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AGRICULTURAL DROUGHT AND FOOD SECURITY STATUS: THE CASE OF MISRAK BELESA WOREDA, AMHARA REGION, ETHIOPIA

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A THESIS SUBMITTED TO CENTRE FOR FOOD SECURITY STUDIES, COLLEGE OF DEVELOPMENT STUDIES, ADDIS ABABA UNIVERSITY PRESENTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN FOOD SECURITY AND DEVELOPMENT STUDIES.

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Abstract

Agricultural drought reduces soil moisture content and limits crop water availability and impacts agricultural food production, food security and socioeconomic development. The main objectives of this study were to investigate agricultural drought and its effects on household food security, examine perception of households and asses current status of food security and its determinants in Misrak Belesa woreda. Quantitative research approach and cross-sectional study design were used to generate data. Agricultural drought quantification using meteorological data and Standardized Precipitation Index at one- and three-month time scales were computed using Standardized Precipitation Index Generator software. Household Food Balance sheet model was used to investigate food security status. A total of 402 households were surveyed to generate data. Binary logistic regression model was used to examine the relationship between food security status and its determinants. The study found wide spread prevalence (89%) of food insecurity among study households. The result of the binary logistic regression model indicated that seven of the independent variables including credit amount, number of donkeys, number of oxen, agronomic practices, soil conservation practices, farm size, and age of household heads had positive coefficients (B>0) indicating a positive correlation and family size had a negative coefficient (B<0) indicating a negative correlation with food security status. Monthly agricultural drought event for rainy months was observed in 40 months from 1981 to 2018. Seasonal agricultural drought for Belg and Kiremt seasons was observed for 20 and 16 years respectively from 1981 to 2018. Overall, the study found that recurrent agricultural drought is the most prevalent natural hazard that made households vulnerable. Key policy recommendation that need to be addressed by all actors and policy makers is forwarded.

Keywords: *agricultural drought, food security, perception, Misrak Belesa, Ethiopia*

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List of Acronyms

AGRA	Alliance for a green revolution in Africa
COVID-19	Corona virus diseases strain 19
CSA	Central Statistical Agency
FAD	Food Availability Decline
GDP	Gross Domestic Product
HIV/AIDS	Human Immunodeficiency Virus/Acquired Immune Deficiency Disease
IFAD	International Foundation for Agricultural Development
IGAD	Inter Governmental Authority on Development
IIRR	International Institute of Rural Reconstruction
IPCC	Inter Governmental Panel on Climate Change
NOAA	National Oceanic and Atmospheric Administration
MoA	Ministry of Agriculture
SSA	Sub Saharan Africa
SPI	Standardized Precipitation Index
UNDP	United Nation Development Project
WFP	World Food Program
SSA	Sub Saharan Africa

CHAPTER ONE

1. Introduction

1.1. Background

In Ethiopia, among all other sectors, the agriculture sector remains the leading sector in terms of contribution to the country's overall economy. It is a major source of food for domestic consumption, of raw materials for the domestic manufacturing industries and of primary commodities for export. In 2019/20, the share of agriculture in GDP was 32.7 percent. The contribution of agriculture to GDP growth was 22.9 percent of which crop production accounted for 65 percent, followed by animal farming & hunting (25.9 percent) and forestry (8.8 percent).

Total grain production reached 335.2 million quintals, of which cereal production accounted for 88.5 percent, while pulses and oil seeds comprised 11.5 percent. Cereals and oilseeds production increased by 6.9 and 7.3 percent over the preceding year owing to 1.2 and 9.8 percent expansion in cultivated land area respectively (NBE, 2020). The Employment in agriculture (% of total employment) (modeled ILO estimate) in Ethiopia was reported at 65.62 % in 2020 (World Bank, 2020).

Even though the Ethiopian crop and Livestock sector are key part for the livelihoods of rural poor and is playing a significant role in the national economy, at a household level its sectoral growth and contribution to the national economy is minimal compared to its potential because of various bottlenecks drought being one of the constraints.

Majority of the farmers depend on rainfall for farming. Erratic rainfall distribution has adversely affected Ethiopian agricultural production, in general and the sustainability of household food security in particular (Mesay, 2011).

Between the 9th century and the Great Ethiopian Famine of 1888-1892, thirteen agricultural drought years were recorded. Between the Great Famine and the 1970s there have been many national and localized droughts and at least 20 major agricultural drought years were noted affecting most parts of the country (IIRR and Save the Children USA 2007).The increasing trend of agriculture drought-induced disaster, associated with other hazards, is reflected in the increasing number of people needing food assistance in Ethiopia. Between 1990 and 2005, on average each year 6.3 million people required food assistance amounting to over 654,000 tones. The drought period from 1995-1997 led to a 78% decrease in cattle herd size and a 45% decrease in camel herd size in farming households in the Somali and Borana areas of Ethiopia along the Kenyan border (Fasiil et al, 2001) annually. The proportion of the population affected is also high in Amhara and Somali regional states. Forty eight of the 105 woreda of Amhara regional state are drought prone and suffer from frequent food shortages as a result of agricultural drought (USAID, 2000). Misrak Bellessa is one of the woredas located in central Gondor zone of Amhara National Regional States and is labeled as prone to frequent shocks of drought. Agriculture remains the back bone and the main source of employment for the rural communities of the majority communities of Misrak Bellessa. However, the livelihood and agriculture sector of the rural communities is constrained by frequent occurrence of agricultural drought. Though agricultural drought affects the different regions of Ethiopia, most research on drought are widely undertaken in Boran zone of Oromia region and Somali regions. So far in Ethiopia particularly in moisture deficit woredas of Amhara region, there are limited empirical studies conducted to investigate the magnitude and frequency of agricultural drought and its effect on the food security status of rural households using standard drought indices. On the contrary Extreme weather conditions like agricultural drought is predicted to increase in severity, frequency, and duration. This study aims to investigate the magnitude and frequency of agricultural drought and current status of food security and its determinants for households of Misrak Bellesa woreda. This research will have the potential to contribute to the sparsely researched subject of quantifying agricultural drought and food security status and its determinants in Misrak Bellesa woreda of Amhara region.

1.2. Statement of the Problem

The development and growth of many poor countries depend mainly on the performance of their agricultural policies and economics. Agriculture remains the back bone and the main source of food, income and employment for the majority of rural communities of Misrak Belesa Woreda. However, the agricultural sectoral production in the woreda is constrained by the effects of recurrent drought thereby affecting the food security status of rural households. Climate change and extremes have been adversely affecting the food security particularly in rain fed agricultural production systems (Behailu et al., 2021)

Agricultural drought undermines farm yields by reducing household food availability, and agricultural income that is derived from crop and livestock sales. Poor harvests threaten food security and livelihoods at household level. Failed food production in any period of year constrains the ability of resource-poor households to access and afford food as physical scarcity and food prices often rise (AGRA, 2014). These losses are further exacerbated by repercussions on employment and food security due to the reduction in agriculture-related employment and reduced food availability, leading to lower family incomes and inflated food prices. The resulting food insecurity then leads to purchasing less food that is of a lower quality resulting in undernourishment, making populations recovering from disasters even more vulnerable to public health risks following disasters. Agriculture droughts have stronger impact on the people who have selected agriculture (crop and livestock production) or its related activities as the main livelihood. Misrak Belesa woreda experienced recurrent agricultural drought, which has not been analyzed, yet. Thus, it is important to assess the magnitude and frequency of agricultural drought condition using recommended drought indices like standardized precipitation index.

In cognizant to the above facts, this study aims to examine the magnitude and frequency of agricultural drought and its main effects on food security of households in Misrak Belesa woreda. The study also attempts to investigate food security status of households. This research will have the potential to contribute to the sparsely researched subject of magnitude and frequency of agricultural drought and its effects on food security in Misrak Belesa woreda of Amhara region. The study methodology uses meteorological data sets and indicators of food security and analyses the correlation that exists with agricultural drought using Agricultural drought index called Standardized precipitation index. Study on investigation of agricultural drought using agricultural drought indices is not widely practiced particularly in moisture deficit woredas of Amhara region including Misrak Belesa. Data driven empirical study on magnitude and frequency of agricultural drought is important for generation of knowledge and informs the study communities, stakeholder and policy makers on agricultural drought disaster risk. The finding could be used by different actors and policy makers operating in the woreda and at regional level to understand and get contemporary information on magnitude of agricultural drought and food security of the communities so that appropriate interventions designed based on evidence-based planning. Thus, the study will fill literature gap on quantitative data on agricultural drought using drought index and presents data on current status of food security and its determinants among households in Misrak Belesa woreda of Amhara region.

1.3 Research Objectives

The main objectives of this study is to quantify magnitude and frequency of agricultural drought using standardized precipitation index and examine its effect on household food security in Misrak Bellesa woreda.

1.3.1 Specific Objectives:

1. Determine the frequency and magnitude of agricultural drought
2. Analyze the effects of agricultural drought on food security of households
3. Examine household perceptions of agricultural drought on their food security
4. Determine the status of household food security of Misrak Belesa woreda.

1.3.2 Research Questions

1. What is the magnitude and frequency of agricultural drought in the study area?
2. How do the rural households perceive about agricultural drought?
3. What are the effects of agricultural drought on food security of households?

4. What is the current status of rural household food security?

1.4. Significance of the Study

As agricultural drought occurrences are predicted to be the future threat to the food security and livelihood of communities, its impacts on food security need to be studied to generate evidence-based data. Empirical study on magnitude and frequency of agricultural drought using standardized precipitation index and study on its impact on food security of households is important for generation of knowledge. The study findings also enable the study communities and stakeholders to design and implement appropriate policy measures on agricultural drought disaster risk reduction

1.5. Scope and limitation of the study

The scope of the study is to investigate and analyses the magnitude and frequency of agricultural drought and its effects on food security of households in Misrak Belesa woreda. The study also investigates Current food security status of households. The following are key expected limitations of the study and ways to minimize them

1. **Some Data are sensitive or are difficult to get**

   Most of the time information on assets/farm out puts are difficult to get the real picture from rural Household. The researcher uses proxy indicators to gather data on income.

2. **Convenience of the Period of data collection.**

   The researcher and enumerators took into consideration that households are at their most convenient time for sharing information. We inquired information on comfortable time for data collection. We avoided peak seasons of farming practices and respect their working time. Data collection time was arranged as per the conveniences of the households.

3. **Cultural issues and local norms**

The researcher and enumerators tried to study cultural issues and issues which are regarded as bad to be raised, discussed or asked first we analyze the context and respected norms of the community.

1.6. Validity and reliability of data and techniques

To assure best, reliable and quality study output, the researcher made sure that all enumerators have ample understanding of the aim of the study and were able to administer the questionnaires properly. To ensure this, a two days training for enumerators was given. All scientific research protocols like appropriate sampling, proper data collection, data entry and analysis were followed with maximum precaution. As much as possible, a reliable work that can show the real picture of the agricultural drought and food security status of the households was undertaken.

1.7. Thesis Organization

This thesis report contains six chapters. The first chapter introduces the background information, statement of the problem, research objective, research questions, the scope and limitation of the study and significance of the study. The second chapter describes about literature review on food security and agricultural drought and conceptual framework. The third chapter elaborates about the materials and research methods followed including description of the study area, data collection tools, methods of data analysis. The fourth chapter presents key findings of the study and the discussion section of the study against the research objective are presented. The fifth chapter presents conclusions and recommendations of the study.

CHAPTER TWO

2. Review of Related Literature

2.1 Concepts of Agricultural Drought and Food Security:

Food security exists when all people, at all times, have access to sufficient safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life (FAO, 2003). Commonly, the concept of food security is defined as including both physical and economic access to food that meets people's dietary needs as well as their food preferences. Household food security exists when all people, at all times, have access to enough food for an active, healthy life. The global food situation is redefined by many driving forces such as population growth, availability of arable lands, water resources, climate change and food availability, accessibility and loss. The combined effect of these factors has undeniably impacted global food production and security (Premanandh, 2011). Food insecurity is therefore the absence of food security and it applies to a wide range of phenomena from famine to periodic hunger due to uncertain food supply.

Food security is composed of availability of food, access to food, and risks related to either availability or access Variation in national, regional or local availability of food can contribute to food insecurity (Von Braun, et al., 1993). The access that a household has to food depends on whether the household has enough income to purchase food at prevailing prices or has sufficient land and other resources to grow its own food (Garrett and Ruel, 1999). The household ability to achieve food security is derived from the household's human, material, and institutional resource bases, which are often collectively referred in the literature as "food security factors." These factors include the educational and employment status, household demographics, agricultural production, assets, saving, formal social assistance or direct transfer, informal social networks, access to clean water and sanitation and cost of living (Bonnard, 2000). Agricultural drought is related to soil moisture availability affecting crop production and results in less water in the soil, streams and reservoirs, less water for livestock and wild-life, and poor crops and pasture. A chain of indirect effects follows an agricultural drought, which may include depressed farm income and closure of farm-supporting industries. Moreover, an agricultural drought induces malnutrition, disease, famine, population migration and a chain of consequences for farm families (Dalezios & Eslamian, 2017)

2.2 Empirical Literature Review

2.2.1. Economic Effect of Agricultural Drought

An ample amount of empirical literature is available in the area of agricultural droughts and their impacts on human well- being. The impact of agricultural drought in Africa is severe due to the backlog in infrastructure development (Fasemore, 2017). Agricultural droughts may disrupt local and regional food production for some time and reduce the food availability in the local area (Devereux, 2007). In a study conducted in Malawi Devereux emphasized that vulnerability to agricultural drought due to the declining access to inputs and infrastructure as a result of population growth and density. This resulted in the reduced cultivation of high-yielding varieties of maize and low yields of staple crops (Devereux, 2002). When food production falls and reduce food availability, food prices rise and food becomes less accessible to the poor.

In addition, when food supplies are interrupted, this will lead to increased malnutrition. Severe agricultural droughts may have an impact on the people who have selected agriculture (food production) or its related activities as their main livelihood (Gunatilake, 2015).The most immediate impact of erratic rainfall on rural livelihoods is on crop and livestock production. Agricultural droughts undermine farm yields thereby reducing household food availability and agricultural income derived from crop sales. On the Study conducted in Pokot county in Kenya Lolemtum argued that crop failure was a major agricultural drought related problem resulting in food shortage (Lolemtum et al., 2017). Poor harvests threaten food security and livelihoods of household. Households and economies that are more diversified are less vulnerable to these direct impacts of agricultural droughts. provided that their alternative income sources are neither correlated with rainfall, nor directly or indirectly dependent on agriculture (Devereux, 2006). Crop failure was reported to be the worst immediate impact of agricultural drought on people's livelihoods (Lolemtum et al., 2017). Birara et al, 2005 argues that "Population pressure, agricultural drought, shortage of farmland, deterioration of food production capacity, plant and animal disease, frost attack, lack of cash income, poor farming technologies; and pre and post-harvest crop loss are major causes of food insecurity." Nyandiko et al on study conducted in Kenya reported that agricultural drought and climate change has had disastrous consequences on maize production. The climate change induced agricultural droughts of 1982, 1992, 2000, 2003, 2007 and 2009 wreaked havoc on maize production and food security in Kenya (Nyandiko et al, 2012). Agricultural drought also results in depletion of assets. Once household exhaust their food stocks, they start selling their assets including jewelry, livestock, furniture and farm tools (IIRR and Save the Children USA, 2007). Agricultural drought results in depletion of water. Disruption of rainfall (amount and distribution) will reduce surface and underground water sources. Streams and wells will dry up, significantly affecting availability of water for people and livestock. Extended agricultural drought will also deplete water used for production of hydro-electric power supply to factories and other users. When food production falls and reduce food availability, food prices rise and food becomes less accessible to the poor. Secondly, when food supplies are interrupted this will lead to increasing malnutrition(Devereux,2007).The livestock sector is also affected by the effects of agricultural drought. Livestock in Ethiopia are critical resources to rural income, nutrition, food security, export earnings, and rural employment. Animal rearing is an integral part of agricultural production. Livestock are kept for various uses including draught power, milk, meat, eggs and various cultural uses. Rapid growth in demand for food of animal origin, stimulated by high population growth, gains in real per capita income, and urbanization, represents a major opportunity to achieve poverty reduction, economic growth, and for making an overall contribution to achieve sustainable development goals. Currently, the per capita consumption of meat and milk in Ethiopia is about 10 kg and 18 liters per person /year respectively. This is far lower than what is recommended for sustainable human growth and development by FAO, 50 kg meat and 200 liters of milk per-capita (FAO, 2009). Food coming from animals contain nutrients commonly lacking in the diets of the poor and the vulnerable communities, yet they are very essential for cognitive and physical growth. Animal protein sources, such as meat, milk and eggs are similar to the protein found in our body. These are considered to be complete sources of protein because, they contain all of the essential amino acids that the human body needs to function effectively.

