The role of small-scale irrigation on rural smallholder food security outcomes in Wolaita Zone of Southern Ethiopia

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DECLARATION

'I declare that "The role of small-scale irrigation on rural smallholders' food security outcomes in Wolaita Zone of Southern Ethiopia" is my work and that all the sources that I have used or quoted have been indicated and acknowledged using complete references. I further certify that the thesis satisfies the established standards for originality after I submitted it to an originality-checking program. I further certify that I have never turned in this work, in whole or in part, for assessment at Unisa for another degree or at any other higher education establishment.'

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Biruk Seifu Koisha

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ABSTRACT

Small-scale irrigation (SSI) started earlier in Wolaita and contributed to food production. However, rural smallholders in the area are still food insecure. This research aimed to understand the role of irrigation on food security outcomes of rural smallholder farmers in Wolaita, southern Ethiopia. Previous studies focused on the role of SSI on food availability and accessibility but lacked the food utilisation and stability dimension. Therefore, this research had intended to understand the role of irrigation interventions in the improvement of rural smallholders' food availability, accessibility, utilisation, stability, and capability.

The study adopted a mixed-method research approach. Before data collection, 139 journal articles were systematically reviewed. The sample size for the quantitative household survey study was 400 participants. Forty key informants were interviewed. Furthermore, ten focus group discussions were conducted. The results were analysed using descriptive statistics, independent sample t-test, multivariate regression, and multinomial regression analysis.

According to the findings, SSI users have shown significantly higher mean total crop harvested (M= 96.9967) than non-users (M= 26.9680), at the p-value of 0.000. Moreover, the findings indicate that SSI users had significantly higher values for the variable "Total Livestock Unit" by sample rural households (M=3.31) compared to the group of non-users of SSI (M=2.38) at the p-value of 0.000. Furthermore, SSI users had higher mean income from annual crop production sold and from animals, animal by-products, and other non-productive asset sales than non-users. The statistical test also provided a significant difference in the household dietary diversity between SSI users (M= 8.63) and non-users (M= 4.94), with SSI users having a significantly higher mean HDDS at $p<0.01$. In contrast, the qualitative analysis indicates that SSI users provide adequate and quality food for children than non-users.

SSI users had lower mean HHS than non-users. Moreover, SSI users (M=3.73) had significantly lower scores for the Household Coping Strategy Index variable, compared to non-users (M=7.88) at $p<0.01$. According to the multivariate regression analysis of HDDS and HHS, the independent variables that determine the rural food security outcome are total crop produced, income from crop sold, sum of purchased food groups, Total Livestock Units, and income from animal, animal by-products, and other assets. Furthermore, as of multinomial logistic regression access to irrigation, sex and education level are the common key determinants of HDDS and HHS. However, owned farmland size and family size are not common determinants of HDDS and HHS in the study area.

The findings, therefore, indicate that unless intensive agriculture is implemented, it is not possible to improve the dietary diversity, reduce the hunger and enhance coping capacity of the rural smallholders in the study area. Therefore, irrigation has a significant role in the food security outcome of rural smallholders specifically in Wolaita Zone, southern Ethiopia, and Ethiopia. So, policymakers and development practitioners in the area should promote sustainable agricultural practices, invest in irrigation infrastructure, provide financial support, strengthen extension services, address gender inequalities and environmental challenges, foster public-private partnerships, and promote nutrition-based agricultural activities.

Key words/concepts: *Rural Smallholders; Small scale irrigation; food availability, access, utilisation, stability; food security outcome; Wolaita, Ethiopia.*

ACRONYMS

ADLI	-	Agricultural-Led Industrialisation
ADLI	-	Agricultural Development Led Industrialisation
AEI	-	Agro-ecological intensification
AGRA	-	Alliance Green Revolution Africa
AVC	-	Agricultural Value Chain
BoFED	-	Bureau of Finance and Economic Development
CAAD	-	Comprehensive Africa Agricultural Development Programme
CC	-	Climate Change
COVID-9	-	Coronavirus Disease 19
CSA	-	Centre of Statistical Agency
CSI	-	Coping Strategies Index
CSIS	-	Coping Strategies Index Score
DAP	-	Di-Ammonium Phosphate
EPRDF	-	Ethiopian Peoples Republic Democratic Front
EPHI	-	Ethiopian Public Health Institute
ETB	-	Ethiopian Birr
FAO	-	Food and Agricultural Organization
FCS	-	Food Consumption Score
FGD	-	Focus Group Discussion
FTC	-	Farmers Training Centres
FES	-	Friedrich-Ebert-Stiftung
GDP	-	Gross Domestic Products
GNP	-	Gross National products
GTP	-	Growth and Transformation Plans
HCSI	-	Household Coping Strategy Index
HDDS	-	Household Dietary Diversity Score
HHS	-	Household Hunger Scale

HHSS	-	Household Hunger Scale Score
HYV	-	High-Yielding Varieties
IARCs	-	International Agricultural Research Organisations
IC	-	Industrial Crop
ICF	-	International Classification of Functioning, Disability & Health
IFAD	-	International Fund for Agricultural Development
IHCs	-	Indigenous Horticultural Crops
IWC	-	Income/wealth/commodities
KII	-	Key Informants Interview
Kshs	-	Kenya Shillings
MCD	-	Multi-dimensional Child Deprivation
MoFED	-	Ministry of Finance and Economic Development
MoWR	-	Ministry of Water and Resource
NARS	-	National Agricultural Services
NEPAD	-	African Union's New Partnership for Africa's Development
NFSA	-	National Food Security Act
NGOs	-	Non-Governmental Organisation
NPS	-	Nitrogen, Phosphorus and Sulphur
NTFPs	-	Non-Timber Forest Products
PASDEP	-	Participatory and Accelerated Sustainable Development to Eradicate Poverty.
PSSIS	-	Participatory SSI Schemes
RDS	-	Relational Developmental Systems
SAIPs	-	Sustainable Agricultural Intensification Practices
SDPRP	-	Sustainable Development and Poverty Reduction Program
SLR	-	Systematic Literature Review
SNAP-Ed	-	Supplemental Nutrition Assistance Program-Education
SNNPR	-	Southern Nation Nationality People's Region

SPSS	-	Statistical Package for the Social Sciences
SSA	-	Sub-Saharan Africa
SSI	-	Small-Scale Irrigation
SSIS	-	Small-Scale Irrigation Schemes
SSRWHT	-	Small Scale Rainwater Water Harvesting Technology
SWP	-	Sustainable Water Partnership
TLU	-	Total livestock Unit
UN	-	United Nations
UN-DESA	-	United Nations - Department of Economic and Social Affairs
UNICEF	-	United Nations International Children's Emergency Fund
Unisa	-	University of South Africa
USAID	-	United State Agency for International Development
USSR	-	Union of Soviet Socialist Republic
VIF	-	Variance Inflation Factor
WADU	-	Wolaita Agricultural Development Unit
WFS	-	World Food Summit
WHCSI	-	Weighted Household Coping Strategic Index
WUAs	-	Water Users Associations
WZDoWEM	-	Wolaita Zone Department of Water, Mines and Energy
WZoFED	-	Wolaita Zone Finance and Economic Development
ZoFED	-	Zone Finance and Economic Development Department

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CHAPTER 1

INTRODUCTION AND BACKGROUND

1.1 INTRODUCTION

Food production can be boosted sustainably by advanced irrigation systems and water management. The contribution of irrigation and water management to increasing food production can be achieved by expanding irrigation and improving existing water supply management (Darko et al., 2016). Given the trends of the past, it is emphasised that future irrigation technologies should focus on enabling the generation, development and promotion of new irrigation practices and management systems to optimise production, with leadership and capacity (ibid.). The quantity and quality of food produced worldwide are not compatible with the demand of the growing population and agricultural practices.

