in the box if no one in the household ate the food in the last 24 hours.

No.	Questions	Coding
a	Any foods made from Tef, Sorghum, Maize, Rice, Wheat, millet and Barley?	
b	Any potatoes, carrot, or any other foods made from roots or tubers?	
c	Any vegetables?	
d	Any fruits?	
e	Any beef, pork, lamb, goat, chicken, liver, kidney, heart, or other organ meats?	
f	Any eggs?	
g	Any fresh or dried fish or shellfish?	
h	Any foods made from beans, peas, lentils, or nuts?	
i	Any cheese, yogurt, milk or other milk products?	
j	Any foods made with oil, fat, or butter?	
k	Any sugar or honey?	
l	Any other foods, such as condiments, coffee, tea?	

### C, Household Food Balance Model (HFBM)

Types of cereals and livestock products	Total produced	Total bought	Food aid	Food for work	Reserved grain	Used for feast	Post-harvest loss	Given to others	Obtained from others	sold
Taff										
wheat										
Sorghum										
Barley										
Hanfets										
Maize										
Finger millet										
Beans										
Peas										
lentils										
Flux										
Sebere										
Nihug										
potatoes										
cabbage										
salad										
tomato										
zeythun										
milk										
butter										
meat										
Chicken meat										
honey										

#### D, Household Food Insecurity Access Model (HFIAS)

No.	questions	Responses	code
	In the past four weeks, did you worry that your household would not have enough food?	1=yes 0=no(skip to Q2)	1
1a	How often did this happen	1 = Rarely (once or twice in the past four weeks) 2 = Sometimes (three to ten times in the past four weeks) 3 = Often (more than ten times in the past four weeks)	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=yes 0=no(skip to Q3)	1
2a	How often did this happen	1 = Rarely (once or twice in the past four weeks) 2 = Sometimes (three to ten times in the past four weeks) 3 = Often (more than ten times in the past four weeks)	2
	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= yes 0 = no(skip to Q4)	1
3a	How often did this happen	1 = Rarely (once or twice in the past four weeks) 2 = Sometimes (three to ten times in the past four weeks) 3 = Often (more than ten times in the past four weeks)	2
	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= yes 0 = no(skip to Q5)	1
4a	How often did this happen	1 = Rarely (once or twice in the past four weeks) 2 = Sometimes (three to ten times in the past four weeks) 3 = Often (more than ten times in the past four weeks)	2
	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= yes 0 = no(skip to Q6)	1
5a	How often did this happen	1 = Rarely (once or twice in the past four weeks) 2 = Sometimes (three to ten times in the past four weeks) 3 = Often (more than ten times in the past four weeks)	2

	In the past four weeks, did you or any household member have to eat fewer meals in a day because there was not enough food?	1= yes 0 = no(skip to Q7)	1
6a	How often did this happen	1 = Rarely (once or twice in the past four weeks) 2 = Sometimes (three to ten times in the past four weeks) 3 = Often (more than ten times in the past four weeks)	2
	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= yes 0 = no(skip to Q8)	1
7a	How often did this happen	1 = Rarely (once or twice in the past four weeks) 2 = Sometimes (three to ten times in the past four weeks) 3 = Often (more than ten times in the past four weeks)	2
	In the past four weeks, did you or any household member go to sleep at night hungry because there was not enough food?	1= yes 0 = no(skip to Q9)	1
8a	How often did this happen	1 = Rarely (once or twice in the past four weeks) 2 = Sometimes (three to ten times in the past four weeks) 3 = Often (more than ten times in the past four weeks)	2
	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= yes 0 = no	1
9a	How often did this happen	1 = Rarely (once or twice in the past four weeks) 2 = Sometimes (three to ten times in the past four weeks) 3 = Often (more than ten times in the past four weeks)	2

### Leading questions

1. How do you perceive the urban expansion trend in your *tabia*? Do you think that it is important or not? Why?
2. Which farmers (displaced or not displaced) are actively participate in buying agricultural inputs? Why?
3. What benefits do you get from urban expansion in your *tabia*?
4. How urban expansion does affects your poverty and food security status?
5. How do you see the rate of compensation provided?