Stunting (stunted growth), a measure of chronic malnutrition, is associated with reduced survival rate, cognitive and motor development economic productivity and higher adult poverty. Globally nearly 1 in 4 children under 5 is stunted. In a study in Ecuador, eating one egg per day at 6 months of age for a period of 6 moths reduced stunting by 46%. On top of their importance as protein source of food and role in food security, livestock play key role in export earnings. They compliment cropping activities through the provision of manure for soil fertility maintenance, draught power for cultivation, transport, cash and food (Powell et al., 2004). Livestock play an important role in these farming systems, as they offer opportunities for risk coping, farm diversification and intensification, and provide significant livelihood benefits (Bossio, 2009). The losses of livestock due to impacts of agricultural drought and diseases associated with agricultural drought have significant economic, food security and livelihood impacts on livestock keepers and the national economy Agricultural drought results in Poor body condition of livestock. Shortage or lack of pasture and water affect the performance of livestock. Most farmers experienced the adverse impact of agricultural drought, which included a shortage in the water supply for both humans and livestock (Sutcliffe, 2016). Yields from livestock including milk, meat, and egg also drop. Studies conclude that elevation of heat stress due to rise in body temperature will have adverse effect on the productivity of dairy animals (West, 2003). Shortage or lack of feed and water affects milk production. During severe agricultural drought cows will not be able to provide any milk. Animals lose body weight, which reduce the price they fetch at market. Agricultural drought also reduces the immunity of livestock and make them vulnerable to diseases resulting in increased livestock diseases: In addition to the poor body condition of livestock, during agricultural drought they travel long distance in search of pasture and water, increasing their exposure to infection. The dry environment can also be conducive for certain livestock diseases. The agricultural drought period from 1995-1997 led to a 78% decrease in cattle herd size and a 45% decrease in camel herd size in farming households in the Somali and Borana areas of Ethiopia along the Kenyan border (Fasil et al, 2001). In a study conducted in India in 1988, the population of sheep and goat declined by 26.19% and 18.6%, respectively following agricultural drought (Kanwal et al., 2020).In a Study conducted in India 7.35% drop in milk yield in indigenous breeds of cattle (Kanwal et al., 2020). Agricultural drought results in Poor terms of trade for crops: Supply of locally produced food crops in the market will be low (although there could be good supply of food aid in local markets around areas where relief distribution takes life). This situation leads to high food price. Lin et al argues that the average price rise of agricultural products is the largest under agricultural drought conditions(Lin et al., 2013). Lin et al on study conducted in china on the effects of agricultural drought on agricultural products, they argue that Compared with an agricultural drought-free situation, the prices of rice, wheat, and beef rise by 0.67 percent, the prices of maize, eggs, and milk products rise by 0.56 percent, and the price of legumes rises by 0.57 percent under the mild agricultural drought scenario(Lin et al., 2013).Agricultural drought leads to shortage of food supplies, which dramatically increased food prices and had a direct and severe effect on the more vulnerable and poor communities

(Kebede et al., 2013).The impacts of agricultural drought go beyond agriculture into related sectors, affecting major food supply chains and resulting in episodes of price spikes. This is because of the reliance of these sectors on agriculture for raw material so as to increase food production, which is needed to provide for the ever-increasing population (Leal, 2012). Agricultural drought has a negative effect on unemployment as farmers lose their alternative source of income. In addition, there is a reduction in growing seasons and in agricultural yields due to the reduction in the area suitable for agriculture (Niang et al, 2014). The agricultural drought period from 1995-1997 in Ethiopia has led to a 78% decrease in cattle herd size and a 45% decrease in camel herd size in farming households in the Somali and Borana areas of Ethiopia along the Kenyan border (Fasil et al, 2001). A study conducted in Tanzania indicated 10% of households involved in raring livestock experienced the death/theft of livestock, 12.76% experienced water shortages and about 2% of households experienced the loss of employment of a household member (Maria, 2015).

2.2.2. Literature gap to be addressed

This study aims to fill the gap in the body of knowledge on magnitude and frequency of agricultural drought and its effects on food security of Misrak Belesa woreda communities of Amhara region. The study helps to understand the trend of agricultural drought. The study also contributes to knowledge of current food security status of the populations at risk. There are limited empirical studies conducted to investigate the magnitude and frequency of agricultural drought and its impact on the food security status of households in Misrak Belesa Woreda.

2.3. Conceptual Framework

2.3.1. Definition and Concepts

Climate change and extremes have been adversely affecting food production particularly in rain fed agricultural production systems in Ethiopia. Drought is one of the most complex and damaging natural disasters that impacts agricultural productivity and socioeconomic development (Potop et.al, 2016). Drought is broadly defined as "a deficiency of precipitation over an extended period, usually a season or more, which results in a water shortage for some activity, group, or environmental sectors" (UNDP, 2010). Depending on the duration, effects and intensity, drought can be classified into four types: meteorological, agricultural, hydrological and socio-economic drought (Crocetti et al., 2020). Meteorological drought is as a result of deficits in precipitation whereas agricultural droughts are based on deficits in soil moisture, and hydrologic droughts on deficits in streamflow, and socio-economic drought occur when the demand of multifarious commodities for water exceeds the supply (Dracup et al., 1980). Agricultural drought refers to the agricultural impacts resulting from deficiencies in the water availability for agricultural use. Agricultural drought is described in terms of crop failure and livestock productivity losses and exists when soil moisture is depleted so that crop yield is reduced considerably (Dalezios & Eslamian, 2017). On the other hand, food security exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life (World Food Summit, 1996). Agricultural drought is the leading cause of food shortages and human suffering in Ethiopia in terms of frequency, area covered and the number of people affected. Agricultural drought generally results from long continues dry weather and a lack of insufficiency of rain which causes exhaustion of soil moisture, destruction of plants, depletion of water supplies and reduction and eventually cessation of stream flow((IIRR and Save the Children USA, 2007). The experience from droughts has underscored the vulnerability of human societies to this natural hazard (Ojos Negros research group, 2004). When drought recurs, the cumulative effect can lead to deterioration of physical wellbeing and failure of traditional coping mechanisms, with the result that severely affected people can become destitute. If drought occurs once every several years, it is possible to recover. But if it occurs again and again at short intervals people's vulnerability increases and their resilience decreases (IIRR and Save the Children USA, 2007).

2.3.2. Agricultural drought and Food Security

Agricultural drought links various characteristics of meteorological drought to agricultural impacts, focusing on precipitation shortages, differences between actual and potential evapotranspiration, soil-water deficits, reduced groundwater or reservoir levels, and so on. Plant water demand depends on prevailing weather conditions, biological characteristics of the specific plant, its stage of growth, and the physical and biological properties of the soil. A good definition of agricultural drought should account for the susceptibility of crops during different stages of crop development. Deficient topsoil moisture at planting may hinder germination, leading to low plant populations per hectare and a reduction of yield. Data sets required to assess agricultural drought are soil texture, fertility and soil moisture, crop type and area, crop water requirements, pests and climate. Agricultural drought undermines farm yields and national harvests by reducing household and national food availability, and agricultural income that is derived from crop and livestock sales. Poor harvests threaten food security and livelihoods at both household and national level as per dependence regime on agriculture for its food and income. Failed food production in any period of year con- strains the ability of resource-poor households to access and afford food as physical scarcity and food prices often rise (AGRA, 2014). Poor crops and pasture Moisture stress affects performance of crops and pasture causing low yields or even total crop failure. Depletion of assets: Once households exhaust their food stocks, they start selling their assets including jewelry, livestock, and furniture and farm tools. Depletion of water: Disruption of rainfall (amount and distribution) will reduce surface and underground water sources. Streams and wells will dry up, significantly affecting availability of water for people and livestock. Extended Agricultural drought will also deplete water used for production of hydro-electric power; when the Agricultural drought is severe, the government rations electricity, disrupting the power supply to factories and other users. Shortage or lack of pasture and water affect the performance of livestock. They lose bodyweight, which reduces the price they fetch at market. In addition to the poor body condition of livestock, during Agricultural drought they travel long distances in search of pasture and water, increasing their exposure to infections. In addition to losses in yields in both crop and livestock production, Agricultural drought is associated with insect infestations, plant disease, and wind erosion. The incidence of forest and range fires increases substantially during extended periods of Agricultural droughts, which in turn places both human and wildlife populations at higher levels of risk. Income loss is another indicator used in assessing the impacts of Agricultural drought. Reduced income for farmers has a ripple effect. Retailers and others who provide goods and services to farmers face reduced business. This leads to unemployment, increased credit risk for financial institutions, capital shortfalls, and eventual loss of tax revenue for local, state, and federal governments. Prices for food, energy, and other products increase as supplies are reduced. In some cases, local shortages of certain goods result in importing these goods from outside the Agricultural drought-stricken region. Reduced water supply impairs the navigability of rivers and results in increased transportation costs because products must be transported by alternative means. Hydropower production may also be significantly affected. The most immediate impact of erratic rainfall on rural livelihoods is on crop and livestock production. Agricultural droughts undermine farm yields thereby reducing household food availability and agricultural income derived from crop sales. Poor harvests threaten food security and livelihoods of household. Households and economies that are more diversified are less vulnerable to these direct impacts of Agricultural droughts.(Devereux,2006).Agricultural drought also results in depletion of assets. Once household exhaust their food stocks, they start selling their assets including jewelry, livestock, and furniture and farm tools. (IIRR and Save the Children USA, 2007). Agricultural drought results in depletion of water. Disruption of rainfall (amount and distribution) will reduce surface and underground water sources. Streams and wells will dry up, significantly affecting availability of water for people and livestock. Extended Agricultural drought will also deplete water used for production of hydro-electric power supply to factories and other users. The effects of Agricultural drought extends also to the livestock production. Agricultural drought results in Poor body condition of livestock. Shortage or lack of pasture and water affect the performance of livestock. Most farmers experienced the adverse impact of Agricultural drought, which included a shortage in the water supply for both humans and livestock

(Sutcliffe, 2014). Yields from livestock including milk, meat, and egg also drop. Shortage or lack of feed and water affects milk production. During severe Agricultural drought cows will not be able to provide any milk. Animals lose body weight, which reduce the price they fetch at market. Agricultural drought also reduces the immunity of livestock and make them vulnerable to diseases resulting in increased livestock diseases: In addition to the poor body condition of livestock, during Agricultural drought they travel long distance in search of pasture and water, increasing their exposure to infection. The dry environment can also be conducive for certain livestock diseases. Agricultural drought also results in disruption of Markets and change in terms of trade. People may die because they are not prepared to face the impacts of the Agricultural drought. Because their livelihoods are not resilient enough. Agricultural drought and its effects on people continue and even intensify due to climate change. The Agricultural drought period from 1995-1997 led to a 78% decrease in cattle herd size and a 45% decrease in camel herd size in farming households in the Somali and Borana areas of Ethiopia along the Kenyan border (Fasil et al, 2001). Agricultural drought results in Poor terms of trade for crops: Supply of locally produced food crops in the market will be low (although there could be good supply of food aid in local markets around areas where relief distribution takes life). This situation leads to high food price. Agricultural drought severely impacts food security by damaging communities and infrastructure, existing crops, or potentially arable land, availability of water, killing livestock assets which all affect food production which is essential element for the availability and access pillars of food security. Agricultural drought impact food security by damaging communities, existing crops, or potentially arable land, Food production is regarded as an indicator of food availability that gives an estimation of the harvest of staple foods. Staple food production in agricultural-based economies is mainly rain-fed and is often affected by changing weather conditions. Agricultural drought diminish overall food production capacity and import activities but increase agricultural trade controls to favor domestic farmers. These losses were further exacerbated by repercussions on employment and food security due to the reduction in agriculture-related employment and reduced food availability, leading to lower family incomes and inflated food prices. The resulting food insecurity then leads to purchasing less food that is of a lower quality resulting in undernourishment, making populations recovering from disasters even more vulnerable to public health risks following disasters. Food access and food utilization dimensions of food security will be negatively affected for households experiencing water shortages. This is because water shortages reduce their access to drinkable water and thus their ability to consume sufficient water (Maria, 2015). Agricultural drought affects the four dimensions of food security – availability, stability, access and utilization (FAO and IFAD, 2013). Agricultural drought also has the potential to cause epidemics affecting human health, animal health, and environmental health. In addition, to the above Agricultural drought has serious impacts on social disruptions like migration of affected people, Interruption of social and religious customs, psychological effect, conflict over natural resources, malnutrition, epidemic diseases and death on affected communities. The combination of the socio-economic and environmental issues has resulted in food insecurity that negatively impacted the well-being of the people, the economy, and the environment (Akrofi et al., 2012). The impact of Agricultural drought in Africa is severe due to the backlog in infrastructure development (Fasemore, 2017). In a study in Malawi Devereux emphasized that vulnerability to Agricultural drought due to the declining access to inputs and infrastructure as a result of population growth and density. This resulted in the reduced cultivation of high-yielding varieties of maize and low yields of staple crops (Devereux, 2002). Studies conclude that elevation of heat stress due to rise in ambient temperature will have adverse effect on the productivity of dairy animals (West, 2003).

Even in case of small ruminants that are more adapted to harsh climatic conditions, the exposure to thermal stress affects voluntary feed intake and maintenance requirement resulting in a decrease of body weight, average daily gain (Shelton, 2000). As dry periods progress, livestock are obliged to mobilize body fat reserves to balance for the nutrient's deficiency in the diet. Eventually, Agricultural droughts cause livestock to lose weight, production and lower birth weights (Oba, 2001).

3.3 Theoretical framework

There are a number of theories of food security. The theoretical frameworks that guided this research are: The general explanation theory which explains and emphasizes on the impacts of agricultural drought, to food security through its effect on agricultural production. According to this theory, agricultural drought results in disruption of agricultural production both crop and livestock and results in decline in food availability (Devereux, 1993). The second theory is Food availability decline theory (FAD). FAD refers to the per capita food availability decline attributed to various interrelated adverse environmental and socio-economic factors. The FAD model argues that anything which disturbs food production, such as drought by reducing the availability of food for extended period of time causes famine. Natural calamities such as earthquake and drought, and manmade disasters like war and conflict may decimate agricultural production and result in pervasive food shortages that may lead to famine (Mesay, 2001). Household food security situation in rural areas is whether the household can produce sufficient food from own production or sell livestock and purchase food grain of the right quality in the market place. This implies availability of enough food and the capacity of the household to acquire it determines household food security. Therefore, household food security means the complementarities of food availability and entitlement (Abi et al., 2015). The third theory is climatic theory. According to this theory, climatic conditions like Drought or flood causes crop failure and can lead to famine in rain-fed agricultural areas. Both scarcity and excessive water have adverse effect upon crops and livestock, the assets which form the main source of livelihood for subsistence peasants. In this study agricultural drought was quantified using standardized precipitation index. The impact of agricultural drought on annual cereal production of teff was examined. Food security status of household which is affected by agricultural drought, demographic and socioeconomic as well as institutional factors is examined. The relationship among variables studied is diagrammatically represented as follows:

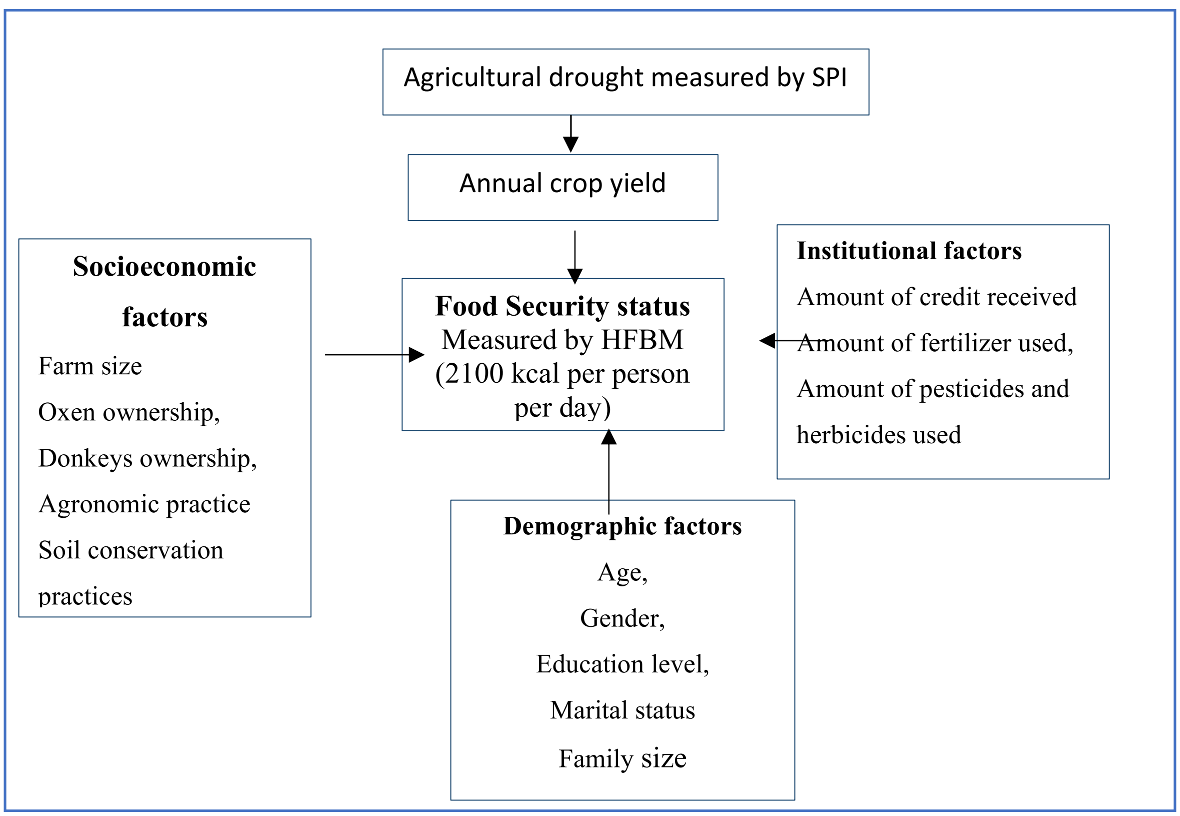


Figure 1. Conceptualization of agricultural drought and food security

CHAPTER THREE

3. Materials and Methods

3.1. Description of the Study Area

Misrak Belesa is located in Amhara region, central Gondor zone. The woreda is 115kms and 173 kms away from Gondor and the regional capital Bahirdar respectively. This woreda is labeled as prone to frequent shocks of agricultural drought by Amhara region (USAID,2000). The woreda has a population of 175,966 of which 93,632 are males and 82, 334 are females (CSA,2012). The woreda has a total area of 181,675.5 hectares out of the total land area, 16, 247.53 hectare is covered by forest, 31,336 hectare is grazing land, 8,320 hectare is covered with shrubs and 87,670 hectare is occupied by public and social infrastructures including church, woreda public offices and residential areas (). The woreda receives minimum annual rainfall of 700mm and maximum annual rainfall of 1200mm and according to the daily air temperature data collected at Belesa station, the mean monthly temperature ranges from 18.9 to 24.9 degree Celsius (NMO, 2022) The woreda has an elevation range of 1189-2613 m a.s.l. Nineteen percent of the total land area has Woinadega and 81 %

kola agro-climates (Misrak Belesa Woreda office of agriculture annual report, 2022)