The interplay between knowledge, technology and socio-political dynamics has implications for addressing challenges related to water resource management, food production and poverty alleviation. Knowledge and technology are never produced in a socio-political vacuum (Aubriot et al., 2018) and should be embedded in each other and produce power relations. Moreover, an integrated sustainable management of water resources at the basin scale and an interdisciplinary approach are essential (Billib et al., 2009).

Global food production system, especially in Asia, is under pressure, as land and water resources are scarce (Rosegrant et al., 2007). Although Asia has made significant progress in improving human well-being, most of the poor and hungry in the region remain in Asia (ibid.). In sub-Saharan Africa, nearly 232 million people were undernourished in 2020-2022, up from 179 million in 2019 (International Fund for Agricultural Development et al., 2022). Estimates showed that 148.9 million children under 5 were stunted in 2021 in Low- and middle-income countries, including nearly 57 million in sub-Saharan Africa (United Nations International Children’s Emergency Fund et al., 2023).

In Ethiopia, according to the 2019 MDHS (Mini Demographic and Health Survey), 38% of children under 5 years are stunted, 10% are wasted or too thin for their height, and 24% are underweight (Ethiopian Public Health Institute & International Classification of Functioning, Disability and Health, 2021). Similarly, United Nations International Children's Emergency Fund (UNICEF) Ethiopia 2022 annual report indicates that approximately 30-40% of children under 5 in Ethiopia are stunted or too short for their age due to chronic malnutrition (UNICEF, 2023). The prevalence of malnutrition in sub-Saharan Africa has increased in recent years, with over 232 million people estimated to be undernourished in 2020-2022 compared to 179 million in 2019 (IFAD et al., 2022). Stunting rates have remained persistently high in many sub-Saharan countries, with 38% of children stunted in Ethiopia as of the 2019 survey (EPHI & ICF, 2021). Stunting reflects long-term poor nutrition and repeated illness.

Water use for irrigation is inefficient because small-scale farmers and managers do not have the right tools to properly plan and manage water supplies to effectively meet crop water requirements (de Oliveira et al., 2009). Improving water sector financing, increasing staffing, technical capacity, strengthening water quality monitoring, water use and law enforcement (United States Agency for International Development & Sustainable Water Partnership, 2021). Understanding the relationship between knowledge and technology, and recognising the intricate interplay between knowledge, technology, power relations, and sustainable resource management for addressing pressing challenges such as water scarcity, insufficient food production and reduction of poverty in regions like Asia and Sub-Saharan Africa, is crucial (Aubriot et al., 2018).

This chapter introduces the role of small-scale irrigation (SSI) in food production and food security, in Ethiopia. The chapter outlines the research problem, research questions, objectives of the study, scope of the investigation, and definitions of the major concepts employed in the study. The chapter outlines the thesis structure and explains the significance of the research.

1.2. BACKGROUND

Economic history notes that economic development is attained first through the establishment of a booming agricultural system (Hazell, 2017). The establishment of a productive and sustainable agricultural system makes an outstanding contribution to food security. However, currently, the world's agricultural food system cannot feed a rapidly growing population. The United Nations (UN) projects the world population to reach around 9.7 billion by 2050, up from 7.9 billion currently (UN-Department of Economic and Social Affairs, 2022). Most growth will occur in developing nations (ibid.). Food production will need to increase by around 60% to meet the demand of a larger population according to Food and Agricultural Organisation (FAO) estimates (IFAD et al., 2022). More than 70% of the world's poor live in rural areas, where most depend on agriculture for their principal livelihood (Searchinger et al., 2019). Since 2002, the availability and price of world food have become highly volatile (ibid) and have critically affected Africa where 70% of the population practises smallholder farming (Hazell, 2017). In Africa, smallholder farmers have an average landholding size of less than two hectares (ibid.). Smallholder farming is vulnerable to diverse natural disasters. Rural smallholders in Ethiopia are food insecure and their agricultural activity is affected by climatic changes and drought. Therefore, adaptation to climate change impacts such as droughts and heat waves will be vital for ensuring future global food security (Ray et al., 2019). The Southern Ethiopia region has the highest population per square kilometre and a status of food insecurity. Thus, adaptation to climate change, and the expansion of intensive agriculture like irrigation is important.

1.2.1 Study Area

Ethiopia is located in the Horn of Africa, on the north-east it borders Eritrea, east and south-east with Djibouti and Somalia, west with Sudan and South Sudan, and south with Kenya (Central Statistical Agency, 2013). The country is the second most populous country in Africa, with a population of 102,998,000 million (CSA, 2013). Ethiopia has about 1.127 million km^2 of surface area and is located between 3° 30 and 14° 50 North latitudes and 32° 42 and 48°12 East longitudes (Awulachew et al., 2004). From this surface area, 1,119,683 km^2 and 7,444 km^2, are land and water respectively (ibid).

The Southern Nations, Nationalities and Peoples Region (SNNPR) is one of the 11 autonomous regional states in Ethiopia. According to the 2017/18 Annual Statistical Abstract of the Regional Bureau of Finance and Economic Development (BoFED), SNNPR is roughly located between 4^o.43 – 8^o.58 N latitude, and 34^o.88 to 39^o.14 E longitudes (BoFED, 2019). The total area of the region is 112,023.90 km^2 (CSA, 2014). The region is divided into 14 administrative zones that are then subdivided into 132 woredas, four special woreda governments, 48 town administrations, 3,730 rural kebeles and 491 urban kebeles (ibid) all of which, under Ethiopia's decentralised system of government, have their governing councils. According to the CSA, (2007), census data its population of 14,968,600 accommodates an enormous diversity of ethnic groups and languages. This population has been projected to be 21,021,000 in 2021 (Urban 3,838,000 / Rural 17,183,000) (CSA, 2013). The number of rural households in the region in 2018 was 3,486,720 (BoFED, 2019). The total fertility rate (women, aged 15-49) is 4.4, just below the national average of 4.6 (UNICEF, 2011). Also, it is the third largest region in Ethiopia in addition to Ethiopian Somali and Oromia, accounting for more than 18.9% of the country's surface area (CSA, 2012). The altitude of the region ranges from 376 to 3500 metres above sea level (BoFED, 2019). Therefore, the region is more geographically diverse.