6. Which farmers (displaced or not displaced) highly exposed to poverty and food insecurity?  
Why?

### **Key informant interview**

**Dear interviewee,**

I am a Ph.D student at Addis Ababa University, College of Development Studies Center for Food Security Studies. This interview is designed to collect primary data for my Ph.D dissertation research entitled, “**Urban Expansion and Its Effects on Food Insecurity And Poverty: Evidence from Peri-Urban Farmers in Axum, Tigray Region, Northern Ethiopia**”. Your genuine contribution during the interview session will have paramount importance to the completion of the study with the required quality and time. Your privacy and confidential information will be kept utmost and will not pass to the third party that may hurt, discriminates, or disadvantages you.

Thank you in advance for your cooperation.

Shishay Kahsay Weldearegay

### **Leading questions**

#### **A. Personal information**

- Gender
- Age
- educational background and level
- Responsibility
- years of service in the area

#### **B) Urban expansion, technology adoption, poverty, and food security**

1. How do you evaluate urban expansion pattern in the Tabia? Do farmers happy in the expansion of urban in the *woreda*?
2. Which farmers are actively participate in technology adoption? Which type of agricultural technologies?
3. What are the factors hindering farmers to adopt agricultural technologies?
4. How do you link urban expansion with poverty in the Tabia?
5. How do you link urban expansion with food security in the Tabia?

Appendix II: Characteristics of respondents

Variable		Household status			
		Non-displaced		Displaced	
		Frequency	Percentage	Frequency	Percentage
Sex	Female	68	28.3	28	27.7
	Male	172	71.7	73	72.3
	Total	240	100	101	100
Marital status	Married	182	75.6	55	54.5
	Divorced	11	4.6	9	8.9
	Widowed	47	19.6	37	36.6
	Total	240	100	101	100
Children	yes	92	38.3	14	13.9
	No	148	61.7	87	86.1
	Total	240	100	101	100
Governmental employment	employed	12	5	9	8.9
	Not-employed	228	95	92	91.1
	Total	240	100	101	100
Compensation	Yes	240	100	99	98
	No	0	0	2	2
	Total	240	240	101	100
Compensation used for	Purchasing food	-	-	11	11.1
	Purchasing agricultural inputs	-	-	2	2
	Opening business	-	-	1	1
	House construction	-	-	16	16.2
	Usuary	-	-	1	1
	Purchasing animal feed	-	-	1	1
	Two or more	-	-	67	67.7
	Total	-	-	99	100
Migration	Yes	27	11.3	22	21.8
	No	213	88.7	79	78.2
	Total	240	100	101	100
Reason for moving	Shortage of land	6	22.2	14	63.5
	Searching better work	10	37.1	5	22.7
	Searching better life	11	40.7	3	13.6
	Total	27	100	22	100
Irrigated land	Yes	66	27.5	20	19.8
	No	174	72.5	81	80.2
	Total	240	100	101	100
Income sources	Farming	125	52.1	70	69.3
	Petty trading	1	0.4	3	3
	Two or more	114	47.5	28	27.7
	Total	240	100	101	100
	Yes	27	11.2	7	6.9

Access to credit	No	213	88.8	94	93.1
	Total	240	100	101	100
Access to extension service	Yes	52	21.7	25	24.8
	No	188	78.3	76	75.2
	Total	240	100	101	100
Access to productive inputs	Yes	237	98.7	95	94.1
	No	3	1.3	6	5.9
	Total	240	100	101	100
Access to PSNP	Yes	29	12.1	7	6.9
	No	211	87.9	94	93.1
	Total	240	100	101	100

Source: Computed from own survey data (2019)