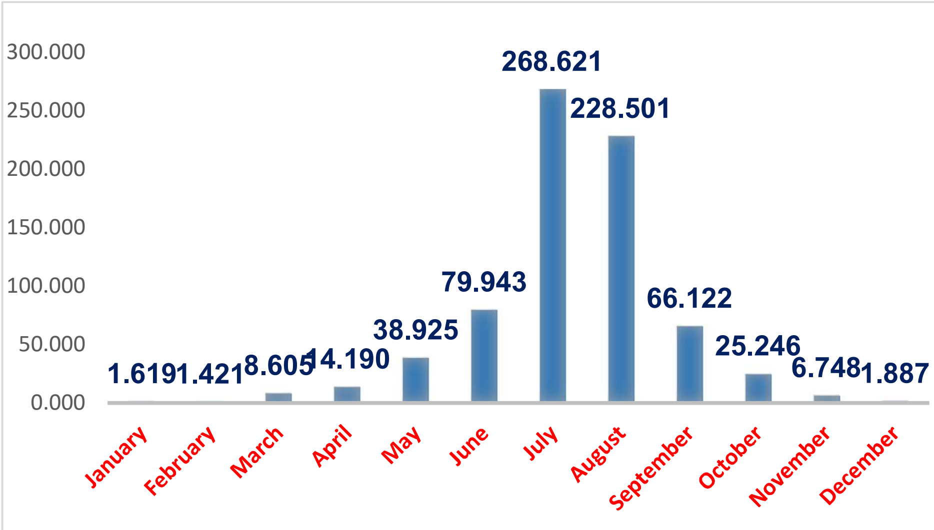


Figure 2.Mean monthly precipitation in mm for Misrak Belesa woreda (1981-2018)

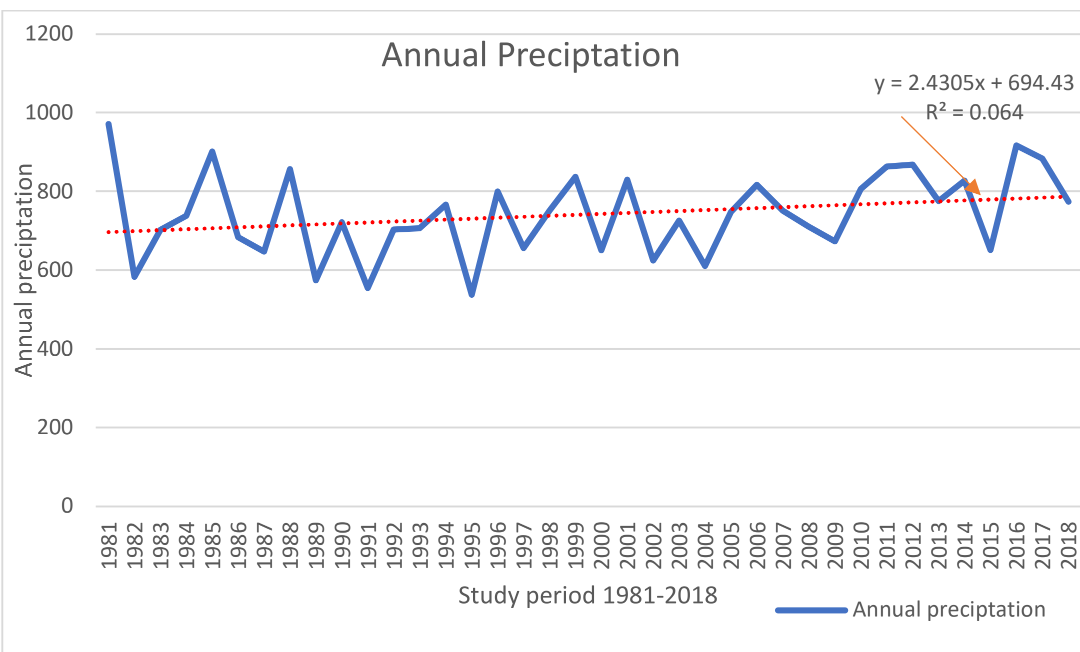


Figure 3. Trend of annual rainfall for the year from 1981 to 2018.

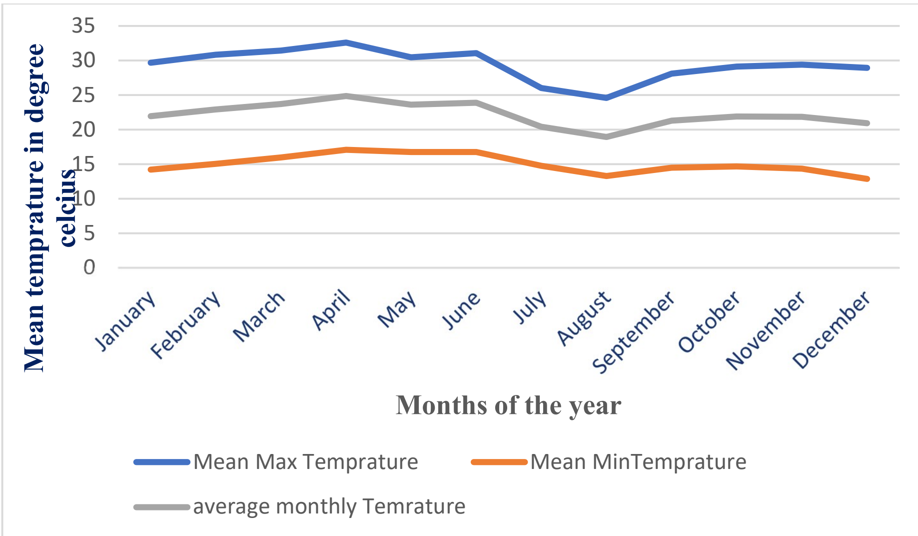


Figure 4. Mean monthly maximum, minimum and average temperature in degree Celsius for Misrak Belesa woreda

The woreda has 30 administrative kebeles of which 16 are kola and 14 Woinadega. Misrak Belesa is bordered in the east by Sahala woreda, in the west-by-West Belesa woreda, in the north by Janamora and Kinfiz and in the south by Ebinat woredas. The area receives from 712 to 1023 mm of rain with a mean annual value of 842 mm.(NMO,2012)

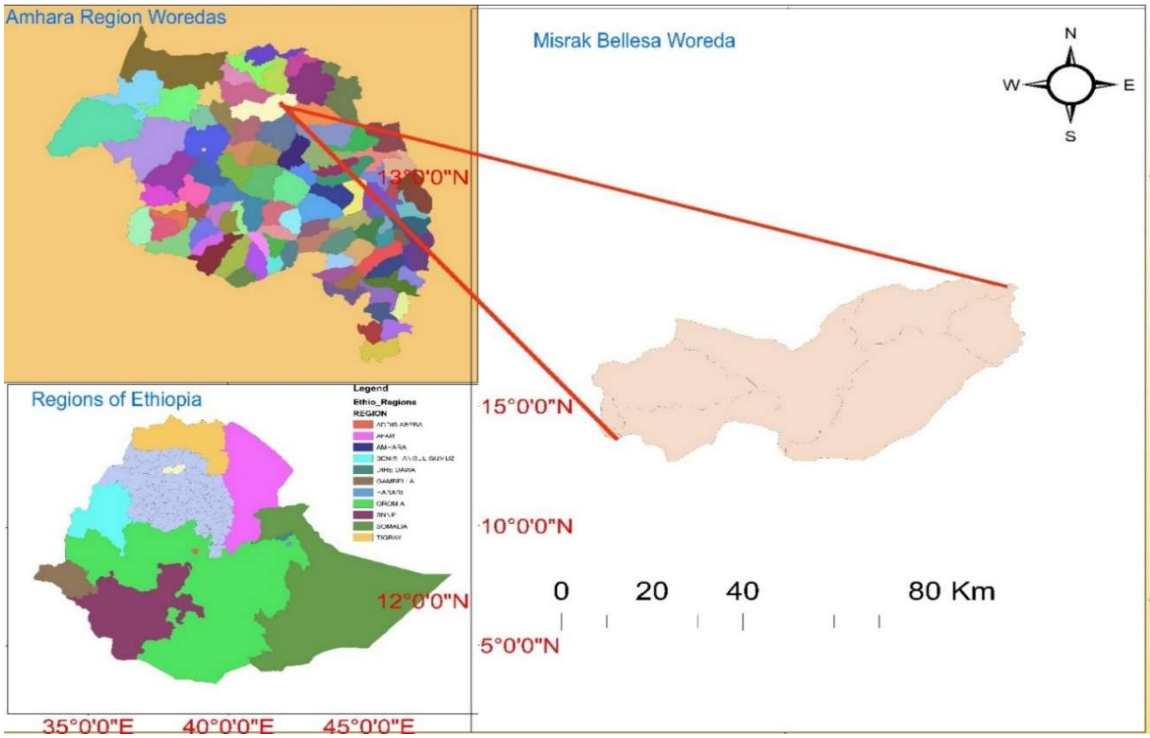


Figure 5. Map of the study area

3.2. Methods

3.2.1. Sample size determination and sampling techniques

Misrak Belesa woreda district was selected purposively due to the fact that the woreda is prone to recurrent agricultural drought and due to the fact that there is little empirical research conducted to examine food security status and impacts of agricultural drought to household food security. Households included under the questioner survey study were selected by multistage probability sampling methods (Catherine, 2007). 1st stage is stratified random sampling by Kebele. There are 30 administrative Kebeles in Misrak Belesa of which 16 are kola and 14 Woinadega. All the 30 Kebeles were stratified based on their agro ecological category. There are two agro ecological zone categories in the woreda the stratification of household kebeles in different agro climatic zones will allow to examine and compare differences in food security by agroecology. The 2nd stage is simple random sampling in this case one sample Kebele was selected randomly from each stratum. In this case Hamusit Kebele which has kola and Zoz Kebele which has Woinadega agro climate have been randomly selected. The 3rd stage systematic random sampling households in the Kebele to be included for sample collection was determined by ratio of from each of the selected Kebeles. List of households from each selected Kebeles was collected from each Kebele administration and the households to be included under this study be selected systematically until our sample size is reached.Sample size was calculated by sample size estimation as recommended by (Yamana, 1967). The list of the households was recorded from Kebele administration data and based on the ratio of N/n and hence, every 6th household was selected. A random number between 1 and 6 was selected and number 3 was randomly selected therefore households from 3rd, 9th 15th 21st… households were included in the survey. Total number of households to be included in the household survey were calculated to be 381 including 10% non-respondent rate. Though the sample size estimated was 381, in this study a total of 402 households was included.201 households from each agroecology were considered during the survey.

Using quantitative formula suggested by Yamana

Using the formula $n = N/ 1+N (e)^{2} =$

$n=2151/1+2151(.05)^{2} = 338$

If we assume 10% non-responder our sample size will be 338+ 33.7= 381

3.2.2. Research design and approach

Quantitative research approach was used to collect data from households using questionnaire survey. Both longitudinal and Cross sectional study design using descriptive and correlational statistics were used to investigate food security status agricultural drought and perception of households on agricultural drought.

3.2.3. Data types and sources

Both primary and secondary data sources were used. Primary data was collected using questioner survey of 402 households. Using questionnaire survey, data including food security status, food security indicators like land ownership, income, access to agricultural technology and information, cereal and livestock production and demographic characteristics of surveyed households, major coping and adaptive strategies and household's perception on climate variability indicators was collected.

Time series Areal gridded (4*4) rainfall and temperature data for the last 38 years for the woreda was collected from National Meteorological Agency for quantification of Agricultural drought. Thirty-seven years' time series rain fall and temperature data was collected to calculate Standardized Precipitation Index (SPI) as an analysis tool for agricultural drought. Meteorological data acquired from national Meteorological agency was used to quantify agricultural drought. Secondary data on annual production of teff was used to examine effects of agricultural drought on food security of households.

3.2.4. Research Methods

Household Food security status was determined using Household food balance sheet model (HFBSM) from a total of 402 surveyed households. Generic question for determination of household food security status was included in the questionnaire survey. The Household survey was carried out from July 10-July 18 2022. Two kebeles representing the two agro climates were randomly selected. Hamusit and Zoz Kebeles were selected for the household survey representing Kola and Woinadega agro climates. From each Kebeles three enumerators (a total of six) and one coordinator (woreda head of agricultural extension services) were used as enumerators. The Extension head had a role of coordinating the data collection process. A training was conducted for the enumerators at each Kebele. Enumerators were also being requested to fill in one sample questioner and that was checked for its correctness and evaluate if the enumerators understood the questioner. Letter of requesting the Woreda Agricultural office for providing data on cereal production was submitted for the woreda agriculture office and data on annual cereal production was collected. Though We requested cereal production data for the period from 1980-2018, the woreda has explained that the woreda was established as Misrak Belesa woreda since 1995 EC as the former Belesa woreda was split into two woredas namely East and West Belesa.In this study, a modified form of a simple equation termed as Household Food Balance Model, originally adapted by (Degefa, 1996) from FAO Regional Food Balance Model and thenceforth used by different researchers in this field (Messay, 2009), was used to calculate the per capita food available. Household food balance model

NGA= (GP+GB+FA+GG)-(HL+GU+GS+GB)

Where:

NGA = net grain available/year/household,

GP = total grain produced/year/ household,

GB = total grain bought/year/household,

FA = quantity of food aid obtained/year/household,

GG = total grain obtained through gift or remittance/year/ household,

HL = post-harvest losses/year,

GU = quantity of grain reserved for seed/ year/household,

GS = amount of grain sold/year/household, and

GV = grain given to others within a year.

One of the most important indicators of food adequacy level of a community is the percapita dietary energy supply measured in kilocalorie. This is the measure of the average daily food available to each person in a sample household. Consequently, after data collection from sample respondents, the researcher has converted the households' annual avail- able food grain supply into kilograms and then by using the conversion factors of major cereals; they were changed into kilocalories. The cutoff value for food secure people being 2100Kcal per capita per day. Food security status of households was determined taking into consideration the difference between food income and food expense. The net available cereal amount will be converted into its equivalent calorie amount using EPHI recommended calorie conversion table for cereal crops. Hence, the difference between calorie availability and calorie demand for households will be used to determine a household's food security status. According to EPHI, the minimum recommended percapita calorie amount is 2100 kcal. That is the daily calorie required average amount a healthy adult need to consume per day to remain and lead a healthy life. Accordingly, households with calorie level below the normal are regarded as food insecure and those with calorie level of the average and above the normal are considered food secure.

The model is represented as follows

$$\text{HHFSi} = \begin{cases} 1, \text{ Yi} \geq 2100kcal \\ 0, \text{ Yi} < 2100kcal \end{cases}$$

Where HHFSi represents Food security status of the ith household and Yi represents the daily percapita calorie consumption. Binary Logistic regression will be used to examine the relationship between the dependent variable, household food security status and the predictor variables under the study. During administration of the household survey, records of households at the Kebele administration was used as sampling frame. To determine the frequency and magnitude of agricultural drought, Time series Areal gridded (4*4) rainfall and temperature data for the last 38 years for the woreda was collected from National Meteorological Agency for quantification of Agricultural drought. Thirty-seven years' time series rain fall and temperature data was collected to calculate Standardized Precipitation Index (SPI) as an analysis tool for agricultural drought. Secondary data on annual teff and sorghum production, was also collected from Misrak Belesa woreda office of agriculture. Magnitude of Agricultural drought was determined using Standardized Precipitation Index (SPI) calculation. For determination of SPI Time series Areal gridded (4*4) rainfall and temperature data for the last 38 years for the woreda was collected from National Meteorological Agency. Thirty-seven years' time series rain fall and temperature data was collected to calculate Standardized Precipitation Index (SPI) as an analysis tool for agricultural drought. Time series

To analyze the effects of agricultural drought on food security of households, secondary data from Misrak Belesa woreda agriculture office for the period from 1995-2014 EC was used to regress the cause-and-effect relation between agricultural drought and teff annual produced by the woreda in quintals. Regression analysis between agricultural drought index values and food security conventional 'availability' indicators such as crop yield, was examined. Teff is the most widely produced cereal crop in the woreda and the annual yield of teff and SPI values was regressed. Household survey was conducted to investigate to examine household perceptions of agricultural drought on their food security and investigate food security status and its determinants.

3.2.5. Tools of data collection

In this study, status of food security of households was measured by employing household food balance sheet model (HFBS). HFBSM was selected as measure of food security due to the fact that majority of the population in the study are agrarians. Structured questionnaires were developed and will be used to collect quantitative data. The generic question under HFBS was included in the questionnaire Survey. The use of HFBS tools for food security assessment allows us to explore food security status from availability and consumption pillar. HFBSM tool and the generic questions required to assess the food security status will be incorporated and will be used to determine level of food security status of households.

.3.2.6. Techniques of data analysis

To determine food security status of households, the household food balance sheet model was used. Quantitative data analysis techniques using descriptive and inferential statistical analysis techniques was used to examine demographic and socioeconomic factors affecting food security of households. The questioner data was coded, cleaned and entered to STATA 14.2 version for analysis. Descriptive summaries such as frequencies, proportions, percentages, mean, standard deviations and prevalence of food in security was determined. Logistic regression analysis was computed to explore relationship between food security status and independent variables. Agricultural drought quantification was carried out using Standardized precipitation index calculator. SPI was calculated using a software called SPI generator/calculator downloaded from National drought Mitigation Webpage: https://drought.unl.edu/monitoring/SPI/SPIProgram.aspx. In this study, a one month for rainy months SPI-1, and a 3-month SPI (SPI-3) for the two main rainy seasons kiremt and Belg was calculated to investigate the magnitude, frequency and severity of monthly and seasonal agricultural drought situation of the woreda. A three months SPI (seasonal for Belg and kiremt) reflects a short- and medium-term moisture condition and enables us to estimate and compare seasonal estimation of precipitation. Monthly SPI, SP-1 was calculated for rainy months of the year. Accordingly, February, March April for Belg season and June, July and August rainy months were considered for Kiremt season. In addition to the monthly SPI values, seasonal SPI for the two rainy seasons accumulated/measured at April for (February-April) and August for the kiremt accumulated 3months SPI was calculated. Regression analysis was carried out between agricultural drought as derived from SPI3 and annual yield of teff. In this study, Annual teff production in quintals was acquired for the years from 1995 to 2014 EC (2002 to 2021) the SPI3 values of Kiremt season of the corresponding years were used to regress between annual yield of teff in quintals and SPI3. In this case the dependent variable was annual teff yield and the explanatory variable used in the model was SPI 3 for the kiremt season.