Africa's large potential for agriculture could boost rural smallholders' food security outcomes through irrigation agriculture. Around 70% of all freshwater withdrawals worldwide come from irrigated agriculture, which is the primary source of water withdrawals. It has increased agricultural yields, stabilised prices and made food more accessible to the world's expanding population (Rosegrant et al., 2009). The total area equipped for irrigation on the global map is 367.039 million hectares (Mha) (Meier et al., 2018). About 72.88% of the total irrigated area is located in Asia (267.5125 Mha), 14.18% in America (52.045 Mha), 7.33% in Europe (26.912 Mha), 4.46% in Africa (16.379 Mha), and 1.14% in Oceania (4.183 Mha) (Meier et al., 2018). Therefore, although Africa has great potential for natural and human resources, it has not yet optimally utilised its agricultural potential to supply enough quality food that is sustainable to the demand of its population. Irrigation technologies have not yet been implemented and spread to transform the traditional agricultural system adequately. In Ethiopia, from a total of 112 Mha of agricultural land, the estimate of arable land is expected to be between 30 - 70 Mha (Awulachew, 2010a). In addition, Awulachew (2010b) has also described in his work that currently only 15 Mha of land is estimated to be under cultivation. From this cultivated area, it is estimated that the total land under irrigation is between 4 and 5% and that irrigation schemes, those with equipped modern irrigation facilities, cover only about 640,000 hectares. Therefore, it is possible to conclude that the irrigated land in Ethiopia is insignificant.

The Southern Nations, Nationalities and Peoples Region is rich in fertile soils, abundant water resources, natural forests and a variety of minerals (BoFED, 2019). The agroclimatic zone of the region includes high land (2200 - 3500 metres above sea level / 9380 hectares /8.6%), midlands (1300- 2200 metres above sea level / 36974 hectares /33.9%) and low land (376-1300 metres above sea level /62714 hectares /57.5%) (BoFED, 2019). The land use coverage (in ha) of the region is cultivated land 3,611,823, arable land 1,261,868, grazing land 1,558,562, forest land 2,725,380, water body 191,021, others 1,247,039 (ibid.). Annual rivers that can be used for irrigation are 64. This indicates that the region has the potential for land, water and favourable agro climatic zones for irrigation.

Thousands of years ago, humankind used irrigation (traditionally) for many years. They have been benefiting from the opportunities of irrigation, especially in achieving their food needs sustainably throughout the year. Irrigation, as a method of agricultural intensification, is crucial to increase agricultural production and productivity (Legesse et al., 2018). Investments in irrigation cause changes in agricultural supply and output; these indirect links function at the regional and national levels and greatly boost the country's economy (Nadeiwa & Koring, 2017a). Natural water resources in Israel have not increased, but agricultural output has improved continuously through irrigation and is currently 1600% higher than it was in 1950 (Worako, 2015). Furthermore, more than 85% of Nile water is withdrawn for irrigation agriculture and water availability in Egypt, with a direct impact on national food security (Bakr & Ghany, 2019). The success of the green revolution in Asia (China, India, Singapore, Vietnam, Taiwan, and South Korea) was achieved through the recent rapid expansion of irrigated areas, combined with the availability and access to new technology in the form of high-performance varieties (HYV), fertilisers and water extraction mechanisms by tube wells and wells (Adebayo et al., 2018; Sani et al., 2011). Evidence suggests that agricultural interventions based on productivity-enhancing agricultural technologies (quality fertilisers, improved seed varieties, improved livestock, and micro-irrigation) resulted in income increases ranging from 80 to 140%, which is significantly higher than investing in other parts of the agricultural value chain (Hystra, 2016). The increase in crop diversity throughout small-scale irrigation schemes and the move from cereal-livestock to cereal-vegetable-livestock systems, are beginning to promote family nutrition diversity by incorporating vegetables into the daily diet (HongBo et al., 2005). Children in households that use small-scale irrigation have lower levels of acute malnutrition (Belete & Melak, 2018). Although it has benefits, the actual water and irrigable land potential of Africa, especially Ethiopia, has not altered and affected the demand for sufficient and quality food.

The availability and access to this vital resource has changed dramatically due to natural and human factors. Maintaining access to water for irrigation is a global concern (in arid and semi-arid areas). Competition for water resources will increase. Small-scale irrigation (SSI) practices are, therefore, challenged by shortage of water, access to improved seeds and increase in farm input costs. Some challenges include unavailability of active family labour, oxen shortage, improper utilisation and management of the upper catchment, maintenance and spare part problem, lack of sense of collective responsibility, flooding, difficulties to equitable access water, and conflict among farmers (i.e., weak association performance of water users). Small-scale irrigation projects are also stalled owing to insufficient beneficiary participation and land insecurity (Mengistie & Kidane, 2016). Access to financial resources is also necessary to improve the adaptation capacity of smallholder irrigation users to climate shocks and changes and is positively associated with market access (Niles & Brown, 2017). The negative environmental effects of small-scale irrigation, such as soil salinity, acidity and waterlogging, as well as increases in some communicable and non-communicable diseases, may offset the positive effect of small-scale irrigation (Zeweld et al., 2015b). Therefore, the region of Africa and Ethiopia should overcome these identified challenges to obtain the potential benefit of irrigation agriculture.

The decision-making dynamics of rural households have a significant impact on overall household income and food security of rural smallholders. A variety of socioeconomic, cultural and political issues can also have an effect. Previous research shows that, in agricultural trends, decisions about the allocation of rural resources are not always taken to ensure the maximum benefit from irrigation infrastructure investments. As a result, irrigation will not be able to realise its potential and expected contribution to improving rural livelihoods and food security (Bjornlund et al., 2019). The decision of small farmers to adopt small-scale irrigation technology in Ethiopia could be one of the solutions for the family to get diverse crops, more production and income from a small plot of farmland to ensure food security, stimulate non-farm activities and use socioeconomic rural institutions.

In Southern Nations, Nationalities and Peoples Region, the structure of the economy is predominantly agrarian. The region has the third largest crop production area in the country and is also known as the major producer/supplier of fruits, vegetables and root crops (BoFED, 2019). From the total cultivated land coverage, 2,115,108 ha of land is covered with annual crops and 1,496,716 ha of land is covered with perennial crops like fruits, mango, avocado etc under rainfed and irrigated agriculture (ibid.). The main types of crops and production in quintal (in 2017/18 production year) are cereal crops such as teff (3,800,290), wheat (8,126,322) barley (276,081), maize (17,082,855), and sorghum (2,268,482) (BoFED, 2019). Root crops include coffee, “Enset” (false banana), cassava, and sweet potato (UNICEF, 2011). Animal husbandry is also another economic activity of the region. The main types of livestock and their population in the region are estimated to be 11,885,548 cattle, 4,639,606, sheep, 4,958,255 goats, 371,298 horses, 811,105 donkeys, 91,461 mules, and 10,491,131 poultry (BoFED, 2019). Therefore, crop production and animal husbandry are well-practised in the region.

During the last decades, food security and consumption patterns have shown some changes in the country as well as in SNNPR. Per capita consumption of cereal products has increased by about 40% in the last ten years in the country, and consumer demand for vegetables and fruits is also increasing (Southern Nations Nationality People Regional Government, 2012). However, many constraints impede effective resource use. For example, agricultural productivity does not seem to be sufficient for the rate of population growth (Friedrich-Ebert-Stiftung, 2017). For this reason, one of the most pressing risks to local communities is food security (ibid.). To improve the food security of households in the country, the government subsidises the construction of small-scale irrigation infrastructure and provides all the required input through the loan. To promote the region's regional economic development, access to education and infrastructure improvement are crucial (FES, 2017). However, the SNNPR is the region with the highest multidimensional child deprivation rate (MCD), 91% of children under the age of 18 or more than eight million are deprived of an average of 4.5 of the five basic needs, services and rights (UNICEF, 2011). Therefore, the situation of food security in the region is a critical problem and requires integrated developmental interventions.