### Appendix III: Characteristics of respondents

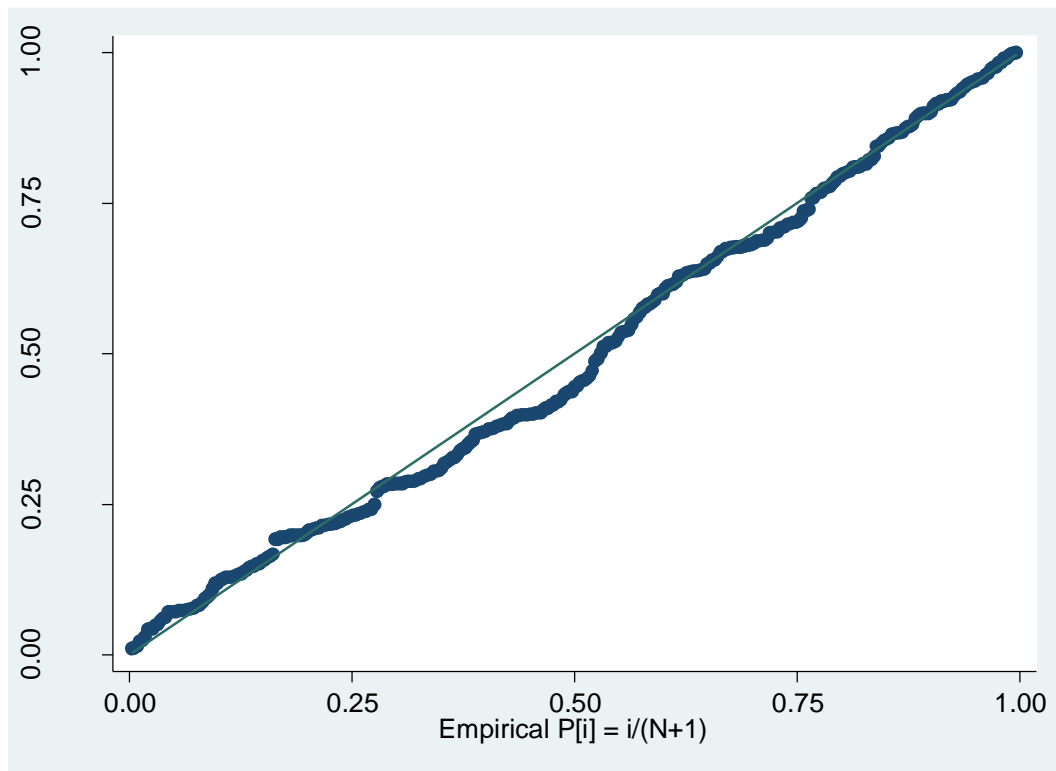
Variable	HH status	Mean	Std.Dev
Age of household head	Not-displaced	50.0	12.9
	Displaced	60.9	13.3
Educational status of household head	Not-displaced	3.0	3.6
	Displaced	1.6	2.7
Family size	Not-displaced	5.0	2.2
	Displaced	6.0	2.4
Farmland size	Not-displaced	0.67	0.28
	Displaced	0.59	0.33
Non-farm income	Not-displaced	5429.0	4450.0
	Displaced	8512.0	3839.0
Tropical livestock unit(TLU)	Not-displaced	2.0	1.5
	Displaced	3.0	2.0
Market distance	Not-displaced	5.0	1.5
	Displaced	1.7	0.65

Source: Computed from own survey data (2019)

Appendix IV: Table of Accuracy Assessment for the 2020 Lu/Lc Classification in Axum town

		Land use/Land cover (Field Observed)						User Accuracy	
		Plantation	Grassland	Bareland	Cropland	Rural Settlement	Built-up Area		
		No.	No.	No.	No.	No.	No.		
Land use/Land cover (office interpreted)	Plantation	8	1	0	0	0	0	9	88.9
	Grassland	1	12	1	0	0	0	14	85.7
	Bareland	0	1	10	1	0	1	13	76.9
	Cropland	0	1	1	18	0	0	20	90.0
	Rural Settlement	0	0	1	0	15	1	17	88.2
	Built-up Area	0	0	1	0	2	16	19	10.5
	Producer Accuracy	9	15	14	19	17	18	92	85.9

Appendix V: Normal probability plot of residuals for HFBM



source: Computed from own survey data (2019)