CHAPTER FOUR

4. Results and Discussion

4.1. Demographic and Socioeconomic Characteristics of Households

In this study, a total of 402 households were surveyed. The total number of Male headed respondents in the study were 335 (83.33%). From the total 402 surveyed households, Women headed households were 67(16.7%). Fifty percent (50 %, n=201) of the respondent households were from Hamusit Kebele which is Kola agro ecology and the remaining 50% were from Zoz Kebele and it is Woinadega Agroecology. The average/mean age of heads of households participated in the survey was 41.4 years. The oldest age of the sampled households was 79 years while the youngest age of sampled household heads was16 years. Close to half of the study population 50.75 %(n=204) were between the age of 31 and 45 years. Nearly a quarter 25.62 %(n=103) of the study population were between the age 46 to 64. Close to two third of the study population 76.3 %(n=307) are between 31- and 64-years age. The mean number of household size for the surveyed households was 5.03(STD Dev=2.04). The minimum number of household size was 1 and the maximum number of household size of surveyed households was 11. The highest percentage76.12 %(n=306) of respondent households were married. Fifteen percent (15.9%, n=64) of the respondent households were single. Five percent (5.5%, n=22) and Two-point five (2.5%, n=10) percent of

Table 1 Summary result of multiple linear regression

```
. reg tothhincome Agroecology Farm_exp no_oxen farm_size credit_amt herb_amt fert
> _amt pest_amt

      Source |       SS           df       MS      Number of obs   =       402
-------------+----------------------------------   F(8, 393)       =     35.03
       Model |  1.5159e+11         8  1.8948e+10   Prob > F        =    0.0000
    Residual |  2.1256e+11       393   540858814   R-squared       =    0.4163
-------------+----------------------------------   Adj R-squared   =    0.4044
       Total |  3.6415e+11       401   908092668   Root MSE        =     23256

------------------------------------------------------------------------------
 tothhincome |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
 Agroecology |  -21880.05   2565.123    -8.53   0.000    -26923.13   -16836.97
    Farm_exp |  -111.2578   130.2922    -0.85   0.394    -367.4147    144.8991
     no_oxen |   2756.328   1362.352     2.02   0.044     77.91746    5434.738
   farm_size |    3854.38   1074.054     3.59   0.000     1742.769    5965.991
  credit_amt |   .4576583   .0696325     6.57   0.000     .3207595    .5945571
    herb_amt |   770.2751   1808.534     0.43   0.670    -2785.337    4325.888
    fert_amt |   94.67246   27.55745     3.44   0.001     40.49399    148.8509
    pest_amt |    6679.79   3302.873     2.02   0.044     186.2813     13173.3
       _cons |   4186.086   4917.046     0.85   0.395    -5480.918    13853.09
------------------------------------------------------------------------------
```

Table 2. Test for Multicollinearity among variables.

Variable	VIF	1/VIF
Number of oxen	1.34	0.745551
Farm size	1.30	0.769885
Agroclimate	1.22	0.817902
Fertilizer amount	1.17	0.853595
Pesticide amount	1.11	0.897623
Farm experience	1.11	0.902247
Herbicide amount	1.09	0.916106
Credit amount	1.09	0.917154
Mean VIF	1.18	

Source: Survey data by author

Similarly, total household income and use of fertilizers and pesticides and herbicide used revealed that there is positive relationship between the respose varaible household income and predictor variables use of amount of chemical fertilizers used and volume of pesticides and herbicide used in the population.On the otherhand, at 95% confidence interval,there is no significance difference between total annual household income and farm experience(Pvalue=0.440).This result indicates that farmers farming skill,knowledge experience has not changed farm outputs. This also realtes to no much change in agricultural technology,innovation and attitud chane.

4.2. Frequency and Magnitude of Agricultural Drought in Misrak Belesa woreda 1981-2018

4.2.1. Frequency and Magnitude of Monthly Agricultural Drought

In this study, agricultural drought was quantified by using Standardized Precipitation Index (SPI) calculator. Frequency and magnitude of agricultural drought was calculated for the period between 1981 and 2018. Area gridded monthly rainfall data for Misrak Belesa acquired from National Meteorological agency headquarter based in Addis Ababa was used to quantify magnitude of agricultural drought. In this study, SPI-1 for only rainy months, and a 3-month SPI(SPI-3) for the two main rainy seasons kiremt and Belg was calculated to estimate the magnitude, frequency and severity of monthly and seasonal agricultural drought situation of the woreda. Monthly SPI, SP-1 was calculated for rainy months of the year. Accordingly, February, March April for Belg season and June, July and August rainy months were considered for Kiremt season. A three months SPI-3(seasonal for Belg and kiremt) reflects a short- and medium-term moisture condition and enables us to estimate and compare seasonal estimation of precipitation.

In addition, to the monthly SPI values, seasonal SPI for the two rainy seasons accumulated were measured at April for (February-April) and August for the kiremt accumulated 3months SPI was calculated. Quantification of agricultural drought using monthly SPI-1 values revealed that monthly agricultural drought of different magnitude was recorded in 40 events(months) between the period 1981 and

2018.From the total 40 recorded agricultural drought events, moderate agricultural drought had highest occurrence with frequency of occurrence of 30. Extreme agricultural drought and severe agricultural drought events had a frequency of 4 and 6 respectively. Monthly Agricultural drought in the form of moderate, severe and extreme agricultural drought, accounted for 75%, 15% and 10% of agricultural drought frequencies.

Table 3. Frequency of Monthly Agricultural drought 1981-2018

S/no	Agricultural drought Category	SPI values	Frequency	Percentage
1	Extreme Agricultural Drought	less than 2	4	10
2	Severe Agricultural Drought	1.5 to-1.99	6	15
3	Moderate Agricultural Drought	1 to 1.49	30	75
4	**Total**		**40**	**100**

Source: Survey data by author

Table 4. Extreme Agricultural drought rainy Months 1981-2018

Year	Month	SPI 1	Agricultural Drought category
1997	August	-2.3	Extreme Drought
1987	July	-2.17	Extreme Drought
2012	April	-2.05	Extreme Drought
2003	April	-2.02	Extreme Drought

From the total 40 recorded agricultural drought events the highest frequency of agricultural drought was recorded in the month of August. 10 Agricultural drought events were recorded in August. This accounts for 26% of frequency of occurrence of Agricultural drought. Out of the 40 recorded agricultural events, 24, 60% was observed in Kiremt season.

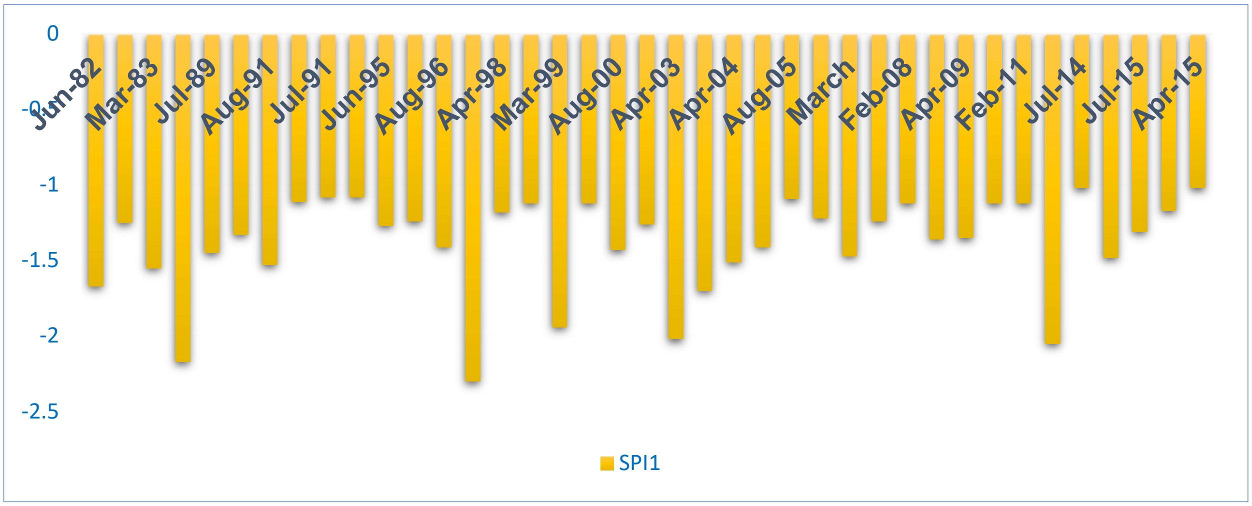


Figure 6. Monthly Agricultural Drought Magnitude 1981-2018

In the current study, the highest monthly agricultural drought was detected in August 1997 with SPI monthly value of -2.3. The analysis of monthly agricultural drought revealed that between the periods 1991 and 2018 extreme agricultural drought was recorded in four episodes. Extreme agricultural drought (SPI≤ 2) was detected in July 1987, August 1997, April 2012 and April 2003 with monthly SPI values SPI-1 of -2.3,-2.17,-2.05 and -2.02 respectively.

Table 5. Agricultural drought by Season from 1981-2018.

Month of Occurrence	**Frequency of occurrence**	**Percen tage**	**Season of Occurrence**	**Frequency by season**	**Percen tage**
August	10	26	Kiremt	24	60
July	7	18	Kiremt		
June	6	15	Kiremt		
March	5	13	Belg	16	40
April	6	15	Belg		
Feb	5	13	Belg		
	39	100		100	100

Source: Survey data by author

When the occurrence of Agricultural drought was examined by decade, the highest frequency of agricultural drought was recorded in the decades 1990-1999 and 2000-2009 with 33 frequency of occurrence in each decade. . High frequency of occurrence (66%) of monthly agricultural drought was recorded between 1990 and 2009. This makes the period from 1990 to 2009 the years with most affected months with Agricultural drought. This makes the period from 1990 to 2009 the years with most affected months with Agricultural drought. Successive Agricultural drought incidence was recorded in all the 4 decades of the study period.

Table 6.Frequency of occurrence of Agricultural drought by decade and its Severity

Decade	Frequency	Percentage	Frequency by severity
1981-1989	5	13	1 Extreme,2 Severe and 2 Moderate
1990-1999	13	33	1 Extreme,2 severe and 10 Moderate
2000-2009	13	33	1 Extreme,2 severe and 10 Moderate
2010-2018	9	21	1 Extreme and 7 Moderate
Total	**40**	**100**	**4 Extreme,6 Severe and 30 Moderate**

Source: Survey data by author

4.2.2. Frequency and Magnitude of Seasonal Agricultural Drought 1981-2018

4.2.2.1. Frequency and Magnitude of Kiremt seasonal Agricultural Drought

Kiremt season of Misrak Belesa Woreda starts in June and ends in August. Kiremt is the largest production season for the woreda. In this study, seasonal agricultural drought for kiremt season was computed at the month of August, the last month of Kiremt harvesting season. Seasonal Agricultural drought in Kiremt season occurred in 16 years between 1981 and 2018. Agricultural drought in kiremt season was recorded in 16 out of 38 years, 43% of the study years. 14 out of 16 (87.5%) observed kiremt season agricultural drought are under the severity of Mild agricultural drought. One extreme kiremt seasonal agricultural drought was observed in the second decade (1990-1999). Another episode of severe agricultural drought in Kiremt season was observed in the first decade (1981-1989). The highest magnitude of kiremt seasonal agricultural drought for was observed in the years 1995 and 1989 with SPI-3 magnitude of -2.4 and -1.64 respectively.

Extreme and Severe Agricultural droughts in Kiremt season were recorded in one year each (1985 and 1989. On the other hand, Mild Agricultural drought events occurred 14 times (years) between the period 1981 and 2018. During the study period, the highest magnitude of agricultural drought was observed in Kiremt season with SPI3 values of -2.4.

Table 7 Kiremt Seasonal Agricultural drought by severity 1981-2018

Decade	Frequency (Number of years)	Percentage	Extreme	Severe	Mild
1981-1989	5	31.25	0	1	4
1990-1999	5	31.25	1	0	4
2000-2009	4	25	0	0	4
2010-2018	2	12.5	0	0	2
Total	**16**	**100**	**1**	**1**	**14**

Source: Survey data by author

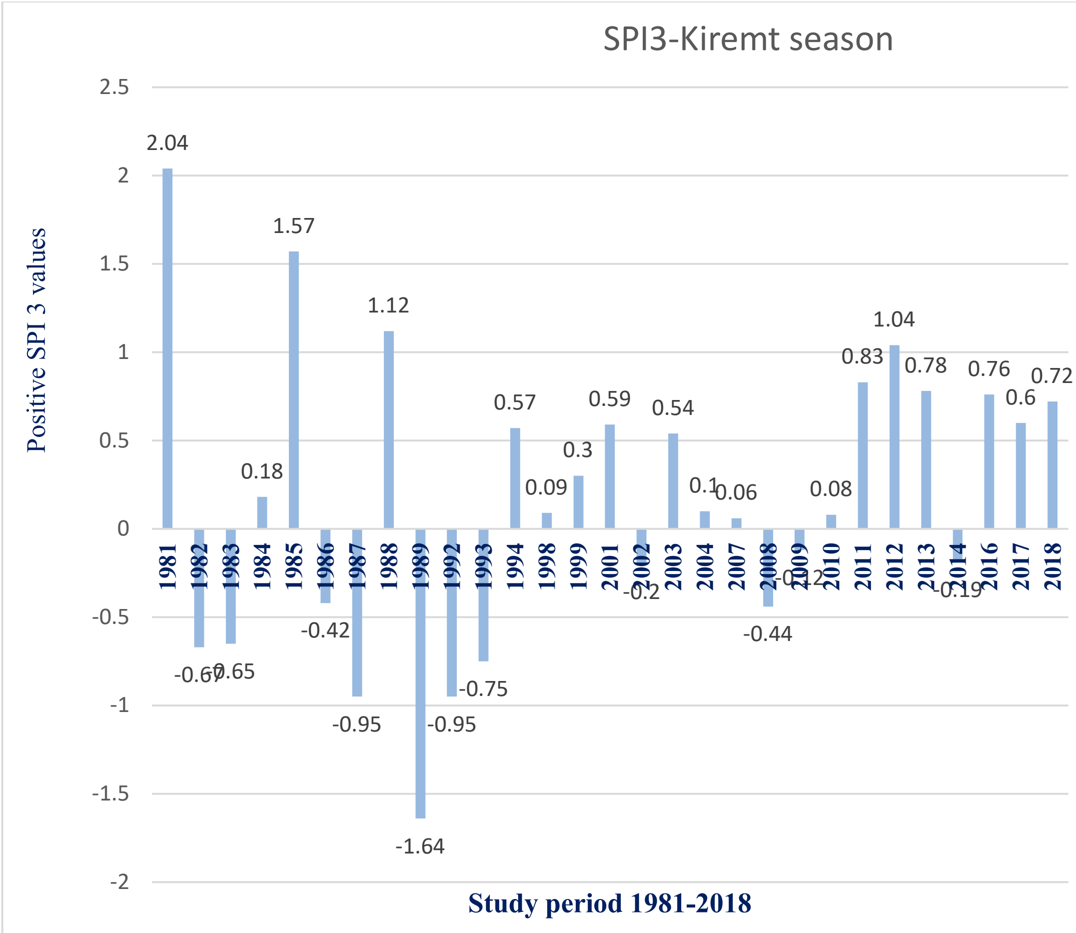


Figure 7. Seasonal Agricultural drought in Kiremt for the periods 1981-2018 (note: negative values represent drought condition)

4.2.2.2. Frequency and Magnitude of Belg seasonal Agricultural Drought

Accumulated seasonal SPI 3 for Belg season (February-April) was computed at the month of April. The highest magnitude of seasonal agricultural drought for Belg season was detected in the year 2000 with SPI value of -1.79. The next highest Seasonal agricultural drought for the Belg season was detected in 1991,2009,2003,1984 with SPI3 values of -1.56, -1.45, -1.43 and -1.04 respectively. Seasonal Agricultural drought for Belg has occurred in 20 years with frequency of 54.05% in 38 years between 1981 and 2018.Severe, Moderate and Mild Agricultural drought events occurred 14, 3 and 2 times for the periods between 1981 and 2018.In the study period, severe Agricultural drought in Belg season was detected in the 2000(SPI3=-1.79) and 1991(SPI3=-1.56). Moderate seasonal Agricultural drought for Belg was detected in the years 2009(SPI3=-1.45),2003 (SPI3=-1.43 and 1984(SPI3=-1.04). High frequency of seasonal Agricultural drought occurred in Belg (20years) than in Kiremt season(16years) frequency of 43.24 % between the period 1981 and 2018

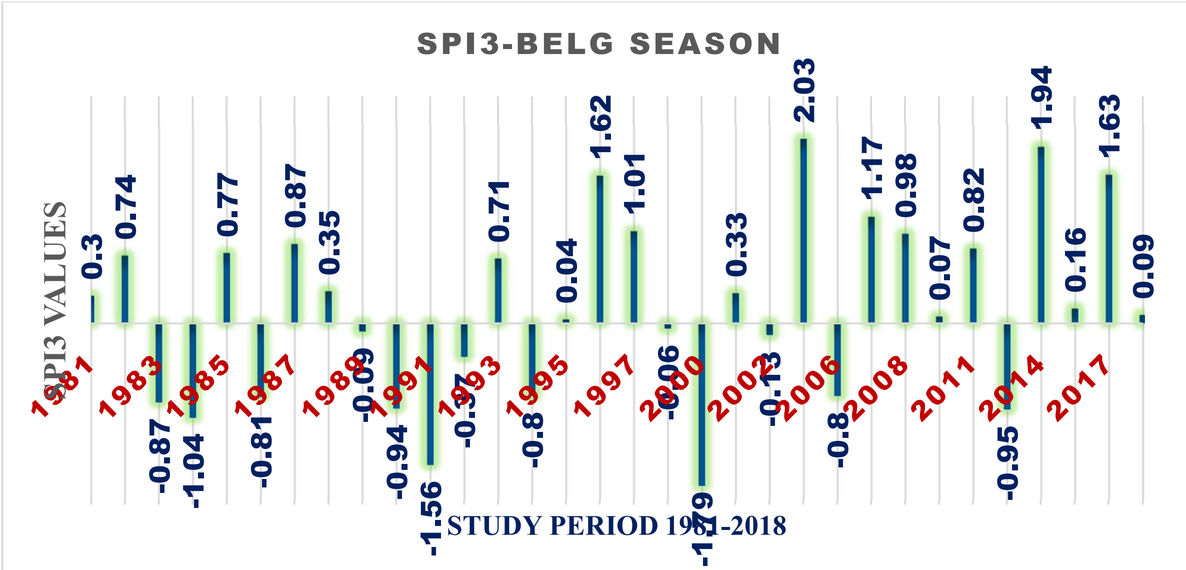


Figure 8. **Seasonal Agricultural drought for Belg for the period 1981-2018(n=38 years) (negative values indicate drought years)**