The administrative zone of Wolaita is one of the 14 zones that include the Hawassa Town Administration in the region (SNNPR). According to the Annual Statistical Abstract for the Wolaita ZoFED 2018/19, it is roughly located between 6.29º and 7.10º N latitude, and 37.13º to 38.08º E longitudes (see Figure 1.1.). The altitude of the zone ranges from 501 metres above sea level (Bilate Tena) to 3000 metres above sea level (Damota mountain area) (Wolaita Zone Finance Economic Development Department, 2019).

Table 0-1 Administration area, Demography, and irrigation infrastructure of SNNPR

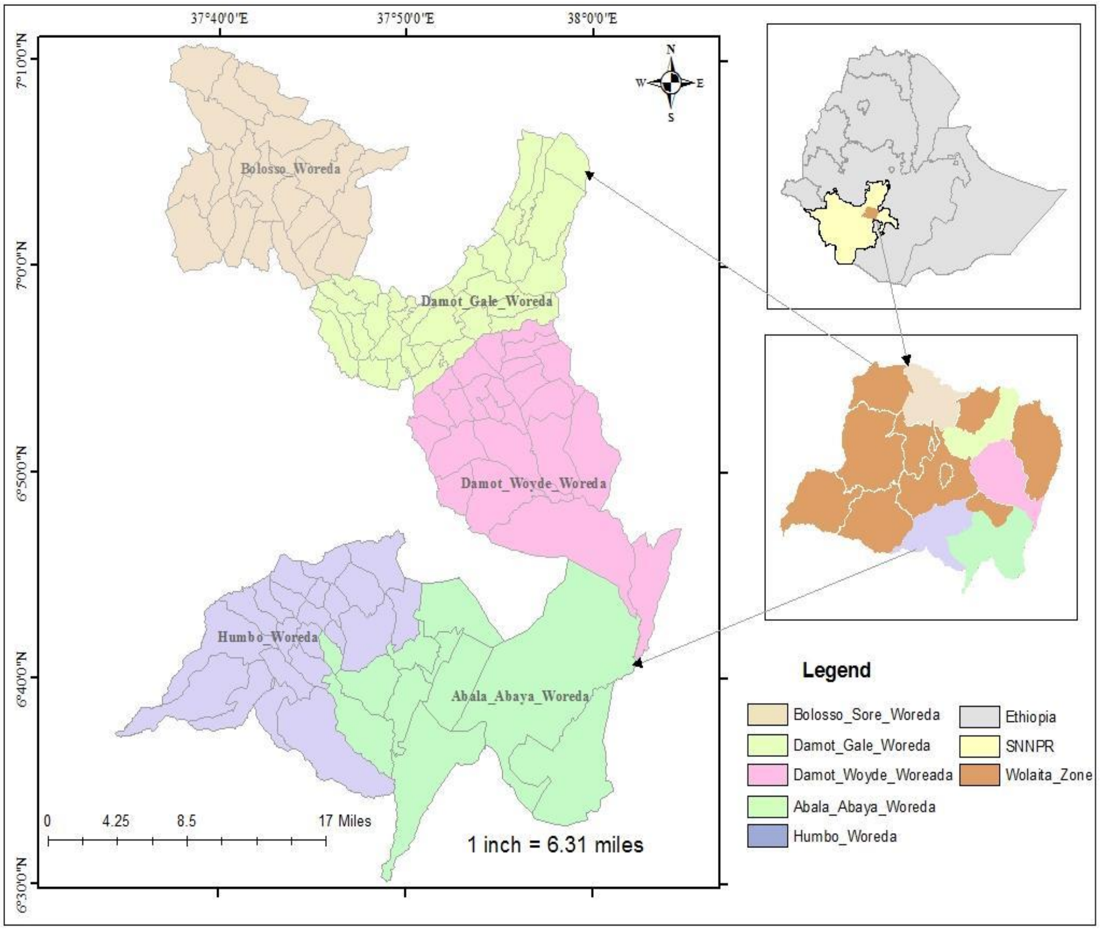
No	Administrative zones	Administrative zones Area (In km^2)	Population size	Population Density per km sq.	Number of Districts
1	Gurage Zone	5,893	1,777,176	302	13
2	Hadia Zone	3,634	1,743,576	480	10
3	Kembata Tembaro Zone	1,356	955,654	705	7
4	Sidama Zone	6,540	4,015,687	614	19
5	Gedio Zone	1,353	1,186,861	787	6
6	Wolaita Zone	4,512	2,096,492	465	12
7	Debub Omo Zone	22,836	790,798	37	8
8	Sheka Zone	2,388	281,010	118	3
9	Kaffa Zone	10,637	1,206,902	113	10
10	Gamo Gofa Zone	12,564	2,213,353	201	15
11	Banch Maji	19,252	908,218	47	10
12	Dawro Zone	4,404	675,237	153	5
13	Silti Zone	2,631	1,094,547	416	8
14	Segeon people's Zone	6,312	802,504	127	5
15	Yem sp. woreda	648	107,511	166	1
16	Basketo sp. woreda	411	79,183	193	1
17	Konta sp. woreda	2,382	125,733	53	1
18	Halaba sp. woreda	995	345,063	347	1
	Total	108,748	20,405,505	188	135

Source: SNNPR Finance and Economic Development Bureau 2017/18 Annual Abstract (2019).

The boundary administrative areas are the Kembata Tambaro zone in the north, the Sidama zone in the east, the Gamo Gofa zone in the south, and the Dawro zone in the west. The area of the zone is 451,170 ha or 4511.7km^2 (ibid.). The zone consists of 16 woredas and six municipal administrations with a total of 368 peasant associations or kebele, among which 289 are rural and 79 are urban kebele (WZoFED, 2019). The zone has three agroclimatic zones, high-land (9%), mid-land (56%) and low-land (35%) and the total projected population for 2019 is

2,347,034 million (male 1,150,867 and female 1,196,167). Of this total population, 1,617,429 (68.91%) and 729,605 (31.09%) live in rural and urban settings, respectively. There are a total of 457,918 households. Among these, 119, 790 are urban and 335,956 are rural in 2019 (WZoFED, 2019).

Figure 0-1 Study Map area.



Source: GIS by Author

Although all developed rural socio-economic institutions did not achieve the desired objective during previous regimes (Feudal & Derg), various types of rural infrastructure and institutions were built in the country in general and in the Wolaita zone in particular. Agricultural offices, Farmers Training Centres (FTC), health posts, health centres, primary and junior schools were built and started to provide various rural development services accordingly at the rural kebele level for all residents without specific privileges.

Despite their contribution to national demand, these rural institutions have mainly targeted their services to improve the competitiveness of rural smallholders and maintain food security at the household and individual levels. Therefore, during the last years, 289 agricultural offices, 306 farmers training centres, 14 animal health laboratories, 1(one) cattle breeding centre, and 1 (one) poultry breeding centre, have been built to provide agricultural service for rural smallholder farmers in the zone. Almost 29 large medium and small-scale irrigation schemes were also built during previous periods (WZoFED, 2019).