Appendix VI: calorie composition estimation

type of cereals	calorie
Barley white hordeum Vulgare L.flour Enjera( Gebes nech Injera	125.8
Barley white hordeum Vulgare L.flour bread( Gebes nech dabboo	202.4
Barley white hordeum Vulgare L.flour porridge( Gebes nech genfo	134.7
Barley white hordeum Vulgare L.whole grain ( Gebes nech yaltefetege	372.3
Barley white hordeum Vulgare L.whole roasted ( Gebes nech yaltefetege qolo	355.8
	1191
	238.2
corn(maize) Zea mays L. white enjera (Beqqello nech injera)	153
corn(maize) Zea mays L. white bread(Beqqello nech dabboo)	223.4
corn(maize) Zea mays L. white porridge (Beqqello nech genfo)	154.7
corn(maize) Zea mays L. white boiled (Beqqello nech nifro)	88.1
corn(maize) Zea mays L. white whole roasted (Beqqello nech yaltefetege qollo)	387.2
corn(maize) Zea mays L. white whole boiled (Beqqello nech yaltefetege nifro)	170.1
corn(maize) Zea mays L. white on cob boiled (Beqqello nech iset yateqelegele)	152
corn(maize) Zea mays L. white on cob roasted (Beqqello nech iset yetetebese)	276.5
	1605
	200.6
millet eleusine coracona L. black enjera (dagusa tiqur injera)	156.1
millet eleusine coracona L. black bread (dagusa tiqur dabboo)	216.5
millet eleusine coracona L. black mixed enjera (dagusa diblliq injera)	174.2
millet eleusine coracona L. black mixed bread (dagusa diblliq dabboo)	222.6
millet eleusine coracona L. black mixed porridge (dagusa diblliq genfo)	154.7
	924.1
	184.8
Sorghum. Sorghum Spp. Red enjera(zengada injera)	136.1
Sorghum. Sorghum Spp. Red bread(zengada dabboo)	224.7
Sorghum. Sorghum Spp. Red whole boiled (zengada yaltefetege nifro)	143.1
Sorghum. Sorghum Spp. Red whole roasted (zengada yaltefetege qolo)	407.6
Sorghum. Sorghum Spp. White bread (mashylla nech dabboo)	203.7
Sorghum. Sorghum Spp. White porridge(mashylla nech genfo)	135.4
Sorghum. Sorghum Spp. White whole grain, boiled(mashylla nech yaltefetege nifro)	124.5
Sorghum. Sorghum Spp. White whole grain, roasted(mashylla nech yaltefetege qolo)	402.4
Sorghum. Sorghum Spp. mixed enjera(mashylla dibliq injera)	168.1
Sorghum. Sorghum Spp. mixed bread(mashylla dibliq dabboo)	234.4
Sorghum. Sorghum Spp. mixed whole boiled (mashylla dibliq nifro)	179.7
	2359.7
	214.6
Tef, Eragrostis tef, (Zucc.) trott;, red enjera (Tef qeyy injera)	155.9

Tef, Eragrostis tef, (Zucc.) trott;, red bread (Tef qeyy dabboo)	220
Tef, Eragrostis tef, (Zucc.) trott;, red porridge (Tef qeyy genfo)	165.4
Tef, Eragrostis tef, (Zucc.) trott;, white enjera (Tef nech injera)	145
Tef, Eragrostis tef, (Zucc.) trott;, mixed enjera (Tef dibliq injera)	150.2
Tef, Eragrostis tef, (Zucc.) trott;, mixed bread (Tef dibliq dabboo)	218.8
Tef, Eragrostis tef, (Zucc.) trott;, mixed porridge(Tef dibliq genfo)	173.4
	1228.7
	175.5
Wheat. Triticum vulgare VIII.:, white enjera ( Sindye nech injerat)	145.6
Wheat. Triticum vulgare VIII.:, white bread ( Sindye nech dabboo)	222
Wheat. Triticum vulgare VIII.:, white porridge ( Sindye nech genfo)	142.7
Wheat. Triticum vulgare VIII.:, white split boiled ( Sindye nech kikk nifro)	65.1
Wheat. Triticum vulgare VIII.:, white whole boiled ( Sindye nech yaltefetege nifro)	211.3
Wheat. Triticum vulgare VIII.:, white whole roasted ( Sindye nech yaltefetege qolo)	391.6
Wheat. Triticum vulgare VIII.:, mixed enjera ( Sindye dibiliq injera)	157.4
Wheat. Triticum vulgare VIII.:, mixed bread ( Sindye dibiliq dabboo)	199.3
Wheat. Triticum vulgare VIII.:, mixed porridge ( Sindye dibiliq genfo)	150.6
Wheat. Triticum vulgare VIII.:, mixed split boiled ( Sindye dibiliq kikk nifro)	70
Wheat. Triticum vulgare VIII.:, mixed whole grain ( Sindye dibiliq yaltefetege nifro)	184.9
Wheat. Triticum vulgare VIII.:, mixed whole roasted( Sindye dibiliq yaltefetege qolo)	394.2
	2334.7
	194.6
Broad beans, Vicia faba L.:, sauce without chili (baqyela wet aiyichi'a)	96.9
Broad beans, Vicia faba L.:, split sauce without chili (baqyela kikk wet alyichi'a)	143.8
Broad beans, Vicia faba L.:, whole fresh boiled (baqyela ishet nifro)	133.7
Broad beans, Vicia faba L.:, whole fresh row (baqyela ishet )	152.6
Broad beans, Vicia faba L.:, whole dried boiled (baqyela di fin dereq nifro)	149.5
Broad beans, Vicia faba L.:, whole dried roasted/boiled (baqyela difin dereq teqelto yeteqecele)	275.9
Broad beans, Vicia faba L.:, germinated boiloed (baqyela beqolt nifro )	137.8
Broad beans, Vicia faba L.:, germinated roasted (baqyela beqolt qolo )	246.6
Broad beans, Vicia faba L.:, germinated row (baqyela beqolt yalteqeqele )	177.5
	1514.3
	168.3
chickpeas, cicer arietinum L.:, sauce without chili (shimbra wet Aliyichi'a)	123.3
chickpeas, cicer arietinum L.:, split sauce without chili (shimbra kikk wet allyichi'a)	142.3
chickpeas, cicer arietinum L.:, whole fresh row (shimbra ishet yalteqeqele)	91.4
chickpeas, cicer arietinum L.:, whole dried boiled (shimbra difin dereq nifro)	180.9
chickpeas, cicer arietinum L.:, dried, roasted, boiled (shimbra dereq teqelto yeteqecele)	289.2
chickpeas, cicer arietinum L.:, germinated, boiled (shimbra beqolt nifro)	184.5
chickpeas, cicer arietinum L.:, germinated, roasted (shimbra beqolt qolo)	301.7
chickpeas, cicer arietinum L.:, germinated, row (shimbra beqolt yalteqeqele)	210