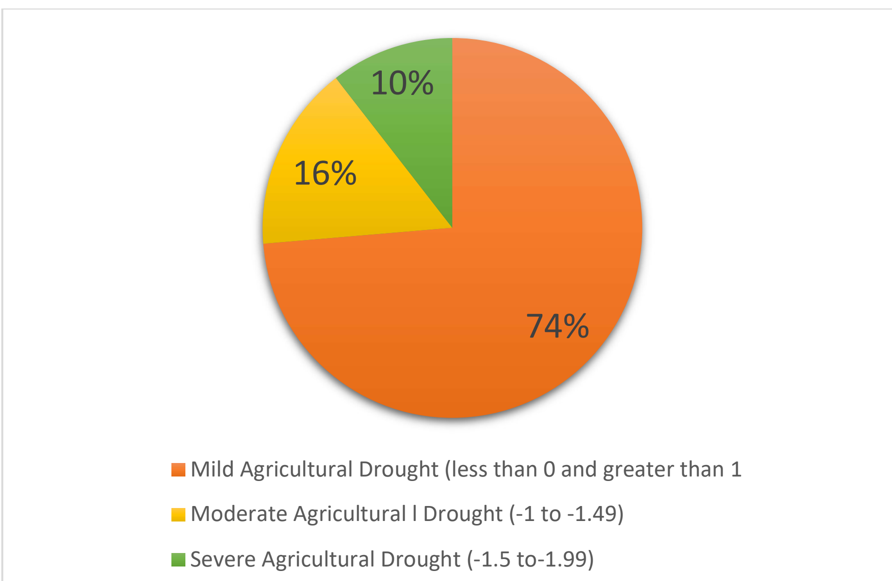


Table 8. Magnitude of Agricultural drought for Belg season 1981-2018(n=38)

Agricultural drought in both seasons of Belg and Kiremt has been observed in 10 years (27%) in the study period. Continuous, uninterrupted agricultural drought in both seasons were observed for 4 years from 1989 to 1992.The longest observed drought period for both seasons was observed between the periods 1981 and 2018. Seasonal Agricultural drought was recorded in every 3 years between the periods 1983-1989 and between the years 2006 and 2009. Seasonal Agricultural drought was recorded every year uninterrupted between the years 1989-1992 successively.

Table 9. Seasonal Agricultural drought for by season 1981-2018

Both season agricultural drought years	Belg Season Severity	Kiremt season Severity
1983	Severe	Mild
1986	Moderate	Mild
1989	Moderate	Severe
1990	Moderate	Mild
1991	Mild	Mild
1992	Mild	Mild
2002	Mild	Mild
2006	Mild	Mild
2009	Mild	Mild
2015	Mild	Mild

Source: Survey data by author

Agricultural drought was observed in both seasons of the year in 12 years during the study period including the years:1983,1986,1987,1989,1990,1991,1992,1993,2002,2006,2009 and 2015.

Table 10.Agricultural drought occurrence by year and Season for 1981-2018

Year	Season of Occurrence	year	Season of Occurrence
1983	Belg	1995	Kiremt
1984	Belg	1982	Kiremt
1986	Belg	1983	Kiremt
1989	Belg	1986	Kiremt
1990	Belg	1987	Kiremt
1991	Belg	1989	Kiremt
1992	Belg	1990	Kiremt
1994	Belg	1991	Kiremt
1998	Belg	1992	Kiremt
1999	Belg	1993	Kiremt
2000	Belg	2002	Kiremt
2002	Belg	2006	Kiremt
2003	Belg	2008	Kiremt
2004	Belg	2009	Kiremt
2006	Belg	2014	Kiremt
2009	Belg	2015	Kiremt
2012	Belg		
2013	Belg		
2015	Belg		

The finding of extreme agricultural drought in July 1987 and in Belg season of 1984 in this study is in agreement with the finding of Mekonen et al., (2020) on the research conducted in Northeast Ethiopia. Similarly, the same author reported extreme agricultural drought in March 2008 in North East Ethiopia. The finding of seasonal agricultural drought in Belg in the year 1984 in this study agrees with the report of Shanko and Camberlin, (1998) who reported that 72% of Ethiopia's region were affected by Belg season agricultural drought. Agricultural drought in both seasons of Belg and Kiremt has been observed in 10 years (27%) in the study period and they were seen from 1983-2015. Three agricultural drought frequencies in each of the three decades of 1981-1989, 1990-1999 and 2000-2009 were recorded. In the decade 2010-2018 only one both seasonal agricultural droughts were recorded. This indicates that the three decades that lie between 1981-2009 were the driest years recorded for Misrak Belesa within the study periods. Continuous, uninterrupted seasonal agricultural drought in both seasons was observed for 4 years from 1989 to 1992.Which is the longest observed drought period for both seasons between the periods 1981 and 2018.

Monthly agricultural drought for the year 2015 in this study was observed in June 2015 SPI 1= -1.48. In July 2015 with SPI1 =-1.31 and in August 2015, SPI1= -1.17. In addition, seasonal agricultural drought for Belg with SPI3= -0.06 and Kiremt season with SPI3= -0.23 were recorded. This finding of agricultural drought in both seasons and in three consecutive months makes the year 2015 an agricultural drought year. This finding is in agreement with the finding of Philip et al., 2018 who reported that the year 2015 in North and central Ethiopia as a very dry year due to the effects of the El Niño.In the current study, multiple time scale occurrence of agricultural drought was observed in the year 2002. Both Belg and Kiremt seasonal agricultural drought with SPI3 values -0.8 and -0.2 respectively were recorded. In addition to the seasonal occurrence of agricultural drought in both seasons, monthly agricultural drought was recorded in four months. These include monthly agricultural drought in February, March, July and August with SPI1 value of -0.24, -0.1, -0.39, and -0.34 respectively. This implies that the year 2002 was an agricultural drought revealed in monthly and seasonal calendars. This finding agrees with the reporting of Alem (2017) who found the year 2002 as a year of short season rainfall affecting all regions of Ethiopia except Somali region affecting ten million people.

Similarly, in this study, Belg and Kiremt seasonal agricultural droughts with SPI3 of -0.38 and -0.98 were observed in the year 2006. In addition to the seasonal agricultural drought incidences, monthly agricultural drought was recorded in March, April and June 2006 with respective SPI values of -0.22, -0.64, -0.09. This finding implies that the year 2006 was agricultural drought year impacting lives and livelihoods of Misrak Belesa Communities. This finding agrees with the finding of Alem (2017) who reported the year 2006 as a year of drought characterized by rainfall failure in both seasons in lowland areas of Amhara and other parts of Ethiopia.

In this study, both seasonal (Belg SPI3= -0.06 and Kiremt SPI= -0.23) and monthly (March SPI1 of -0.29) agricultural drought was also observed in the year 2015. Alem (2017) also reported the year 2015 as a year of El Nino induced drought affected nearly all nine regions of Ethiopia affecting ten million people.The study used only rainy months and farming seasons of Belg and Kiremt to quantify agricultural drought. The dry periods were not considered in the analysis. According to the survey 100% of the study households practice rain fed agriculture. The use of irrigation for farming in the woreda is almost nil. This aggravates the vulnerability of the households to the effects of agricultural drought.The finding of this study indicated that crop farming and livestock production practices of the woreda were vulnerable to the recurrent agricultural drought episodes. This study measured the food security status of the 402 households and 89% of the study households were found food insecure while Food production accounted for the 65.1% share of net available dietary energy for the study households. The finding of the monthly and seasonal agricultural drought indicated that agricultural drought is a recurrent natural hazard impacting lives and livelihoods of populations at risk in Misrak Belesa woreda. The result of monthly and seasonal analysis of agricultural drought clearly showed recurrent agricultural drought incidences with varied magnitude and frequency between the year 1981 and 2018. Though, agriculture is the main source of food, income and employment for the study households, its performance and productivity has been under threat of varied degrees of agricultural drought episodes. This finding implies agricultural drought has been impacting agricultural practices of the households of the woreda and hence the food production of the study households was under threat. This finding is well confirmed with the finding of high prevalence of food insecurity among the study households. This finding agrees with the reports of Williams et al,(2011) who reported that agricultural drought is regarded as the leading cause of food insecurity in sub-Saharan Africa (SSA) since the region depends on rain-fed agricultural production (Williams et al., 2011).The current finding also agrees with Mesay (2011) who reported that erratic rainfall distribution has adversely affected Ethiopian agricultural production, in general and the sustainability of household food security in particular. The finding of the current study agrees with the reports of USAID which reported Forty eight of the 105 woreda of Amhara regional state are drought prone and suffer from frequent food shortages as a result of agricultural drought (USAID, 2000). This finding is also in agreement with Ngcamu & Chari, 2020 who stated that the frequency, duration, and intensity of agricultural droughts have generally increased worldwide, posing a constant threat to world food security.

4.3. Effects of agricultural drought on food security of households

This study attempted to examine the effect of Agricultural drought on food security of study households through its effect on productivity of cereal crops. The annual cereal production data was collected from Misrak Belesa Agriculture office through an official letter. (See annex). Accordingly, data for teff and sorghum produced per annum for the periods from 1995 to 2014 was collected. The annual production of teff was regressed against its corresponding seasonal SPI 3 for June, July and August rainy months were considered for Kiremt season to examine its effect on teff productivity. The time series regression analysis between annual teff production data and SPI3 for kiremt revealed that there is a negative association between SPI3 and annual teff production. The result of the model indicated that a unit increase in SPI3 results in drop of teff production. This result indicates that agricultural drought impacts crop productivity and hence food security of rural households in Misrak Belesa woreda. Teff is the most widely produced crop in Misrak Belesa and it has been selected for the analysis. Agricultural drought impacts damage to crops and pasture thereby reducing productivity of rain fed agriculture.

Table 11. Regression between teff annual production and SPI-3 with time variable

```
. reg Teff_prodperanum SPI3_Kiremt t

      Source |       SS           df       MS      Number of obs   =        14
-------------+----------------------------------   F(2, 11)        =      0.11
       Model |   158921410         2   79460705   Prob > F        =    0.8944
    Residual |  7.7511e+09        11  704641336   R-squared       =    0.0201
-------------+----------------------------------   Adj R-squared   =   -0.1581
       Total |  7.9100e+09        13  608459700   Root MSE        =     26545

------------------------------------------------------------------------------
Teff_prodp~m |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
 SPI3_Kiremt |  -8603.263   18163.19    -0.47   0.645    -48580.17    31373.65
           t |   452.7962   2066.661     0.22   0.831    -4095.895    5001.487
       _cons |   115339.8   15147.21     7.61   0.000     82000.97    148678.5
------------------------------------------------------------------------------
```

Source: Survey data by author

Table 12. Data on annual yield of Teff and Sorghum Misrak Belesa woreda

Year	**Agricultural drought Observed**	**Land covered withTeff in ha**	**Teff production in Quintal**	**Teff Productivity per ha**	**land covered with Sorghum ha**	**Sorghum productivity per ha**	**Sorghum productivity**
2002	Belg and Kiremt Mild Agricultural drought	9938	129181	13	7000	112000	16
2003	Extreme Drought monthly in April and Belg Mild Agricultural drought	9848	104388.8	11	7010	113562	16.2
2004	June monthly severe and Belg Mild Agricultural drought	9930	109230	11	7031	105465	15
2005	Moderate Monthly agricultural drought in August	9801	122512.5	13	7200	104400	14.5
2006	Belg and Kiremt Mild Agricultural drought	9870	118440	12	7100	104725	14.75
2007		10087	100870	10	7140	99960	14
2008	Moderate in June, Kiremt Mild Agricultural drought	10287	100891	10	7210	152735	21.2
2009	Belg Mild and Kiremt Mild agricultural drought	12360	117420	10	8340	62550	7.5
2010	Moderate monthly in February	11088	110880	10	7893	94716	12
2011	Moderate monthly in February	14021	118896	8	7950	112478	14.15
2012	Extreme monthly in April and Belg Mild Agricultural drought	16291	146268	9	5247	58590	11.17
2013	Belg Mild Agricultural drought	16007	162995	10	5679	96416	16.98
2014	Moderate monthly in June and Kiremt Mild Agricultural drought	16007	126557	8	56416	91991	1.63
2015	Moderate monthly in July and Belg Mild and Kiremt Mild	14149	54540	4	5709	48174	8.44
2016		14870		0	7981	95140	11.92
2017		16275	150796	9	5513	72078	13.07
2018		15710	147674	9	4790	64665	13.5
2019		16652	148631	9	439	50139	114.2
2020		16849	164159	10	4322	52645	12.2
2021		16686	196600	12	4538	60691	13.4

Source: Agriculture office of Misrak Belesa Woreda and author computation of SPI3.

The finding of opposite relationship between SPI3 and annual teff production indicates that agricultural drought has effect on crop and livestock farming of Misrak Belesa woreda. This finding is in agreement with the literature facts reported by different scholars including Gunatilake (2015) who reported that Severe agricultural droughts may have an impact on the people who have selected agriculture (food production) or its related activities as their main livelihood. Pokot County in Kenya reported that agricultural droughts undermine farm yields thereby reducing household food availability and agricultural income derived from crop sales. Poor harvests threaten food security and livelihoods of household. In support of the current finding, Crop failure was reported Lolemtum et al., (2017) to be the worst immediate impact of agricultural drought on people's livelihoods. Birara et al (2005) argues that "Population pressure, agricultural drought, shortage of farmland, deterioration of food production capacity, plant and animal disease, frost attack, lack of cash income, poor farming technologies; and pre and post-harvest crop loss are major causes of food insecurity." Nyandiko et al (2002) on study conducted in Kenya reported that agricultural drought and climate change has had disastrous consequences on maize production. The climate change induced agricultural droughts of 1982, 1992, 2000, 2003, 2007 and 2009 wreaked havoc on maize production and food security in Kenya. Alem (2017) reported that 1984, 2002 droughts were the most devastating and historic in creating huge food shortage for a large proportion other population that relied heavily and predominantly on subsistent-rain-fed agriculture and pastoral livelihood. In the current study also, agricultural drought in both seasons and monthly were observed in these years and their impact is expected to be high for rain fed agriculture dependent communities of Misrak Belesa. Singh et al. (2016) reported that the impacts of the 2015 agricultural drought go beyond total precipitation deficits, both the timing and the spatial distribution of rainfall impacted livelihood activities, such as agriculture and pastoralism. This finding agrees with the current finding of agricultural drought impacting of teff production in Misrak Belesa woreda. Kebede et al., (2013) reported that agricultural drought leads to shortage of food supplies, which dramatically increased food prices and had a direct and severe effect on the more vulnerable and poor communities The finding of the negative effects of agricultural drought on cereal production is supported by various theories of food security. The FAD model argues that anything which disturbs food production, such as drought by reducing the availability of food for extended period of time causes famine. Natural calamities such as earthquake and drought, and manmade disasters like war and conflict may decimate agricultural production and result in pervasive food shortages that may lead to famine (Mesay, 2001).

4.4. Household perceptions on agricultural drought and its effect on their food security

Households were asked to choose which type of natural shock they have encountered in the past two years. 69.3%(n=278) of respondents perceived that agricultural drought and desert locust infestation as the most frequently occurring hazard in the past two years that had major effects on their crop dependent livelihoods.16%(n=64) of respondents agreed that agricultural drought, flood and animal diseases are as the most frequently occurring hazard in the past two years. The remaining 15 %(n=60) agreed that agriculture drought and animal diseases were hazards of importance that have occurred the past two years. Agriculture drought was the most important hazard perceived by majority of households in the study. The study Household's perception on satisfying the food needs of the household following their own production and stocks last year. It was found out that high number of study households 82 %(n=329) agree that households failed to meet food needs of the household following their own production and stocks last year (2014). Similarly, 72%(n=72) of the households agreed that they have to meet food needs of the household following their own production and stocks last year (2014).

Table 13. Household response on meeting food needs of their households in 2014 EC

Perception Satisfy HH food need	Freq.	Percent	Cum.
Yes	**329**	**81.84**	**81.84**
No	**72**	**17.91**	**99.75**
No comment	**1**	**0.25**	**100**
Total	**402**	**100**	**100**

Source: Author survey data

72.3%(n=238) and 26.7%(n=88) 1%(n=3) respondent households who perceived that they do not meet the needs of their household food needs last year agreed that production shortfalls due to agricultural drought and high market price of agricultural inputs respectively were considered as the two most important reasons for not meeting the food needs of their households last year.

All household members agree that between now and 40 years ago hazard agricultural drought has increased. Similarly, 99.75 %(n=401) agree that surface temperature of the woreda has increased.99.5 %(n=400) agree that water bodies decreased between now and 40 years back.