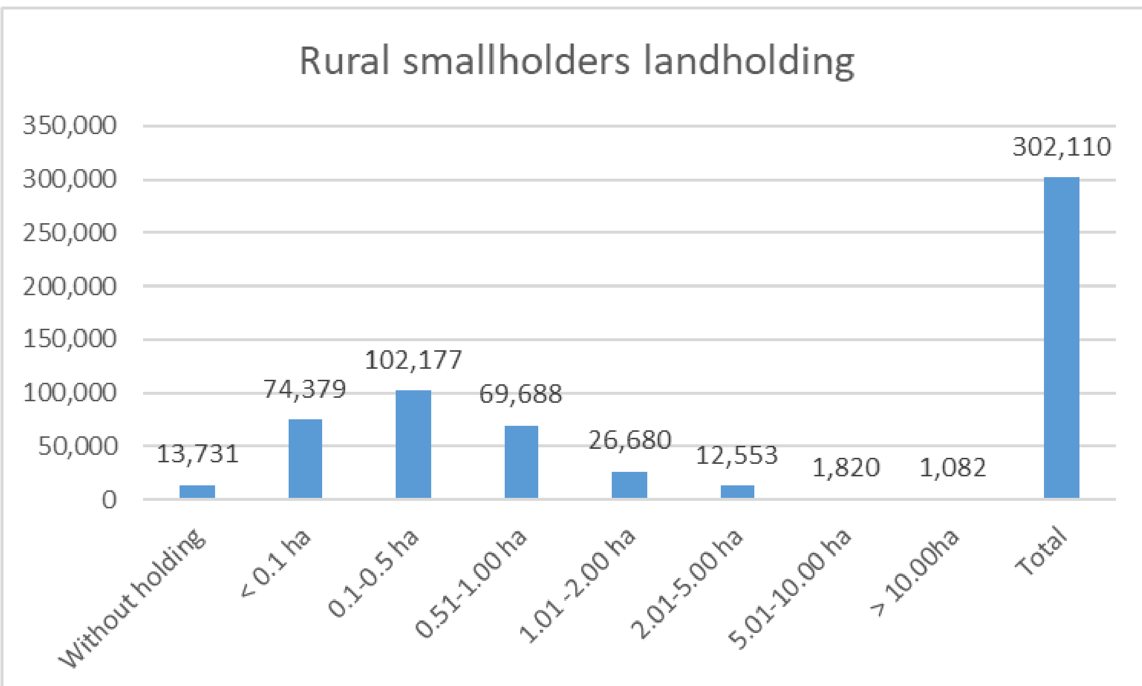
According to the 2018/19 Annual Statistical Abstract of the Wolaita Zone Finance and Economic Development Department (2019), the agricultural sector has supported 80% of the population and is the main contributor to the income of the individual household. The main types of food crops grown in the zone are maize, teff, wheat, sorghum, barley, vegetables, fruits, false banana ('Enset'), haricot bean, root crops, coffee, spices, oil seeds, etc. The land use patterns of the zone are cultivated land 292,488ha (221,223 ha for annual crops and 71,265 ha for perennial crops), cultivable land (62,475 ha), forest land (4,9161 ha), grasslands (40,409 ha) and miscellaneous land (6,636 ha) (WZoFED, 2019). Of the total cultivated land, only 3,874 ha of land was covered under modern irrigation infrastructures and growing annual and perennial crops such as cereals, vegetables, fruits, etc.

To improve the economic and social well-being of the population, the government used intensive development programmes to realise the growth and transformation of rural smallholder farmers. Until 2019, 1,711 extension workers were recruited to provide technical support to rural farmers. The ratio of these extension workers to the available households in 2019 is 1:183. In 2019, more than five million livestock populations were supported by 365 veterinarians.

Livestock is an important asset in the Wolaita Zone, helping to improve the nutritional status of its owners and contributing to economic growth. A key feature of livestock in the area is that they perform multiple roles, ranging from draught power to providing manure, milk and meat. The lack of adequate pasture is an important constraint due to the growth of the population and encroachment of pastureland for food crop production. Institutional constraints include insufficient animal clinics, lack of research and market distortions. The estimated livestock in the Wolaita Zone is 5,782,725, among those cattle 2,001,526, sheep 526,060, goat 553,114, poultry 2,441,893, horse 8,958, donkey 125,587 and mule 125,587 in 2019 (WZoFED 2019). Wolaita Zone is favourable for animal production and has the potential to the improvement of household nutritional status.

Rural households in Wolaita have small landholdings of less than 2 ha. Few households own more than 2 ha of land. According to Wolaita Zone Finance and Economic Development Department (2019), 5% of households have no land holdings and 94% of households have land holdings below and above 0.1 to 2 ha (Fig. 1.2). About 99% of households own less than 2 ha. Therefore, farmers in Wolaita Zone must intensify and diversify their agricultural activity (crop and animal production) to maintain the food security of their family members. The Wolaita Zone characteristics are typical of rural smallholders in SNNPR.

Figure 0-2 Rural Household landholding distribution in Wolaita zone



Source: W ZoFED (2019).

Social institutions contribute more to improving the capacity of rural smallholders. Health and education status are among the most important indicators of economic development for a country and the Wolaita Zone in particular. The coverage of the health services in the zone is 93.3% and as to the facilities there are seven hospitals and a ratio of 1:290,052; health centres 68 and its ratio is 1:29,858; health posts 343 and its ratio is 1:5,919 (WZoFED, 2019). On the other hand, according to data obtained from the CSA 2007 projection, the school population for the primary school group (1-8) in 2018 was 610,253, of which 289,307 were male and 320,946 females. The school population for secondary school (9-12) is 336,810 (male 145,449 and female 191,361) (WZoFED, 2019). The number of schools was also expanded: primary grade from 1 to 4 (50), junior grade from 1 to 8 (436), secondary schools from 9 to 12 grade 71 (seventy-one). However, the distribution varies between districts. For primary-level education, the qualified teacher-pupil ratio in 2017 for grades 1-4 is 1:83, for elementary schools (1-8) is 1:61 and for secondary (9-12) is 1:23 (WZoFED, 2019). Therefore, this growing school-age group should have adequate and quality food, health and education services.

A systematic literature review was conducted to understand the findings of previous literature on the roles of small-scale irrigation in rural smallholder food security outcomes and factors affecting food security outcomes are indicated in detail in Chapter 2. As a summary of the findings of the systematic literature review indicated that, the role of small-scale irrigation has not been studied comprehensively on all four dimensions of food security and its outcomes. Furthermore, few studies were conducted in the Wolaita Zone in southern Ethiopia. Factors that affect the food security of rural smallholders and the performance and efficiency of irrigation were studied more but few studies covered food security outcomes under variable contexts. The process and methodological review of previous literature are indicated in detail in Chapter 4. Based on the findings of the systematic literature review, the below-mentioned problem statement of the research is generated.