	1523.3
	190.4
Peas, field pisum Sativum L. sauce without chili ( Ater wet allyichi'a)	100.6
Peas, field pisum Sativum L. split sauce without chili ( Ater kikk wet allyichi'a)	162
Peas, field pisum Sativum L. whole fresh row ( Ater difin ishet yalteqecele)	139.5
Peas, field pisum Sativum L. whole dried boiled ( Ater difin nifro)	157.8
Peas, field pisum Sativum L. whole roasted boiled ( Ater difin teqelto yeteqecele)	271.3
Peas, field pisum Sativum L. germinated boiled ( Ater beqolt nifro)	166.7
Peas, field pisum Sativum L. germinated roasted ( Ater beqolt qolo)	245
Peas, field pisum Sativum L. germinated row ( Ater beqolt yalteqecele)	175.9
	1418.8
	177.4
Vetch, Lathyrus Sativus L.sauce without chili( Gwayya wet Allyichi'a)	124.1
Vetch, Lathyrus Sativus L.boiled( Gwayya nifro)	177.7
	301.8
	150.9
beef, boiled (yebere siga qiqil)	177.4
beef, grilled (yebere siga tibis)	212.3
Chicken whole boiled ( doro mulu qiqqil)	148.1
meat goat boiled(Yefiyel siga qiqil)	200
meat goat grilled(Yefiyel siga tibis)	176.8
mutton boiled ( yebeg siga qiqqil)	152.9
mutton grilled ( yebeg siga tibis)	194.4
egg whole boiled (inqulal difin qiqqil)	152.9
	1414.8
	176.9
Buttermilk cow (yelam wetet aryera)	38.6
cottage cheese cow ( yelam wetet ayib)	132.4
	171
	85.5
honey (mar)	360.5

#### Appendix VII: HFIAS Classification

	Location	Occurrence		Frequency		
		Yes	No	Rarely (1)	Sometimes (2)	Often (3)
1. In the past four weeks, did you worry that your household would not have enough food?	Non-displaced	64	175	45	19	0
	displaced	44	57	18	23	3
2. In the past four weeks, were you or any household member not able to eat the kinds of foods	Non-displaced	58	182	52	5	0
	displaced	32	69	28	3	2

you preferred because of a lack of resources?						
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?	Non-displaced displaced	111 47	129 54	73 27	37 17	1 3
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?	Non-displaced displaced	34 30	206 71	33 25	1 4	0 1
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?	Non-displaced displaced	25 16	214 85	23 18	2 3	0 0
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?	Non-displaced displaced	9 11	231 90	8 9	1 2	0 0
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?	Non-displaced displaced	- -	240 101	- -	- -	- -
8. In the past four weeks, did you or any household member go to sleep at night hungry because there was not enough food?	Non-displaced displaced	- -	240 101	- -	- -	- -
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?	Non-displaced displaced	- -	240 101	- -	- -	- -

Computed from own survey data (2019)