Table 14 Hazard phenomenon and household perception on its trend

```
. tabulate ag_drought
```

ag_drought	Freq.	Percent	Cum.
1	402	100.00	100.00
Total	402	100.00	

```
. tabulate temprature
```

temprature	Freq.	Percent	Cum.
1	401	99.75	99.75
2	1	0.25	100.00
Total	402	100.00	

```
. tabulate water_body
```

water_body	Freq.	Percent	Cum.
1	2	0.50	0.50
2	400	99.50	100.00
Total	402	100.00	

Source: Survey data by author

4.5. Household food Security Status

It was found out that the study Households practice crop farming as their main source of income and food. Teff, Sorghum, Maize and Mungbean were the most widely cultivated cereal grains as source of income and food. In 2014 E.C farming season, the study households produced a total of 2,380, 1,421.8 698 and 486 quintals of teff, Mungbean, Sorghum and Maize respectively.

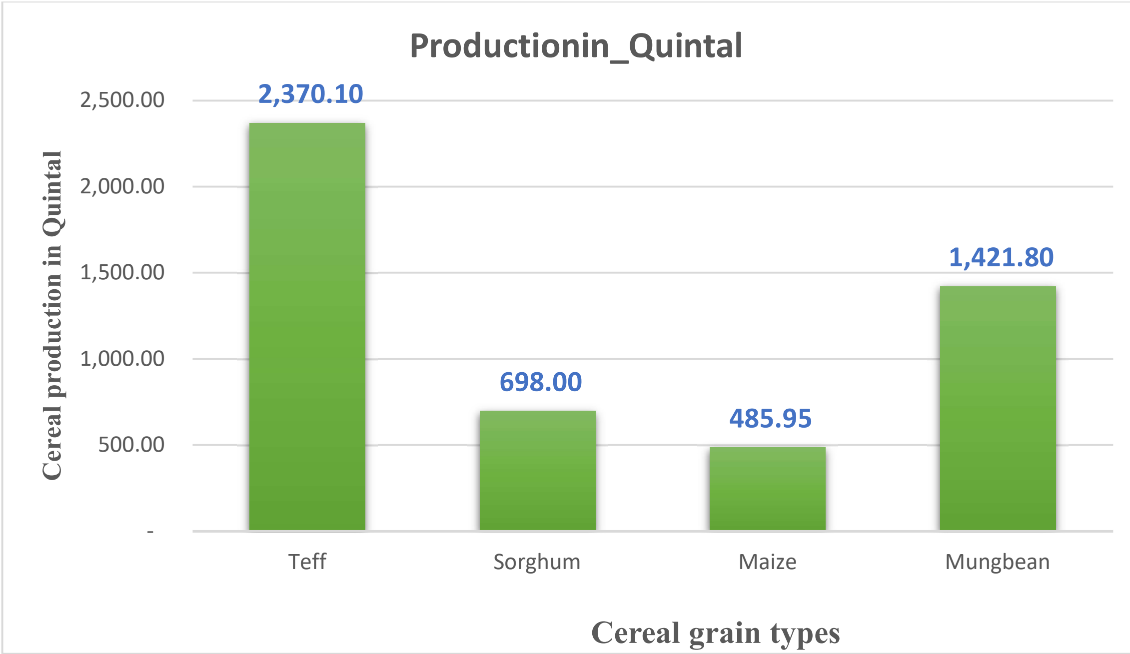


Figure 9. Cereal annual production of study households in 2014 EC

Similarly, each study household produced on average 5.9, 1.7, 0.4 and 1.2 quintals of teff, Sorghum, Mungbean and Maize respectively in 2014.

Table 15. Summary of total cereal production of households in 2014 EC

Variable	Obs	Mean	Std. Dev.	Min	Max
Totalteffp~l	402	5.895771	6.985832	0	72
TotalSorgh~l	402	1.736318	1.814014	0	10
TotalMaize~l	402	1.208831	4.082235	0	80
MungbeanP~10	402	.3536816	.4204927	0	4.5

Source: Survey data by author

Mungbean farming is becoming an emerging crop farming practice in Misrak Belesa Woreda. Mungbean is produced as a cash crop and households earn good price from sale of Mungbean grains. In 2014 production season, the study households have produced a total of 1,421.8 quintals of Mungbean. A total of 333(75.4%) households have produced Mungbean in 2014 farming year.287 households (71.4%) have sold 60% 838.35 quintals of the total produced to earn income. Making it an emerging cash crop produced in the woreda. A kilo of Mungbean is sold for 50 birrs from the woreda while teff and sorghum are sold at 36 and 28 ETB per kilo in the woreda.

It was found that 64.2% of study households received food aid. Study households received wheat as food aid through safety net program. The study households received a total of 403.2 quintal of wheat through food aid. Each household received on average 1 quintal of wheat. In the study, 65% of households obtained maize grain through purchase from the local market. Maize is used as food and for production of local drink called tella.

Table 16 Summary of aid food received by households

Variable	Obs	Mean	Std. Dev.	Min	Max
Wheataid_Q	402	1.002985	.9972549	0	8.1

Table 17.Share of Household food entitlement

Cereal Type	Source of Entitlement	100gm of edible portion	Net available energy in Kcal	Contribution
Teff	Production	150.2	254,977,267.00	35.45169795
Sorghum	Production	168.1	84,604,730.00	11.76332843
Maize	Purchase	153	150,346,597.50	20.9039897
Mungbean	Production	347	128,452,460.00	17.85985812
Wheat	Food aid	205.3	100,843,360.00	14.02112581
Total			719,224,414.50	100

Source: Survey data by author

Food production, accounts for the 65.1% share of net available dietary energy for the household. Food entitlement through purchase accounted for 21% and entitlement through food aid accounted for 14% of the net available energy.

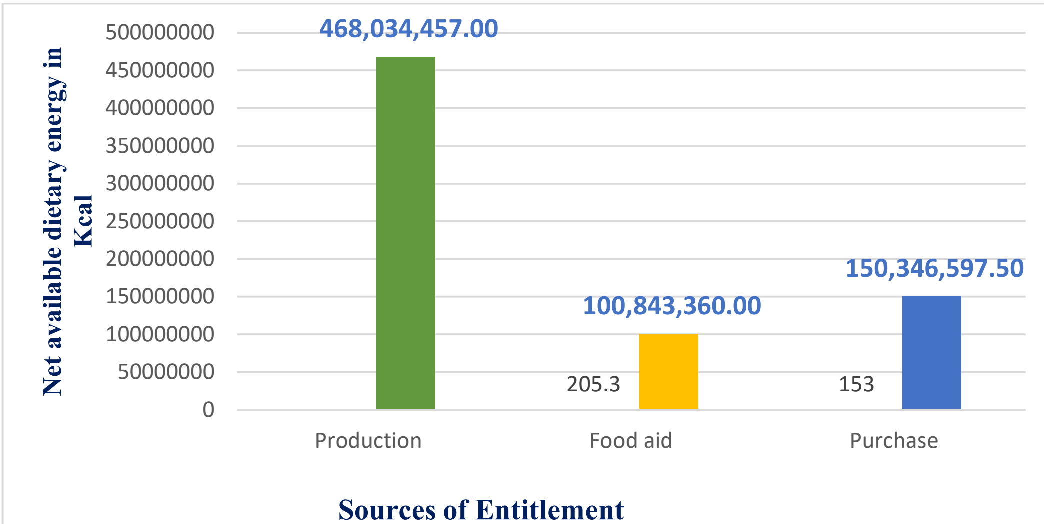


Figure 10. Entitlement shares of available energy in Kcal

Household food security status was measured using household food balance sheet Model. Food security status of households was calculated based on the information on which type of cereal grain is produced, purchased, obtained through food aid as gift from others and the most widely consumed form of food. The most widely produced grain type in the woreda is Sergegna (dibilik) teff. The households use teff, sorghum and maize in the form of injera. Wheat is used as bread. Mungbean is used as sausage (wot). The calorie content of 100g of edible portion is taken from Food composition table used in Ethiopia.

Table 18.Cereal grain and their estimated calorie in 100 grams of edible portion

S/no	Food and description	Food energy in 100g of edible portion

1	**Teff, ergotis teff (Zuuc), Trott, dibiliq injera**	**150.2**
2	**Wheat, tricum Vulgaae VIII, Black, Bread**	**205.3**
3	**Sorghum mixed, Injera**	**168.10**
4	**Corn (Maize) White, Injera**	**130.00**
5	**Mungbean sause**	**347**

Source: Survey data by author

Household food balance sheet model HFBSM was calculated to determine food security status of the study households. Percapita consumption of 2100kcal is used as cutoff value for food security status of household members. Those who consumed 2100 kcal and above are considered food secure. Accordingly, eighty nine percent 89 %(n=358) of the households were found to be food insecure and 11% of the households were Food secure.

4.1.7. Household Food Security Status by Agroecology

Out of the 358 food insecure households, 189 were from Zoz Kebele and 169 were from Hamusit Kebele. Zoz is Woinadega and Hamusit is kola in agroecology. Similarly, from 44 food secure households 32 were from Hamusit and 12 were from Zoz Kebele. Fifty two percent 52.8 %(n=189) of food insecure households were from Zoz Kebele and 47.2% were from Hamusit Kebele. Similarly, seventy-two point seven 72.7 %(n=32) percent of food secure households were from Hamusit Kebele and the remaining 27.3 %(n=12) were from Zoz Kebele. Nighty four 94% (n=189/201) of households in Zoz Kebele and 84 %(n=169/201) of households in Hamusit Kebele were found to be food insecure.

Table 19 Food security status by Agroecological belts (Hamusit= Kola; Zoz = Woinadega

Kebele	Food Secure	Food Insecure	Total
Hamusit	169	32	201
Zoz	189	12	201
Total	**358**	**44**	**402**

Source: Survey data by author

The mean percapita dietary consumption for Kola and Woina Dega agroecology were 1,217.14kcal (STD, Dev=1050.46) and 1,169.77 kcal (STD Dev=1032.79)

Table 20 .Summary of Mean Per capital Dietary energy in Kcal by Agroecological belts (Hamusit= Kola; Zoz = Woinadega

Agroecology	Mean	Std. Dev.	Freq.	Percentage
Woina Dega	1,217.41	1,050.46	201.00	50.00
Kola	1,122.13	1,032.79	201.00	50.00
Total	**1,169.77**	**1,041.46**	**402.00**	**100.0**

Source: Survey data by author

4.1.8. Household Food Security Status by Gender

Out of 358 food insecure households, 84.1 %(n=301) were male headed households and the remaining 15.9 %(n=57) were Women headed households. From the total of 44 food secure, households, 77.3 %(n=34) were male headed households and the remaining 22.7 %(n=10) were women headed households. From the total of 335 male headed study households, 89.9% (n=301) were food insecure and the remaining 10.1% (n=34) were food secure.57 out of 67 (85.1%) female head households were food insecure and the remaining 10 out of 67 female headed households were food secure.

Gender	Food insecure	Food secure	Total
Male	301	34	335
Female	57	10	67
Total	358	44	402

Table 21. Food security status by gender of head of household

Source: Survey data by author

The mean percapita dietary energy consumed by male and female headed households was 1,152.78 (STD Dev=1,021.83) and 1,254.71(STD Dev=1,138.96) respectively.

Table 22. Summary of Percapita Dietary energy consumption by gender

Gender	Mean	SD	Freq.	Percentage
Male	1,152.78	1,021.83	335.00	83.33
Female	1,254.71	1,138.96	67.00	16.67
Total	1,169.77	1,041.46	402.00	100.00

Source: Survey data by author

4.1.9. Household Food Security status by Age group of respondent household heads

The net available calorie of different age groups was examined. Close to half of the study population 50.75%(n=204) with age category between the age of 31 and 45 years consumed mean percapita dietary energy of **1,126.3kcal (Std Dev= 998.08676)**. Nearly a quarter 25.62 %(n=103) of the study population which were between the age of 46 to 64 had percapita consumption of dietary energy of **956.3(STD Dev= 684.558) Kcal.**

Table 23. Mean Percapita dietary energy by age group of respondent household heads

Age group	Frequency	Percentage	Mean Per capital Dietary energy in Kcal	SD
Less than 30 years	77	19.15	1,538.044	1411.4012
31 to 45 years	204	50.75	1,126.3425	998.08676

46 to 64	103	25.62	956.35368	684.5582
Greater than 65 years	18	4.48	1,312.0787	1,020.1502
Total	**402**	**100**	**1,169.7714**	**1,041.4578**

Source: Survey data by author

4.1.10. Household food security status By Family Size

Nearly sixty percent of the study whose households had a family size of less than five had mean Percapita dietary energy consumption of 1,505(Std Dev=. 1,228.69). Thirty nine percent 39 %(n=158) of the study households who had family size between 6 and 9 recorded mean Percapita dietary energy of 689.11(Std Dev=292.18) In the current study, households with more number of family size had less quantity of available dietary energy. Food consumption increased

Table 24. Summary of Percapita Dietary energy consumption

Family Size group	Mean	Std. Dev.	Freq	Percentage
Less than 5	1,505.34	1,228.69	238	59
6 to 9	689.11	292.18	158	39
Greater than 10	657.42	193.26	7	2
Total	**1,169.77**	**1,041.46**	**402**	**100**

Source: Survey data by author

4.1.11. Household food security status by Marital

Mean Dietary percapita energy consumption was higher for households with single marital status (mean=1,655.12, SD 1,538.35) and divorced marital status (mean=1,114.39, SD=518.06). This could be due to smaller household sizes in both single and divorced households.

Table 25 Summary of Mean percapita energy consumption

Marital Status	Mean	Std. Dev.	Freq.	Percentage
Single	1,655.12	1,538.35	64.00	15.92
Married	1,088.46	923.69	306.00	76.12
Divorced	1,114.39	518.06	22.00	5.47
Widowed	673.48	198.66	10.00	2.49
Total	**1,169.77**	**1,041.46**	**402.00**	**100.00**

Source: Survey data by author

4.1.12. Household food security status by level of education

Net available dietary energy for Diploma holders and those with adult education was higher. Mean percapita dietary energy for households with no school was less than those who went to school. This indicates that education is important for improving food security of households.

Table 26. Summary of percapita consumption.

Education Level	Mean	Std. Dev.	Freq.	Percentage
No School	1,071	901	224	56
Adult Education	1,304	745	7	2
Primary School	1,279	1,215	164	41
Diploma	1,778	830	6	1
Degree and above	895	-	1	0
Total	1,170	1,041	402	100

Source: Survey data by author

Household food security status was measured using modified household food balance sheet model. Food security status of households was calculated based on the information collected from the household survey data. Percapita consumption of 2100kcal is used as cutoff value for delineating food secured households and food insecure household members. The result of the computation of food security status using household food balance sheet model revealed that eighty nine percent 89 %

(n=358) of the households were found to be food insecure and 11% (n= 44) of the households were food secure. The study found out that food production accounts for the biggest share of food entitlement for the study households. It was found that food production took 65.1% of share of net available dietary energy for the household. Food entitlement through purchase accounted for 21% and entitlement through food aid accounted for 14% of the net available energy. It was found that 64.2% of study households received food aid. The high prevalence of food insecurity reflected in this study among the study household could be attributed to the high dependency of the households on agricultural food production (65%) for food entitlement. On the contrary, the food production/agricultural farming of the study households underwent through continuous threat of recurrent agricultural drought which was revealed by agricultural drought quantification result of the current study. In addition to the effects of recurrent agricultural drought, shortage of farmland, the high stone fragment cover and content of the farm land and shortage of resources could be attributed to the ravaging widespread food insecurity of communities of Misrak Belesa. It was observed that most of the agricultural farm land of the woreda is characterized by being covered with widespread rock fragments of different size (See picture annexed). The average farmland size of the study households was 2.5 hectares which is higher than the regional average of 1.09. However, most of the farm land in use by the farmers is covered with ample stone fragments of different size. The stone fragments were so abundant and it is clear that the stone fragments shrink the farmland productivity as these covers and deny large surface area of farm contact with seeds.

The finding of high percentage of food insecure households in this study the woreda is expected as the woreda was labeled as one of 105 food insecure woredas in Amhara region. In this study it was found that the woreda has been under threat by recurrent agricultural drought. Agricultural drought impacts crop production and hence reducing the annual yield of cereal crops. This is also reported by IIRR and Save the Children USA (2007) that increasing number of droughts induced disaster, associated with other hazard, is reflected in in the increasing number of people needing food assistance in Ethiopia. The current finding is also in agreement with the reporting of Gunatilake (2015) who stated severe agricultural droughts may have an impact on the people who have selected agriculture (food production) or its related activities as their main livelihood. The finding of this study is in agreement with the findings of Agidew & Singh (2018) who reported drought, shortage of rainfall, and shortage of farmland are believed to be the major causes of food insecurity. The finding of high percentage of study households being food insecure and its probable attribution to recurrent agricultural drought affecting food production is also in agreement with the theories of general explanation theory, Food Availability Decline Theory (FAD) and climatic theory. According to these theories, climatic conditions like drought or flood causes crop failure and can lead to famine in rain-fed agricultural areas. Binary logistic regression model was used to examine determinants of food security status of households. Food security status was used as dependent variable and eight explanatory variables were used as independent variables. The independent variables fitted into the model include: credit amount, number of donkeys, number of oxen, agronomic practices, soil conservation practices, farm size, age of household heads and family size. Test for multicollinearity between independent variables was performed using Variance inflation factor. The result of the variance inflation factor for the independent variables is close to one and a value of one indicates there is no correlation between the given explanatory variable and another independent variable in the model. The model's goodness of fit is also checked with pseudo R squared which is 47% and this indicates the model is well fitted. The result of the binary logistic regression model indicated that seven of the independent variables including credit amount, number of donkeys, number of oxen, agronomic practices, soil conservation practices, farm size, and age of household heads had positive coefficients (B>0) indicating a positive relationship with the dependent variable which food security status. On the contrary family size had a negative coefficient (B<0) indication a negative relation with the response variable food security status. The result of the binary regression model implies that an increase in a unit value of credit amount, number of donkeys, number of oxen, agronomic practices, soil conservation practices, farm size and age of household heads increases the likelihood of households being food secure. On the contrary, an increase in family size decreases the likelihood that households become food secure. This finding is in consistent with the finding of Feleke et.al. (2005) who reported that technology used, farming systems, farm size, soil quality, family size are some of the factors affecting household food security in Ethiopia. Castro and Little (2000) indicated lack of oxen and shortage of farm land as underlying factors for vulnerability of rural households to food insecurity. The finding of this study showed that ownership of donkeys had positively affected household food security status. This could be due to the fact that donkeys as pack animals are used to transport inputs and outputs of farm products to the market. In addition to the transportation service of donkeys, unlike in other parts of Ethiopia, farmers were seen ploughing their farm land with donkeys (see Picture annexed). Those farmers who do not own two oxen, pair their ox with a donkey or a non-pregnant heifer or cow. The finding of this study showed that farmers who employ agronomic practices and soil and conservation measures have better likelihood of being food secured. Farmers in the woreda practice agronomic practices like crop rotation and use chemical fertilizers, and pesticides and improved seeds. The farms also practice soil and water conservation practices like watershed management and stone bunds.