Wolaita Zone has the potential for all agricultural activity, has a resource and ample rural socioeconomic institutions and professionals. However, due to the high population growth rate and other factors, the available agricultural land could not meet the need for enough quality and nutritious food at the household and individual levels. Beyond the expansion of the institutions, their role in the food security outcomes of rural farmers and integration with each other have not yet been well-researched and documented. Moreover, the agricultural sector is not yet modernised and could be the main engine to achieve the required results in food security and rural transformation in the future. Therefore, this research sought to examine the potential of small-scale irrigation to achieve sustainable rural food security outcomes, such as improving rural smallholder food utilisation, stability, and capacity, under current demographic, socioeconomic, environmental, political, cultural, situations, and developmental ideals where every citizen has the right to the development, access and use of resources. The study focuses on the context of southern Ethiopia in general and specifically the Wolaita Zone.

1.3 PROBLEM STATEMENT

Irrigation farming requires experience, adequate extension services, financial capital, and intensive use of chemicals, improved seeds, fertiliser, labour, and fuel for diesel pumps. To fully exploit these issues, small rural holders should improve their economic, human and social capacity. Because they are risk-averse, their decision to participate or not participate in irrigation is based on the value of the expected utility of wealth from adoption and non-adoption (Zeweld et al., 2015). Although small-scale irrigation schemes were introduced earlier and farmers are familiar with the technology in Wolaita Zone, southern Ethiopia, farmers are confronted with extreme famine and drought. Students who drop out, lose attendance at school, retake of classes, and lack of adequate and quality food owing to the shortage of production, income and lack of awareness of the outcomes of food security are problems in the area. They reveal no change in the outcomes of food security for the household and individual. The adoption of technical innovation occurs in less developed countries under several imperfect situations, such as market imperfections, restricted access to productive resources and a lack of certain institutions (Zeweld et al., 2015a). The sustainability of small-holder farming depends on productivity, which in turn depends on farming technology, extension services, physical infrastructure, and human capital.

Although previous studies looked at the impact of irrigation on productivity, production and income (Agidew, 2017; Asayehegn, 2012; Astatike, 2016; Belete & Melak, 2018; Gebremariam & Ghosal, 2016; Legesse et al., 2018; Leza et al., 2020; Han et al., 2019; Mohammed, 2016; Siraw, 2016; Zeweld et al., 2015; Tesfaye et al., 2008), they were not comprehensive empirically to use the methodology that could evaluate the main variables from each food security dimension such as food availability, accessibility, utilisation and stability together to describe the issues indicated in the definition, especially 'active and healthy life'. Therefore, this study aimed first to systematically review previous studies, findings and identify the interventions' pathways to achieve food security outcomes and mix the results obtained after empirical analysis of the short, medium and long-term roles of small-scale irrigation schemes in the food security outcomes of smallholders in Wolaita Zone, southern Ethiopia. Additionally, it reviewed the main factors that determine the outcomes of food security of small farmers' rural households and communities of Wolaita.

This study identified the role of irrigation in improving the utilisation of food by rural households (dietary food consumption and healthy life), stability (physical and economic access to food always), and ability (autonomy of smallholders), and finally, it identifies the lessons gained and contributes to the existing body of knowledge. Cumulatively, it describes the results in the context of Wolaita Zone specifically and generalises to the region of southern Ethiopia, Ethiopia, Africa, and world contexts, since its role would vary between different governments and contexts owing to varying political, policy, market, socioeconomic, and infrastructure factors.

1.4 AIM

The aim of the study was to understand the role of irrigation in the outcomes of food security for smallholder farmers in Wolaita, southern Ethiopia.

1.4.1 Specific objectives

1. Understand the role of Small-scale irrigation in food production among smallholder farmers in Wolaita.

2. Assess the role of irrigation in the diversification of the food of smallholder farmers in Wolaita.

3. Assess the role of irrigation in food security outcomes among smallholder farmers in Wolaita.

4. Establish the factors that influence the sustainable food security outcomes in small-holder rural households in Wolaita.

5. Contribute to existing knowledge on the role of irrigation food security outcomes and rural development in Wolaita.

1.5 RESEARCH QUESTION

What is the role of irrigation in the outcomes of food security for rural smallholders, the community and its contribution to rural development in Wolaita?

Specific research questions:

1. What is the role of small-scale irrigation in the food production of smallholder farmers in rural areas?

    1.1. What is the role of Small-scale irrigation in improving crop production among small-holder farmers in Wolaita?

2. What is the role of irrigation in the diversification of food for smallholder farmers in rural areas?

    2.1. What is the role of Small-scale irrigation in the diversity of crop food consumption among smallholder farmers at the household level in Wolaita?

    2.2. What is the role of Small-scale irrigation in the diversity of animal food consumption among rural smallholders at the household level in Wolaita?

3. What is the role of irrigation in the food security outcomes of smallholder rural farmers?

3.1 What is the role of small-scale irrigation in income generation among smallholders in Ethiopia in general and in Wolaita specifically?

3.2 What is the role of small-scale irrigation in the nutritional status of small-holder rural households in Ethiopia in general and Wolaita specifically?

3.3 How has small-scale irrigation development improved the physical well-being of rural smallholders in Ethiopia in general and in Wolaita specifically?

3.4. How has small-scale irrigation intervention improved the cognitive capacity of rural smallholders and affected the lives of rural farmers in Ethiopia in general and in Wolaita specifically?

4. What are the factors that affect the sustainable food security outcomes among smallholder farmers in Wolaita?

5. What are the lessons learned from the role of irrigation in improving food security outcomes in Wolaita and their contribution to existing knowledge?

1.6 SCOPE AND LIMITATIONS

The Southern Nation Nationalities Peoples Regional State (SNNPRS) is among Ethiopian regions and has 14 zones (administration level below States) and four special districts. Wolaita Zone is one of the SNNPR state zones. The study considers small-scale irrigation schemes that exist within the Wolaita Zone, which are currently functional, constructed by the government and managed by both local authorities and the community together. Participants of the research are irrigation users, non-users, government and community-based institutions, and stockholders who are directly or indirectly responsible for the development, expansion, and utilisation of small-scale irrigation schemes. Therefore, owing to the limited time and resources, the study does not consider SSI schemes that exist within other ten regional states such as Amhara, Oromia, Tigray, Somali, Gambela, Benishangul Gumuze, Afar, Harari, Sidama, and Western Ethiopia. Furthermore, it does not also include medium- and large-scale irrigation schemes and all households available within two city administrations such as the Addis Ababa and the Dire Dawa city administrations.

The research is limited to small-scale irrigation schemes (<200 ha) (Mor, 2018) and rural smallholders. The study focused on the role of small-scale irrigation intervention in food security outcomes. Food security exists ‘when all people have always physical and economic access to sufficient, safe and nutritious food that meets their nutritional needs and food preferences for an active and healthy life’ (Vuppalapati, 2022:1). The results describe the benefits that the engagement is designed to deliver. They often relate to changes in levels, are localised in terms of scale, might be quantitative or qualitative, and often take place over a slightly longer timescale (e.g., over the lifetime of a project, rather than immediately after a single engagement activity) (Nigel, 2015). Therefore, the outcome of food security is defined as a comprehensive long-term effect on food availability, food access, food utilisation, and food stability at the household or community level (Nicholson et al., 2021). Moreover, it is about health, nutritional status, physical well-being, socioemotional skills, cognitive development, and the ability of rural smallholder households. This study analyses the responsiveness and behavioural change of the household to food security outcomes such as decision-making, social interaction, work culture, food intake habits, childcare, student school participation (school enrolment and dropout) and performance.