#### Appendix VIII: Multicollinearity test

Variable	VIF	1/VIF
Treatment	2.71	0.368592
MarketDis	2.36	0.422978
Farmingyear	2.11	0.473834
Fsize	2.06	0.484602
TLU	1.76	0.567520
lsize	1.74	0.575248
EDHH	1.46	0.683522
SexHH	1.45	0.690330
AccessEx	1.27	0.790174
Nfarmincome	1.19	0.841328
Irrsize	1.16	0.858663
AccessCrdt	1.06	0.939727
Remittance	1.05	0.952034
Mean VIF	1.65	

## Appendix IX: Binary regression result of HFBM

```

Logistic regression                Number of obs   =       341
                                   Wald chi2(13)    =      102.82
                                   Prob > chi2       =       0.0000
Log pseudolikelihood = -83.454718  Pseudo R2      =       0.6171

```

ADEQU	Robust				
	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]
Treatment	-.7780576	.6885965	-1.13	0.259	-2.127682 .5715668
SexHH	.8359252	.4764949	1.75	0.079	-.0979876 1.769838
EDHH	.0221262	.075785	0.29	0.770	-.1264097 .170662
Fsize	-2.166077	.2362377	-9.17	0.000	-2.629094 -1.703059
lsize	1.032083	.9510517	1.09	0.278	-.8319436 2.89611
Irrsize	-1.964236	3.488419	-0.56	0.573	-8.801411 4.872939
Remittance	.0000209	.0000226	0.93	0.354	-.0000234 .0000652
Farmingyear	.0262119	.0201074	1.30	0.192	-.013198 .0656217
Nfarmincome	.0001026	.0000501	2.05	0.041	4.31e-06 .0002008
TLU	.4741813	.1876606	2.53	0.012	.1063733 .8419894
MarketDis	.2044529	.14364	1.42	0.155	-.0770764 .4859822
AccessEx	.0443142	.6039597	0.07	0.942	-1.139425 1.228053
AccessCrdt	.5296089	.9397451	0.56	0.573	-1.312258 2.371475
_cons	4.996987	1.206961	4.14	0.000	2.631388 7.362587

## Appendix X: Ordered regression result of HFIAS

Ordered logistic regression                      Number of obs     =        341  
    Wald chi2(13)     =        84.13  
    Prob > chi2        =        0.0000  
 Log pseudolikelihood = -311.13026              Pseudo R2         =        0.1222

HFIAScategories	Robust					
	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]	
Treatment	-.0639031	.4418528	-0.14	0.885	-.9299187	.8021125
SexHH	-2.140049	.3175531	-6.74	0.000	-2.762442	-1.517656
EDHH	.0568385	.0390688	1.45	0.146	-.019735	.133412
Fsize	.4518091	.0808253	5.59	0.000	.2933945	.6102237
lsize	-1.40053	.5198157	-2.69	0.007	-2.41935	-.3817101
Irrsize	-.8745347	1.118581	-0.78	0.434	-3.066914	1.317845
Remittance	.0000353	.000012	2.95	0.003	.0000118	.0000587
Farmingyear	.0165537	.0128504	1.29	0.198	-.0086326	.04174
Nfarmincome	-.0000118	.000029	-0.41	0.684	-.0000687	.0000451
TLU	-.1470933	.0824609	-1.78	0.074	-.3087137	.014527
MarketDis	-.0066694	.0875562	-0.08	0.939	-.1782764	.1649377
AccessEx	.0689703	.3036506	0.23	0.820	-.526174	.6641146
AccessCrdt	-.4953934	.3354843	-1.48	0.140	-1.152931	.1621438
/cut1	.0296962	.7610805			-1.461994	1.521387
/cut2	1.63539	.7793897			.1078146	3.162966

## Appendix XI: Ordered regression result of FCS

Ordered logistic regression                      Number of obs     =        341  
    Wald chi2(13)     =        36.85  
    Prob > chi2        =        0.0004  
 Log pseudolikelihood = -226.68051              Pseudo R2         =        0.1116