4.1.13. Determinants of household food security status

Binary logistic regression model was used to examine determinants of food security status of households. Food security status was used as dependent variable and eight explanatory variables. The output of the model indicated that an increase in a unit value of credit amount, number of donkeys, number of oxen, agronomic practices, soil conservation practices, farm size and age of household heads increases the likelihood of households being food secure. On the contrary, an increase in unit value of family size decreases the likelihood that household's food security status. Test for multicollinearity between independent variables was performed using Variance inflation factor. The result of the variance inflation factor for the independent variables is close to one and a value of one indicates there is no correlation between the given explanatory variable and another independent variable in the model. The model goodness of fit is also checked with pseudo R squared which is 47%.

Table 27. Summary of Binary logit model output.

```
Logistic regression                               Number of obs     =        401
                                                  LR chi2(8)        =     131.65
                                                  Prob > chi2       =     0.0000
Log likelihood = -72.899545                       Pseudo R2         =     0.4745
```

FoodSec_Status	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
credit_amt	9.13e-06	7.98e-06	1.14	0.252	-6.50e-06	.0000248
no_donk	.3124663	.1776701	1.76	0.079	-.0357607	.6606933
no_oxen	.3405448	.2341409	1.45	0.146	-.118363	.7994525
agron_pract	.0102508	.0174663	0.59	0.557	-.0239826	.0444842
soil_conserv	.2074408	.451701	0.46	0.646	-.6778768	1.092758
farm_size	.4705298	.1810066	2.60	0.009	.1157634	.8252962
Family_size	-1.625297	.236086	-6.88	0.000	-2.088017	-1.162577
age	.0650231	.0190796	3.41	0.001	.0276278	.1024184
_cons	-1.190194	1.022576	-1.16	0.244	-3.194406	.8140178

Table 28, Test for Multicollinearity among independent variables

```
. vif
```

Variable	VIF	1/VIF
age	1.38	0.726843
Family_size	1.31	0.763982
farm_size	1.27	0.789290
no_oxen	1.25	0.797728
no_donk	1.14	0.876331
soil_conserv	1.09	0.918753
credit_amt	1.05	0.949078
agron_pract	1.02	0.980847
Mean VIF	1.19	

Source: Survey data by author

CHAPTER FIVE

5. Conclusion and Recommendation

5.1. Conclusions

The main objectives of this study were to quantify magnitude and frequency of agricultural drought and its effect on household food security, to examine perception of households on agricultural drought and investigate current status of food security and its determinants in Misrak Belesa woreda. The study result showed that agricultural drought for Belg has occurred in 20 years and for Kiremt season occurred in 16 years for the period between 1981 and 2018. Agricultural drought in both seasons of Belg and Kiremt has been observed in 10 years (27%) in the study period. Continuous, uninterrupted agricultural drought in both seasons were observed for 4 years from 1989 to 1992.

Overall, the study found that recurrent agricultural drought is the most prevalent natural hazard that made rural households of Misrak Belesa woreda vulnerable to food insecurity. The result of the computation of food security status using household food balance sheet model revealed that eighty nine percent 89 % (n=358) of the respondent households were found to be food insecure and 11% (n= 44) of the households were food secure. The study found out that food production accounts for the biggest share of food entitlement for the study households. It was found that food production took 65.1% of share of net available dietary energy for the household. Food entitlement through purchase accounted for 21% and entitlement through food aid accounted for 14% of the net available energy. It was found that 64.2% of study households received food aid. The high prevalence of food insecurity reflected in this study among the study household could be attributed to the high dependency of the households on agricultural food production (65%) for food entitlement. On the contrary, the food production/agricultural farming of the study households underwent through continuous threat of recurrent agricultural drought which was revealed by agricultural drought quantification result of the current study. In addition to the effects of recurrent agricultural drought, shortage of farmland, the stone cover and content of the farm land and shortage of resources could be attributed to the ravaging widespread food insecurity of communities of Misrak Belesa. It was observed that most of the agricultural farm land of the woreda is characterized by being covered with widespread rock fragments of different size (See picture annexed). The average farmland size of the study households was 2.5 hectares per family which is higher than the regional average of 1.09. However, most of the farm land in use by the farmers is covered with ample stone fragments of different size, and most farms are found on steep slope. The stone fragments were so abundant and it is clear that the stone fragments shrink the farmland productivity as these covers and deny large surface area of farm contact with seeds.

The finding of high percentage of study households being food insecure and its probable attribution to recurrent agricultural drought affecting food production is also in agreement with the theories of general explanation theory, Food Availability Decline Theory (FAD) and climatic theory. According to these theories, climatic conditions like drought or flood causes crop failure and can lead to famine in rain-fed agricultural areas. Similar to the national and Amhara regional context, agriculture or food production is the main livelihood of people who live in Misrak Belesa woreda. Agriculture remains the back bone and the main source of, food income and employment for the rural communities of the majority communities of Misrak Belesa. However, the livelihood and agriculture sector of the rural communities is constrained by frequent occurrence of agricultural drought of various magnitude and severity. On the contrary Extreme weather conditions like agricultural drought is predicted to increase in severity, frequency, and duration. Therefore, measures that focus on mitigating the adverse effects of recurrent agricultural drought need to be closely followed appropriate measures be taken. It must be born in the mind of our readers is that the current study was conducted in Misrak Belesa woreda over a short period of time. Further in-depth research on agricultural drought using tools other than SPI is hence important to substantiate the current finding.

5.2. Recommendations

Agriculture is the main source of income, food and employment for households in Misrak Belesa Woreda. The finding of the study revealed widespread food insecurity and recurrent agricultural drought in the woreda. Agricultural drought impacts damage to crops and pasture thereby reducing productivity of rain fed agriculture. To improve the ravaging effects of agricultural drought and improve the livelihood and food security status of Misrak Belesa woreda communities the following recommendations need to be addressed and taken up by all actors including public and private, donors NGOs, communities and policy makers:

1. Strengthen and establish strong and functional agricultural drought early warning system and monitoring.
2. The government and all stakeholders need to implement disaster risk reduction approach that includes building of capacity of the communities through

prevention and mitigation measures and integrating these measures with the long-term development plan of the woreda is crucial.

3. Transform the current backward practice of rain fed agriculture with irrigation farming. As the woreda practices almost (100%) rain fed agriculture, the impact of agricultural drought is eminent from the study and irrigation practice is recommended.
4. Intensification of agricultural practices and soil and water conservation practices like integrated watershed management, afforestation need to be strengthened as these helps to improve farm productivity.
5. Public awareness on modern farming, environmental management, food security
6. Diversification of livelihoods and income sources. Government and aid organizations working in the area should focus on Livelihood diversification intervention through production of drought resistant livestock species. The agroecology of kola Kebeles are suitable for pastoral farming and goat and camel and poultry species which are relatively resistant to agricultural drought
7. Government and aid organizations should work on long term water development schemes and water and sanitation intervention that considers the recurrent agricultural drought situation sustainably so as to improve water availability and improve health of the woreda population. Further in-depth study on magnitude and frequency of agricultural drought using other methodologies and indices. In-depth research on the root causes of recurrent agricultural drought and their mitigation

References

Abi, M., Degaga, D. T., & Tolossa, D. (2015). HOUSEHOLD FOOD SECURITY STATUS AND ITS DETERMINANTS IN GIRAR JARSO WOREDA, NORTH SHEWA ZONE OF OROMIA REGION, ETHIOPIA *Journal of Sustainable Development in Africa*, *17*(7). https://www.researchgate.net/publication/326068971

Agidew, A. Meta A., & Singh, K. N. (2018). Determinants of food insecurity in the rural farm households in South Wollo Zone of Ethiopia: the case of the Teleyayen sub-watershed. *Agricultural and Food Economics*, *6*(1). https://doi.org/10.1186/s40100-018--4

Behailu, G., Ayal, D. Y., Zeleke, T. T., Ture, K., & Bantider, A. (2021). Comparative Analysis of Meteorological Records of Climate Variability and Farmers' Perceptions in Sekota Woreda, Ethiopia. *Climate Services*, *23*, 100239. https://doi.org/10.1016/j.cliser.2021.100239

Bonnard, P.(2000) Assessing Urban Food Security: Adjusting the FEWS Rural Vulnerability Assessment Framework to Urban Environment. USAID, Washington, D.C., 2000

Bossio,D.(2009).Livestock and water: Understanding the context based on the 'CompressiveAssessment ofWater Management in Agriculture', The Rangeland Journal, 31(2), 179–186.

Castro, A. P., & Little, P. D. (2000). Food Security and Resource Access: A Final Report on the Community Assessments in South Wollo and Oromiya Zones of Amhara Region, Ethiopia. https://www.researchgate.net/publication/42764597

Catharine Dawson, (2007) A Practical Guide to Research Methods, A user friendly manual for Mastering research techniques and projects, Third edition, howtobooks, Oxford United Kingdom

Collaborative, U., & Team, P. (2000). *AMHARA NATIONAL REGIONAL STATE FOOD SECURITY*

Crocetti, L. (2020), Earth Observation for agricultural drought monitoring in the Pannonian Basin (southeastern Europe): current state and future directions, Regional Environmental Change (2020) 20: 123 https://doi.org/10.1007/s10113-020-01710-w DOI, 10.1007/s10113-020-01710-w

CSA. (2012). Ethiopian Welfare Monitoring Survey 2011. National Statistical Summary Report. Addis Ababa, Ethiopia: Population Census Commission.

Degefa Tolosa. (1996) Belg crop production as a strategy of Households' Food security: A comparative Study of Belg Grower and non-Belg farmers in Munessa Woreda, Arsi Zone. MA Thesis, Addis Ababa University, Ethiopia

Dalezios, N. R., & Eslamian, S. (2017). *Principles of Drought and Water Scarcity Chapter 5 Agricultural Drought Indices : Combining Crop , Climate and Soil Factors*. *January*.

Devereux, S. (1993). Theories of famine. Harvestor wheatsheaf: New York and London.

Devereux, S. (2000). Food Insecurity in Ethiopia: A discussion paper for DFID. IDS, Sussex. FAO

Devereux, S. (2006). *The Impact of Droughts and Floods on Food Security and Policy Options to Alleviate Negative Effects*.

FAO. (2003). Trade reforms and food security: Conceptualizing the linkages. Rome: FAO

FAO. (2009). Climate Change and Food Security: A Framework Document. Food and Agriculture Organization of the United Nations, Rome, Italy.

Fasil, K., T. and Synnevag, G (2001). "Traditional CopingStrategies of the Afar and Borana Pastoralists in Response to Drought." Drylands Co-ordination Group Report No. 17. Noragric, Norway.

Fasemore, O.A.(2017). The Impact of Drought on Africa. Hitachi Rev. 2017, 66, 680–681.

Gunatilake, M. M. (2015). *Drought and Household Food Security in Rural Sri Lanka : A Case Study*. *2*(7).

Feleke S.T., Kilmer R.L., and Gladwin C.H. (2005). "Determinants of food security in Southern Ethiopia at the household level", Agricultural Economics 33/3: 352-363.

Garrett, J.L. and Ruel, M.T. (1999). Are Determinants of Rural and Urban Food Security and Nutritional Status Different? Some Insight from Mozambique. World Development 27(11) 1959-1875, 1999

IIRR and Save the Children USA,(2007).Leaving Disasters Behind, A guide to disaster risk reduction in Ethiopia.International Institute of Rural Recnstruction,Nairobi and Save the Children USA,Addis Ababa

Kebede, A., Diekkrüger, B., Moges, S.A., (2013). An Assessment of Temperature and Precipitation Change Projections using a Regional and a Global Climate Model for the Baro-Akobo Basin, Nile Basin. Ethiopia. J Earth Sci Climate Change 4, 133. https://doi.org/10.4172/2157-7617.1000133.

Kanwal, V., Sirohi, S., & Chand, P. (2020). Effect of drought on livestock enterprise: Evidence from Rajasthan. *Indian Journal of Animal Sciences*, *90*(1), 94–98.

Leal Filho, W (2012). Climate Change and the Sustainable Use ofWater Resources; Springer: New York, NY, USA, 2012.

Lin, Y., Deng, X., & Jin, Q. (2013). Economic effects of drought on agriculture in North China. *International Journal of Disaster Risk Science*, *4*(2), 59–67. https://doi.org/10.1007/s13753-013-0007-9

Lolemtum, J. T., Mugalavai, E., & Obiri, J. (2017). *Impact of Drought on Food Security in West Pokot*. *June*.

Mesay Mulugeta. (2001). Study on Rural Households Food Security of Kuyu Woreda, Oromiya Regional State. MA Thesis. Addis Ababa University.

Mesay Mulugeta.(2009). Causes of Rural Household Food Insecurity: A Case from Kuyu District, Central Ethiopia. Journal of Sustainable Development in Africa 11:286-304. Clarion University of Pennsylvania, Clarion, Pennsylvania.

Messay Mulugeta . (2011). Determinant of agricultural productivity and household food security: Case studies from Kuyu district, Central Ethiopia. LAP LAMBERT Academic publishing.

Mekonen, A. A., Berlie, A. B., & Ferede, M. B. (2020). Spatial and temporal drought incidence analysis in the northeastern highlands of Ethiopia. *Geoenvironmental Disasters*, *7*(1). https://doi.org/10.1186/s40677-020-0146-4

Meteorological, W., Wmo, O., Water, G., & Gwp, P. (n.d.). *Handbook of Drought Indicators and Indices* (Issue 1173).

Misrak Belesa Woreda office of agriculture annual report, 2022

NBE. (2020). Ethiopia : Macroeconomic And Social Indicators NBE Annual report 2019/2020. *NBE Annual Report*, *05*(2019/2020), 1–119.

Ngcamu, B. S., & Chari, F. (2020). *Drought Influences on Food Insecurity in Africa : A Systematic Literature Review*. 1–17.

National Oceanic and Atmospheric Administration NOAA, (2002). Droughts Facts. 2002. Available online: http://threeissues.sdsu.edu/three_issues_droughtfacts01.html.

Niang, I.; Ruppel, O.C.; Abdrabo, M.A.; Essel, A.; Lennard, C.; Padgham, J.; Urquhart, P. Climate Change(2014): Impacts, Adaptation and Vulnerability. In Contribution of Working Group II to the Fifth Assessment Report of the Inter-Governmental Panel on Climate Change; CaMisrak Bellessa ridge University Press: CaMisrak Bellessa ridge, UK; New York, NY, USA, 2014; pp. 1199–1265.

Oba G and Kotile D G. (2001). Assessments of landscape level degradation in southern Ethiopia: pastoralists versus ecologists. Land Degradation and Development 12(5): 461– 75.

Ojos Negros research group. (2004), Impact of drought on Ojos Negros valley, Mexico, accessed on DeceMisrak Bellessa er 28,2021 from web://threeissues.sdsu.edu/three_issues_droughtfacts05.html

Powell, J. M., Pearson, R. A., and Hiernaux, P. H. (2004). Review and interpretation. Crop-livestock interactions in the West African Drylands, Agron. J., 96, 469–483.

Philip, S., Kew, S. F., van Oldenborgh, G. J., Otto, F., O'Keefe, S., Haustein, K., King, A., Zegeye, A., Eshetu, Z., Hailemariam, K., Singh, R., Jjemba, E., Funk, C., & Cullen, H. (2018). Attribution analysis of the Ethiopian drought of 2015. *Journal of Climate*, *31*(6), 2465–2486. https://doi.org/10.1175/JCLI-D-17-0274.1

Philipose, A.(2018) Policy Implications of Droughts and Food Insecurity in Malawi. In Case Study (7-3): "Food Policy for Developing Countries: Domestic Policies for Markets, Production, and Environment"; Cornell University Press: Ithaca, NY, USA, 2018; p. 161.

Potop, V.; Možný, M. (2016). The Application a New Drought Index-Standardized Precipitation Evapotranspiration Index in the Czech Republic. Available online: http://www.cbks.cz/SbornikSMlyn11/Potop1.pdf (assessed on 8 October 2016).

Premanandh, J. (2011). Factors affecting food security and contribution of modern technologies in food sustainability. In Journal of the Science of Food and Agriculture (Vol. 91, Issue 15, pp. 2707–2714). https://doi.org/10.1002/jsfa.4666

Rankoana, S.A.(20160. Perceptions of climate change and the potential for adaptation in a rural community in Limpopo Province, South Africa. Sustainability 2016, 8, 672.

Shanko D, Camberlin P (1998) The effects of the Southwest Indian Ocean tropicalcyclones on Ethiopian drought. Int J Climatol 18(12):1373–1388

Shelton M. (2000). Reproductive performance of sheep exposed to hot environment. Sheep Reproduction in Hot and Arid Zones. Published by the Kuwait Institute for Scientific Research, pp. 155–162

Singh, R., and Coauthors, (2016): Reality of resilience: Per- spectives of the 2015–16 drought in Ethiopia. BRACED Resilience Intel,No. 6, http://www.braced.org/resources/i/?id518256c98-2a10-4586-9317-17a68b45c1a7.

Sutcliffe et al, (2014) Evidence and perceptions of rainfall change in Malawi: Do maize cultivar choices enhance climate change adaptation in sub-Saharan Africa? Reg. Environ. Chang. 2014, 16, 1215–1224

Von Braun, J.; McCo , J.; Fred-Mensah, B.K. and Pandya-Lorch, R., (1993) Urban Food Insecurity and Malnutrition in Developing Countries. Trends, Policies and Research Implications. International Food Policy Research Institute, Washington, D.C.,

United Nations Development Programme.(2010). Gender, Climate Change and Community-Based Adaptation; UNDP: New York, NY, USA, 2010.