The diverse food available (through production and purchase) and income earned on the farm could be used for nutritional food, improve health status, social capital, and school expenditure. Research considers only small rural landowners who have a rural farmland size below 2 ha, that is, the maximum range of rural smallholder farmland in Africa (FAO, 2017b). The research does not consider medium-scale irrigation systems (200-300 hectares), large-scale irrigation systems (>300 hectares) (Mor, 2018) and urban households (family members do not base their life in rural farming and agricultural sector and reside under authorised city administration). However, it reviews the role of irrigation technologies that are available in all categories for rural smallholder beneficiaries. The household in the selected sample is taken as the unit of analysis. The study analysed the role of small-scale irrigation only in the outcomes of food security of acute indicators owing to time and resources. The researcher or other scholars could extend it further to chronic and other acute food security outcomes indicators, which are not included in this research, and require time, well-trained enumerators, and resources.

1.7 SIGNIFICANCE

Integrated rural development interventions for the sustainable use of resources such as water, farmland and human resources is critical to meet the increased demand for food. Most developing countries meet their food demand through rain-fed agriculture. However, owing to climate change and various problems, the rain-fed agricultural system cannot meet the required food demand in quantity and quality. Sustainable use of water resources is necessary to meet the food demand. Irrigation agriculture is resilient to climate change and provides adequate and quality food items which are essential for human development. Irrigation stimulates other activities and services in a rural community. Animal husbandry (including fishery using ponds), non-farm activities, health, nutrition, education status, management of natural resources, expansion, and development of infrastructures (like road, market, and Telecommunication) financial and extension services institutions and empowerment of women are among the major activities and services. Small-scale irrigation intervention is a nucleus to enhance other rural development interventions in small-holder rural communities.

Passarelli et al. (2018) researched the contribution of small-scale irrigation to income and diversity of food items, and its impact on nutrition. Few studies have documented the role of small-scale irrigation technologies in more than one dimension of food security. This study focuses on different components of food security and their effects on the ability of small rural landholder households and their members. The study contributes to the existing knowledge gap in the role of small-scale irrigation development.

1.8 DEFINITION OF KEY TERMS

Small-Scale Irrigation (SSI): Although it has variable definitions, in this study, it refers to “intense agricultural activity, small-scale, administered locally and/or mixed with government, conducted using any irrigation technologies or systems to divert water from the source and cultivate below 200 ha" (Mengesha, 2018:2).

Food Security: According to the World Food Summit, FAO (1996), "Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life" (Vuppalapati, 2022:1).

Food Availability refers to "the degree to which food is consistently physically obtainable in desired quantities, shaped by the production, distribution and exchange patterns of food goods" (Carson & Boege, 2020:7).

Food Access refers to **"**access by individuals to adequate resources (entitlements) for acquiring appropriate foods for a nutritious diet. Entitlements are defined as the set of all commodity bundles over which a person can establish command given the legal, political, economic and social arrangements of the community in which they live (including traditional rights such as access to common resources)" (Vuppalapati, 2022:1).

Food Utilisation: "Use of food through adequate diet, clean water, sanitation, and health care to reach a state of nutritional well-being where all physiological needs are met. This highlights the importance of non-food inputs in food security" (Vuppalapati, 2022:1).

Food Stability: To be food secure, a population, household, or individual must always have access to adequate food. They should not risk losing access to food owing to sudden shocks (for example, an economic or climatic crisis) or cyclical events (for example, seasonal food insecurity). The concept of stability can, therefore, refer to "both the availability and access dimensions of food security" (Vuppalapati, 2022:1).

Outcome refers to "the likely or achieved short-term and medium-term effects of intervention's outputs" (Intrac for civil society, 2017: 2).

1.9 CHAPTER LAYOUT

This thesis has ten chapters. Chapter 1 outlines the introduction and background of the study, research problem, research questions, objectives of the study, scope of the investigation, significance of the research and definitions of the major concepts employed in the study. It concludes with an outline of the thesis structure and chapter contents.

Chapter 2 begins with the systematic literature review of the role of irrigation on rural household food production, food diversity, and challenges of food security. It summarises the conceptual and theoretical aspects of the study and operationalises the human development and capacity theory, presents the analytical approaches and frameworks preferred for this study.

Chapter 4 discusses the global socialist command economies and free-market economic strategies. The chapter also examines Ethiopia's political and macroeconomic systems, rural development policies and institutional contexts, as well as their implications for various sectors and the country's overall economic performance.

In chapter 4, the author systematically describes the research design and methods of previous work, study population, sample size and its determination, data type and data collection methods, study instruments and their applications, and data analysis methods.

Chapter 5 presents the role of small-scale irrigation in food production among small farmers. It interprets the results of the role of small-scale irrigation in improving crop food production in Wolaita, southern Ethiopia. Chapter 6 explains small-scale irrigation to food diversification. It interprets the findings on the impact of small-scale irrigation on improving household consumption of multiple categories of crop and animal food among smallholder farmers in Wolaita, southern Ethiopia.

Chapter 7 covers the influence of small-scale irrigation on the outcomes of rural small-holder food security. It explains the qualitative and empirical findings on the role of Small-scale irrigation in achieving three indicators of food security outcomes

HDDS, HHS and WHCSI. Chapter 8 presents the factors influencing the outcomes of food security in rural smallholders.

Chapter 9 discusses the objectives under the nutritional capability approach framework. It summarises the key findings, responds to the research question, discusses the study limitations, and makes recommendations policy, planning practice to improve the role of small-scale irrigation food security outcomes for rural smallholders.

Chapter 10 concludes based on the objectives of the study and food availability, accessibility, utilisation, stability, and capability of rural smallholders. It makes recommendations for Wolaita rainfed and irrigated agriculture system and further research.

CHAPTER 2

CONCEPTUAL AND THEORETICAL FRAMEWORK

2.1 INTRODUCTION

This chapter begins with the systematic literature review of the role of irrigation on rural household food production, food diversity, and food security. The challenges, constraints that affect rural smallholders' food security and performance of small-scale irrigation are followed by the conceptual and theoretical framework on the concepts of rural smallholder agriculture, discourses on the concept of food security, types of irrigation and dimensions of food security. The chapter summarises the conceptual and theoretical aspects of the study and indicates the operationalisation of human development and capacity theory that exhibits analytical approaches and frameworks used in this study.

2.2 SYSTEMATIC LITERATURE REVIEW

2.2.1 Role of smallholder farmers agriculture in food security

Small-scale farmers contribute more to global food security. However, they make up the largest proportion of the world's disadvantaged communities (Addinsall et al., 2017b). Small-holder farmers in developing nations account for a large proportion of world food insecurity and malnutrition (Sibhatu & Qaim, 2017a) especially in Africa. African farm households are known to consume a significant portion of their crops (ibid.). However, little is known regarding how much subsistence agriculture contributes to household nutrition and how this varies seasonally (Sibhatu & Qaim, 2017). Bosch & Zeller (2019) analysed the contribution of wage work and income generated from the jatropha crop project and found that income generated from wage work contributed to dietary diversity but did not reduce the subjective lack of food during the lean season because they did not store the harvest (Bosch & Zeller, 2019). Addinsall et al (2017b) studied smallholder farming activity in the South Pacific toward agro ecological tourism and its contribution to food security and livelihood outcomes for rural smallholders. Addinsall et al (2017b) found that the shift from traditional gardening to cash-cropping monocultures affected the food security. Despite the quality of raw milk, small-scale dairy products play a socioeconomic role in improving food security in low-income rural areas of semi-arid Brazil (Meira et al., 2021). Oladimeji et al (2020) indicated that intercropping and mixed cropping were the most common strategies adopted by farmers in mitigating land degradation. Reduction in land degradation increases crop production. Rural smallholder farming is vulnerable to climate change, underinvestment and challenged by growing competition for land and resources, but it remains critical to contributing to rural food security.