FCG2	Robust					
	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]	
Treatment	-.3682627	.4351792	-0.85	0.397	-1.221198	.4846728
SexHH	.7927967	.3323558	2.39	0.017	.1413913	1.444202
EDHH	-.0159189	.0441134	-0.36	0.718	-.1023796	.0705418
Fsize	-.0369773	.0736879	-0.50	0.616	-.1814029	.1074483
lsize	-.0759634	.5566096	-0.14	0.891	-1.166898	1.014971
Irrsize	3.837322	1.570141	2.44	0.015	.7599022	6.914741
Remittance	.0000269	.0000232	1.16	0.245	-.0000185	.0000723
Farmingyear	.0343574	.0128065	2.68	0.007	.009257	.0594577
Nfarmincome	.0000912	.0000313	2.91	0.004	.0000298	.0001527
TLU	.1956748	.0902893	2.17	0.030	.0187111	.3726385
MarketDis	-.1207859	.0921713	-1.31	0.190	-.3014384	.0598666
AccessEx	.1831562	.3176982	0.58	0.564	-.4395208	.8058331
AccessCrdt	-.2707021	.3734216	-0.72	0.468	-1.002595	.4611907
/cut1	-3.100268	.967717			-4.996959	-1.203578
/cut2	1.809061	.7638899			.3118647	3.306258

## Appendix XII: Ordered regression result of HDDS

Ordered logistic regression                      Number of obs        =        341  
    Wald chi2(13)        =        41.38  
    Prob > chi2         =        0.0001  
 Log pseudolikelihood = -299.18943               Pseudo R2            =        0.0613

HDDScategories	Robust		z	P> z	[95% Conf. Interval]	
	Coef.	Std. Err.				
Treatment	-.1797518	.4225277	-0.43	0.671	-1.007891	.6483872
SexHH	.2412902	.2983396	0.81	0.419	-.3434448	.8260252
EDHH	.0833849	.040116	2.08	0.038	.004759	.1620109
Fsize	.0219864	.0725118	0.30	0.762	-.1201341	.164107
lsize	-.2168217	.5034636	-0.43	0.667	-1.203592	.7699488
Irrsize	3.257641	1.301839	2.50	0.012	.7060835	5.809199
Remittance	7.81e-06	.000013	0.60	0.549	-.0000177	.0000334
Farmingyear	.0313527	.0112103	2.80	0.005	.009381	.0533244
Nfarmincome	.0000201	.000024	0.84	0.403	-.000027	.0000671
TLU	.2153637	.0763356	2.82	0.005	.0657487	.3649786
MarketDis	.0035371	.0875044	0.04	0.968	-.1679683	.1750426
AccessEx	-.0719267	.2945264	-0.24	0.807	-.6491878	.5053343
AccessCrdt	-.4901232	.3852793	-1.27	0.203	-1.245257	.2650104
/cut1	-.2364633	.5599043			-1.333856	.860929
/cut2	2.817915	.5820503			1.677118	3.958713

## Appendix XII: Translog elasticity result of TE

Stoc. frontier normal/exponential model                      Number of obs        =        341  
    Wald chi2(27)        =        19289.29  
    Prob > chi2         =        0.0000

Log likelihood = -17.5517

lnTeffoutput	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]	
<b>Frontier</b>						
lnchemicalfertilizer	.6671259	.2969816	2.25	0.025	.0850526	1.249199
lnTeffseed	1.029571	.7478947	1.38	0.169	-.4362759	2.495417
lnquaherbicides	-.1289668	.0997584	-1.29	0.196	-.3244897	.0665561
lnnumberplow	-.5433043	.6338549	-0.86	0.391	-1.785637	.6990285
lnlandsizeha	.317946	.4334297	0.73	0.463	-.5315606	1.167453
lnTLabor	-.2877723	.6134288	-0.47	0.639	-1.490071	.914526
squareferti	-.0007326	.0113948	-0.06	0.949	-.023066	.0216008
squareseed	-.4178498	.2799436	-1.49	0.136	-.9665293	.1308296
squareherbi	-.0982589	.0430122	-2.28	0.022	-.1825614	-.0139565
squarplow	-.01281	.0109642	-1.17	0.243	-.0342994	.0086794
squarsize	.097451	.3011158	0.32	0.746	-.4927252	.6876272
squarlabor	-.1609161	.123341	-1.30	0.192	-.4026599	.0808278
lncheicalfertilizerTeffseed	-.1427066	.0488276	-2.92	0.003	-.238407	-.0470061
lncheicalfertilizerherbicide	.0228348	.011263	2.03	0.043	.0007598	.0449099
lncheicalfertilizerplow	-.113318	.0833691	-1.36	0.174	-.2767183	.0500824
lncheicalfertilizerlandsize	.0953048	.0581198	1.64	0.101	-.0186079	.2092176
lncheicalfertilizerLabor	.0171575	.0228934	0.75	0.454	-.0277128	.0620277
lnTeffseedherbicide	.0388009	.0223378	1.74	0.082	-.0049805	.0825822
lnTeffseedplow	.1530023	.2050053	0.75	0.455	-.2488008	.5548053
lnTeffseedlandsize	.0967468	.183204	0.53	0.597	-.2623265	.45582
lnTeffseedLabor	.1594586	.198588	0.80	0.422	-.2297667	.5486839
lnquaherbicidesplow	-.0339443	.0186882	-1.82	0.069	-.0705726	.002684
lnquaherbicideslandsize	-.0300897	.0227836	-1.32	0.187	-.0747447	.0145653
lnquaherbicidesLabor	-.0135225	.0122536	-1.10	0.270	-.037539	.0104941
lnnumberplowlandsize	-.1067926	.1826384	-0.58	0.559	-.4647573	.2511722
lnnumberplowLabor	.2293258	.1187551	1.93	0.053	-.0034298	.4620814
lnlandsizehaLabor	-.0735174	.1678902	-0.44	0.661	-.4025761	.2555412
_cons	4.474455	1.424696	3.14	0.002	1.682102	7.266808
<b>Usigma</b>						
_cons	-2.654091	.1719806	-15.43	0.000	-2.991167	-2.317015
<b>Vsigma</b>						
_cons	-4.190452	.2381775	-17.59	0.000	-4.657272	-3.723633
sigma_u	.2652598	.0228098	11.63	0.000	.2241178	.3139544
sigma_v	.1230424	.014653	8.40	0.000	.0974286	.1553901
lambda	2.155841	.0332982	64.74	0.000	2.090577	2.221104