United Nations Development Programme, (2004). The Preparation Team for Reducing Disaster Risk: A Challenge for Development a Global Report 2004.

USAID, (2000). USAID Collaborative Research Support Team, Amhara National Regional State Food Security Assessment Report.

USAID, (2003).Planning for the next Drought: Ethiopia Case Study

Williams AP, Funk C.(2011). A westward extension of the warm pool leads to a westward extension of the Walker circulation, drying eastern Africa. Clim Dyn. 2011; 37(11-12):2417–35. doi:10.1007/s00382-010-0984-y

West J W., (2003). Effects of heat-stress on production in dairy cattle. Journal of Dairy Science 86(6): 2131–44.

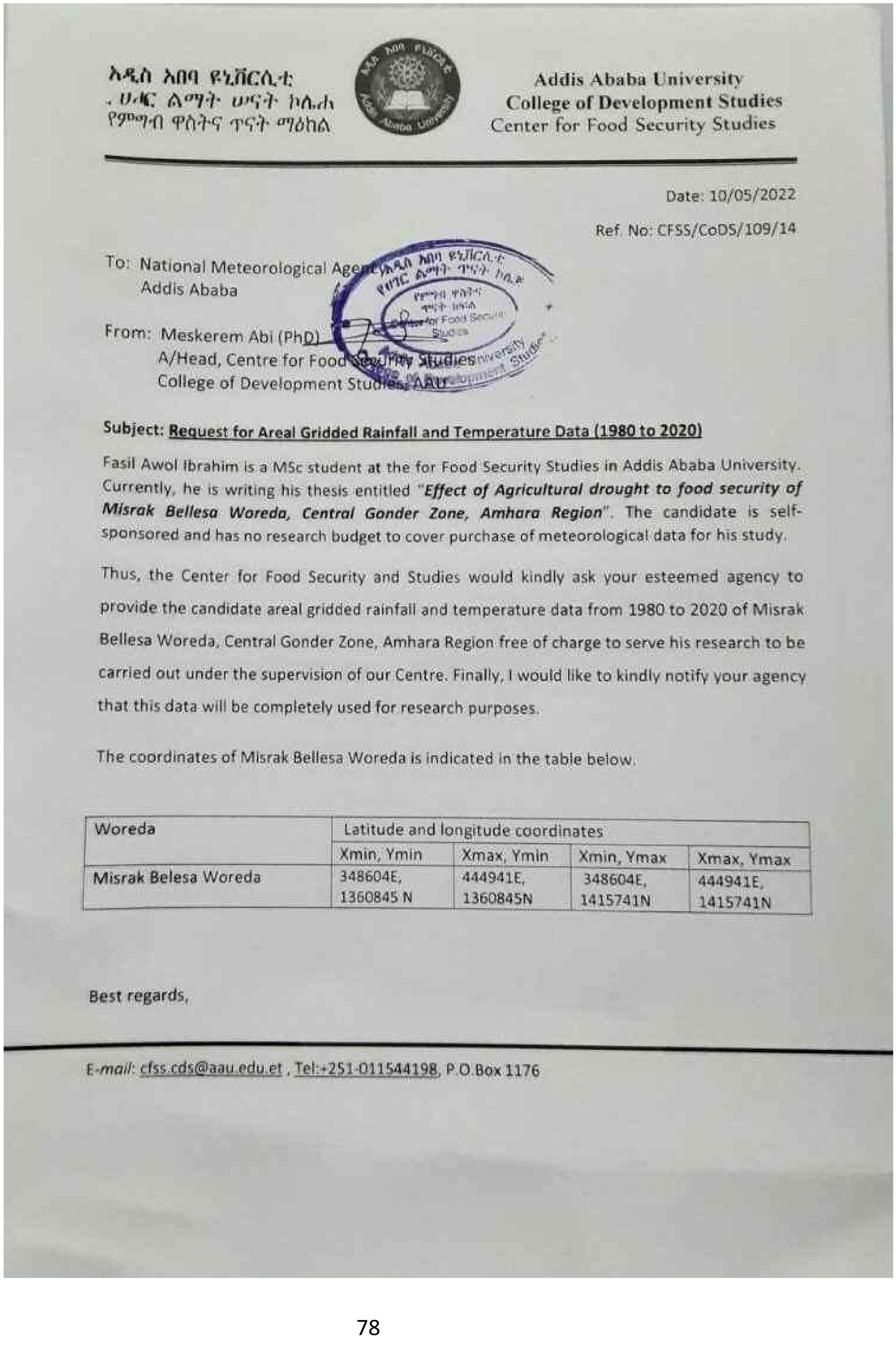
World Bank Group, (2020). Strengthening Hydromet and Early Warning Services in Belarus. World Bank, Washington, DC, p. 110.

Yamane, Taro. (1967). Statistics: An Introductory Analysis, 2nd Ed., New York: Harper and Row.

Yehuala, S., Melak, D., & Mekuria, W. (2018). The Status of Household Food Insecurity: The Case of West Belesa The Status of Household Food Insecurity: The Case of West Belesa, North Gondar, Amhara Region, Ethiopia. *Ethiopia Article in International Journal of Scientific Research and Management*. https://doi.org/10.18535/ijsrm/v6i6.ah02

Appendices

1. Official Letter written to National Meteorological Agency



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Addis Ababa University
College of Development Studies
Center for Food Security Studies

Date: 10/05/2022

Ref. No: CFSS/CoDS/109/14

To: National Meteorological Agency
Addis Ababa

From: Meskerem Abi (PhD)
A/Head, Centre for Food Security Studies
College of Development Studies, AAU

Subject: <u>Request for Areal Gridded Rainfall and Temperature Data (1980 to 2020)</u>

Fasil Awol Ibrahim is a MSc student at the for Food Security Studies in Addis Ababa University. Currently, he is writing his thesis entitled "***Effect of Agricultural drought to food security of Misrak Bellesa Woreda, Central Gonder Zone, Amhara Region***". The candidate is self-sponsored and has no research budget to cover purchase of meteorological data for his study.

Thus, the Center for Food Security and Studies would kindly ask your esteemed agency to provide the candidate areal gridded rainfall and temperature data from 1980 to 2020 of Misrak Bellesa Woreda, Central Gonder Zone, Amhara Region free of charge to serve his research to be carried out under the supervision of our Centre. Finally, I would like to kindly notify your agency that this data will be completely used for research purposes.

The coordinates of Misrak Bellesa Woreda is indicated in the table below.

Woreda	Latitude and longitude coordinates			
	Xmin, Ymin	Xmax, Ymin	Xmin, Ymax	Xmax, Ymax
Misrak Belesa Woreda	348604E, 1360845 N	444941E, 1360845N	348604E, 1415741N	444941E, 1415741N

Best regards,

E-mail: cfss.cds@aau.edu.et, Tel:+251-011544198, P.O.Box 1176

2. Official letter written to Misrak Belesa woreda

አዲስ አበባ ዩኒቨርሲቲ
. ሀብ ልማት ሠናት ኮሌጅ
የምግብ ዋስትና ጥናት ማዕከል

Addis Ababa University
College of Development Studies
Center for Food Security Studies

Date: 10/05/2022

Ref. No: CFSS/CoDS/110/14

To: Misrak Bellesa Woreda Office of Agriculture

From: Meskerem Abi (PhD)
A/Head, Centre for Food Security Studies
College of Development Studies, AAU

Subject: Request for cereal production data (1980 to 2020)

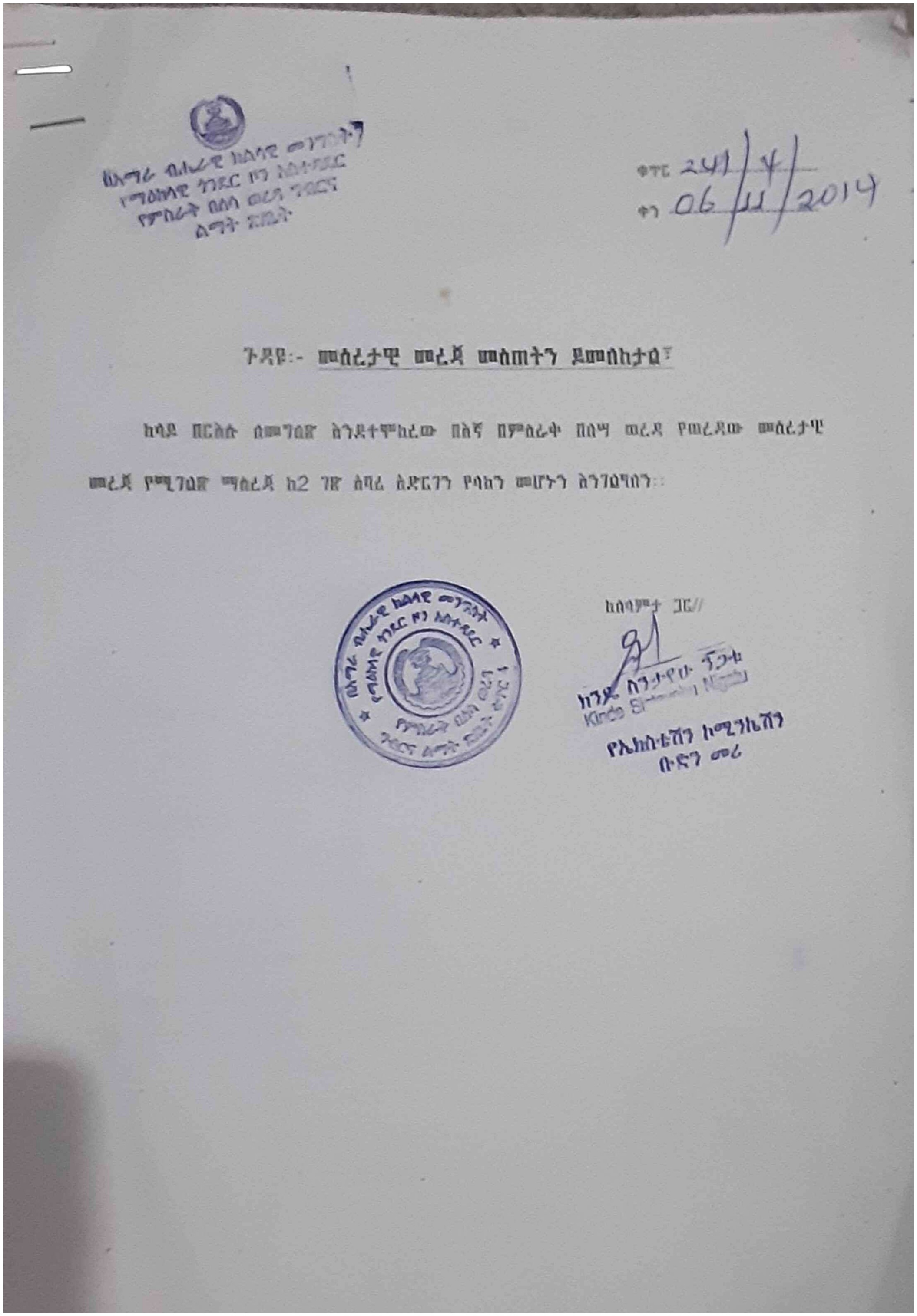
Fasil Awol Ibrahim is a MSc student at the for Food Security Studies in Addis Ababa University. Currently, he is writing his thesis entitled ***"Effect of Agricultural drought to food security of Misrak Bellesa Woreda, Central Gonder Zone, Amhara Region"***. The candidate is self-sponsored and has no research budget to cover purchase of data for his study.

The Center for Food Security and Studies would kindly ask your esteemed office to provide the candidate annual production of major cereals for the period from 1980 to 2020 data of Misrak Bellesa Woreda, Central Gonder Zone, Amhara Region free of charge to serve his research to be carried out under the supervision of our Centre. Finally, I would like to kindly notify your office that this data will be completely used for research purposes.

Best regards,

E-mail: cfss.cds@aau.edu.et, Tel:+251-011544198, P.O.Box 1176

3. Official Letter from Misrak Belesa woreda on data provided



ቁጥር 241/4/

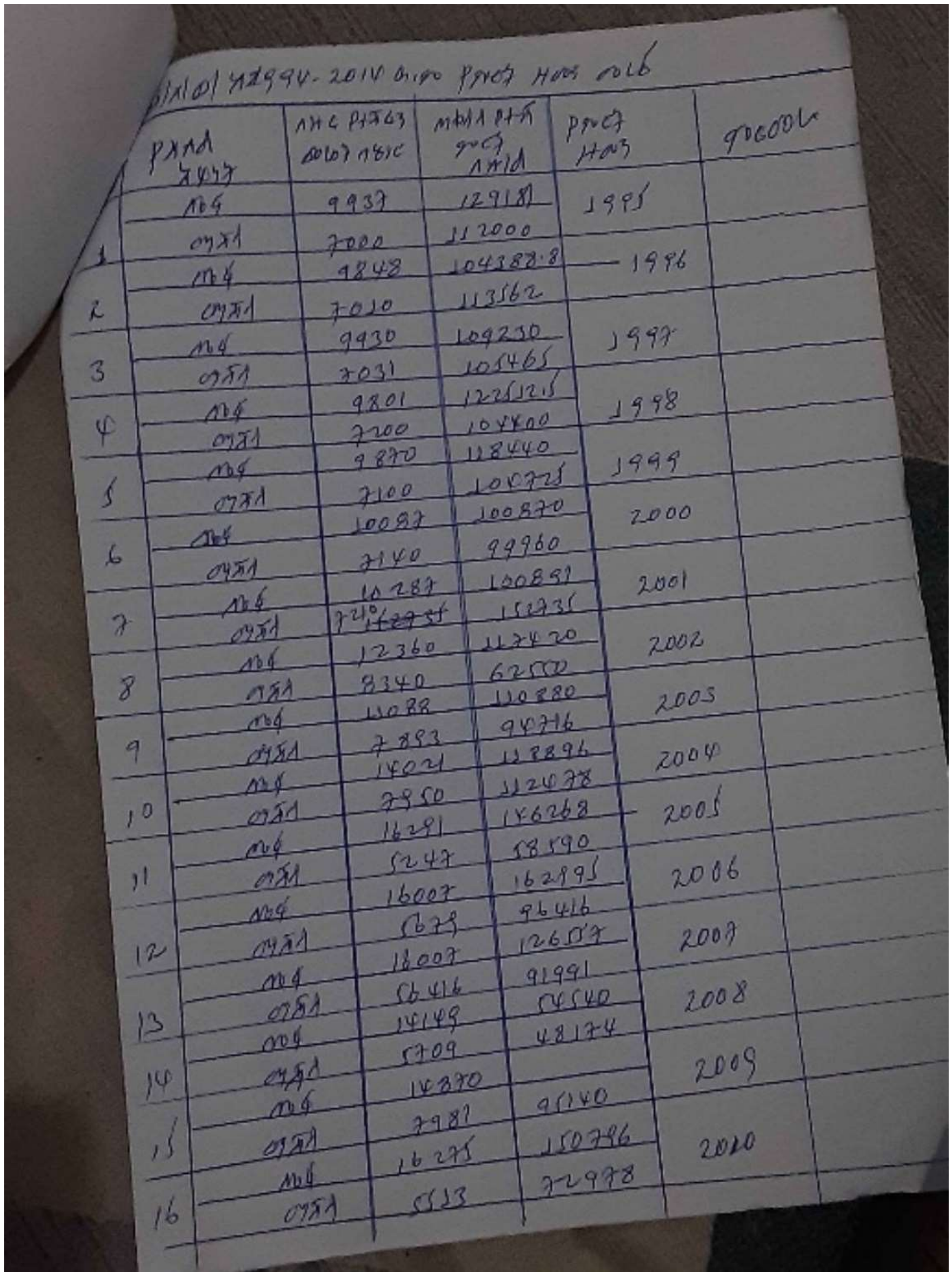
ቀን 06/11/2014

ጉዳዩ:- መሰረታዊ መረጃ መስጠትን ይመለከታል።

ከላይ በርዕሱ ለመግለጽ እንደተሞከረው በእኛ በምስራቅ በለሣ ወረዳ የወረዳው መሰረታዊ መረጃ የሚገልጽ ማስረጃ ከ2 ገጽ አባሪ አድርገን የላክን መሆኑን እንገልፃለን::

ከሰላምታ ጋር//

የኤክስቴሽን ኮሚኒኬሽን ቡድን መሪ



[illegible] ከ1994-2014 ዓ.ም የምርት ዘመን መረጃ

ተ.ቁ	የአዝመራ ጊዜያት	በዘር የተሸፈነ መሬት በሄክታር	ጠቅላላ የተገኘ ምርት በኩንታል	የምርት ዘመን	ምርመራ
	በልግ	9937	129181	1995	
1	መኸር	7000	112000		
	በልግ	9848	104388.8	1996	
2	መኸር	7020	113562		
	በልግ	9430	109230	1997	
3	መኸር	7031	105465		
	በልግ	9801	1225121	1998	
4	መኸር	7200	104400		
	በልግ	9870	118440	1999	
5	መኸር	7100	100725		
	በልግ	10087	100870	2000	
6	መኸር	7140	99960		
	በልግ	10287	100891	2001	
7	መኸር	7210 ~~14295~~	152735		
	በልግ	12360	112420	2002	
8	መኸር	8340	62500		
	በልግ	11088	110880	2003	
9	መኸር	7893	94716		
	በልግ	14021	118896	2004	
10	መኸር	7950	112478		
	በልግ	16291	146268	2005	
11	መኸር	5247	58590		
	በልግ	16007	162995	2006	
12	መኸር	5679	96416		
	በልግ	18007	126507	2007	
13	መኸር	56416	91991		
	በልግ	14149	54540	2008	
14	መኸር	5709	48174		
	በልግ	14870		2009	
15	መኸር	7987	95140		
	በልግ	16275	150796	2010	
16	መኸር	5513	72978		