### Appendix XIII: Translog elasticity result of TE

Stoc. frontier normal/exponential model

Number of obs = 341  
 Wald chi2(20) = 35733.85  
 Prob > chi2 = 0.0000

Log likelihood = -53.3077

lnTeffprice	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]	
<b>Frontier</b>						
lnTotpriceFertilizer	.5480382	.4188344	1.31	0.191	-.2728622	1.368939
lnTpriceHerbiprice	-.0053886	.0781752	-0.07	0.945	-.1586093	.1478321
lnTeffseedprice	.9390665	.4077581	2.30	0.021	.1398753	1.738258
lnplowingPrice	-.3659637	.6381746	-0.57	0.566	-1.616763	.8848355
lnlaborwage	.0785842	.874423	0.09	0.928	-1.635253	1.792422
squaaferti	.0154755	.0106801	1.45	0.147	-.0054571	.0364081
squalaborwage	.1121314	.1146113	0.98	0.328	-.1125027	.3367656
squaplow	.1654714	.21846	0.76	0.449	-.2627023	.5936452
squa herb	-.0104181	.0047154	-2.21	0.027	-.01966	-.0011761
squatseed	.0022192	.1956321	0.01	0.991	-.3812127	.385651
lnlaborwageFertilizer	.0303984	.0172993	1.76	0.079	-.0035076	.0643044
lnlaborwageFHerbi	-.0069555	.0073963	-0.94	0.347	-.0214521	.007541
lnlaborwageTeffseed	-.0606604	.1161276	-0.52	0.601	-.2882663	.1669456
lnlaborwageplow	-.0743867	.1456672	-0.51	0.610	-.3598891	.2111157
lnTotpriceFertilizerHerbi	.0034277	.007188	0.48	0.633	-.0106605	.0175159
lnTotpriceFertilizerTeffseed	-.0572628	.0270778	-2.11	0.034	-.1103343	-.0041912
lnTotpriceFertilizerplow	-.0560216	.0472424	-1.19	0.236	-.1486149	.0365717
lnTpriceHerbipriceTeffseed	.0066606	.0087263	0.76	0.449	-.0104972	.0237093
lnTpriceHerbipriceplow	-.0039532	.0111958	-0.35	0.724	-.0258966	.0179902
lnTeffseedpricePlow	.0498791	.1083802	0.46	0.645	-.1625422	.2623003
_cons	2.860399	1.613288	1.77	0.076	-.3015874	6.022385
<b>Usigma</b>						
_cons	-2.700031	.1940166	-13.92	0.000	-3.080297	-2.319766
<b>Vsigma</b>						
_cons	-3.582819	.1970087	-18.19	0.000	-3.968949	-3.196689
sigma_u	.2592362	.0251481	10.31	0.000	.2143493	.3135229
sigma_v	.166725	.0164231	10.15	0.000	.1374529	.2022311
lambda	1.554873	.0371293	41.88	0.000	1.4821	1.627645