Smallholder agriculture comprises variable farm activities. Improved understanding among smallholder farmers is essential to achieve sustainable intensification in smallholder farming systems (Elisante et al., 2019). Attention is needed to help farmers understand the benefits of using inputs and good practices (Gebete & Fengying, 2016a). Post-drought analysis in Kenya revealed high diversification in crops and livestock that are drought-tolerant, fast maturing and generate high income such as camels, rabbits and dairy goats while horticultural and fruit production sustains food security, income and livelihoods of smallholders (Ngaruiya, 2014). These reactive adaptation activities originate from active public-private cooperation that promotes knowledge exchange (ibid). Elisante et al. (2019b) found that after training, most farmers recognised honeybees (99%), hoverflies (54%), and solitary bees (62%) by name. Farmers recognised the value of honeybees (95%), hoverflies (65%) and solitary bees (60%) as crop pollinators and natural enemies (Elisante et al., 2019). The farmers recognised the environmental benefits of biopesticides over synthetic pesticides, and the importance of field margins in supporting pollinators and other ecosystem services (Ochieng et al., 2015a). Commercial-oriented farmers had a diverse diet than non-commercial farmers and bought other foods to supplement their production (ibid). Commercialisation has a positive effect on the safety of household food. This significantly increases the diversity of household food and reduces the number of coping strategies adopted during food shortages (Ochieng et al., 2015a). The integration of natural and artificial agricultural inputs and training rural farmers into the intensive agricultural system have a significant contribution to the food security of small farmers in rural areas.

Although rainfed smallholder farming is traditional and has problems in sustainable food production, it plays a vital role in food security and the livelihoods of rural households in Ethiopia. According to Sibhatu and Qaim (2017b), on average, subsistence production contributes 58% of the calorie consumption of rural households, that is, 42% of the calories consumed are from purchased foods. However, a study in Kembata Tembaro Zone, Southern Ethiopia found that rural households (41.6%) were involved in farm activity (Getinet & Lorato, 2020). About 22.54%, 21.41% and 14.37% of practiced on-farm plus off-farm, on-farm plus non-farm and on-farm plus off-farm plus non-farm livelihood diversification activities respectively. Aseres et al. (2019) reported that the adopters of sustainable intensification practices (SIPs) have 55% greater food security, 51% more access to clean water and sanitation and consume at least one additional food item daily compared to Ethiopian non-SIP adopters. Demeke et al. (2009) found that households with food security were from male-dominated and educated families, economically active families, had higher livestock, better rainfall harvest, and more participation in local savings groups. They showed that household size, livestock ownership and participation in local savings clubs all have a positive impact on the food security of rural smallholders. Misselhorn and Hendriks (2017), reported homestead gardening increased the social capital of the community or the household. Bagson and Kuuder (2013) found an improvement in food security situation by implementing dry season gardening and getting vegetables that can complement staple foods of the rainy season. Due to the improvement of cooperation and network between neighbours and different officials during gardening, households who practised food gardening improved their knowledge of the preference and use of food dietary, for good health and social capital at the household level (Misselhorn & Hendriks, 2017). Averbeke and Khosa (2007) found that agriculture improves the nutritional status of households by increasing monetary income and reducing household food expenditure. Although rainfed smallholder farming had challenges, Ethiopia promoted market-oriented vegetable production and sustainable intensification in rural areas. Since smallholder farmers contribute to the economy of the country, the government strengthened rural smallholders' capacity and competitiveness by intervening in sustainable agricultural and development activities.

2.2.2 Effect of Irrigation Agriculture in Ethiopia.

This section covers irrigation types, i.e., large, medium, small-scale, traditional, and modern irrigation systems in rural areas is reviewed. Agriculture plays a vital role in Ethiopia's economy and the lives of its citizens. The government to places a high premium on initiatives to advance rural development and increase the productivity of smallholder farmers. In Africa, rural development programmes have a long history, and Ethiopia is no exception (Welteji, 2018). Ethiopia's economy and citizens' livelihoods depend on agriculture (agrarian). The performance of the Ethiopian economy is highly correlated with the agricultural sector. Having a share of roughly 44% of GDP, agriculture employs approximately 80% of the workforce and accounts for 70% of export earnings (FAO, 2017a). More needs to be done to improve rural livelihoods and boost productivity to the necessary level government prioritisng smallholder farmers and the country's agricultural sector (Welteji, 2018). This highlights the significance of policies and programmes for strengthening rural development.

Ethiopia has a diverse, cultivable agro-ecological system, adequate water resources, wide biodiversity, and human resources. These resources could favour development of the agricultural system and the larger economy. However, agriculture is dominated by smallholder farmers and dependent on rain. In addition, access to land is crucial in determining agricultural production and income (Samuel, 2006). Owing to the high population growth rate (3%) (Bielli, Berhanu & Isaias, 2001), the per-capita landholding size in rural areas is small and less productive. History (1970s and 1980s), shows the country faced famine, drought, and economic stagnation (Shiferaw, 2017). Successive five-year strategic plans (Growth Transformation Plan I, II and III) and current ten-year prosperity plans derived from policy documents indicate the concern with rural smallholders agricultural and irrigation development. The Ethiopian government has shown interest in irrigation development.

Ethiopia has an annual rainfall that appears to be sufficient for food crop production and cattle pastures. However, the rainfall distribution is excessively unequal in terms of space and time. Due to the temporal imbalance in rainfall distribution and the resulting non-availability of essential water at the required time, reliable food supply is nearly impossible (Ministry of Water Resource, 1999). The National Strategy for Economic Development placed emphasis on the agricultural sector to improve the self-sufficiency of food and ensure household food security and, in the long term, to develop an industrial development based on agriculture (MoWR, 2006). The goal can be achieved through improved agricultural productivity, which requires mitigation of water shortages. An improved economy can be achieved by developing the water resources, expanding irrigation systems to promote agricultural production and addressing the water shortage problem caused by rainfall variability (MoWR, 2006). The irrigation policy was designed under the water resource management policy.

The goal of irrigation policy is to exploit the vast potential of irrigated agriculture to produce food crops and raw materials for agricultural industries efficiently and sustainably while preserving the fertility of the production fields and water resources (MoWR, 2006). More than half of the policy's six specific objectives focus on the development and expansion of small-, medium and large-scale irrigation systems for food security, self-sufficiency and raw material supply at the industrial level (ibid.). This shows governmental prioritisation of SSI development to enhance food production and achieve self-sufficiency at the national and family levels (Kloos, 1991). Although Ethiopia's irrigation policy shows the government's dedication to advancing SSI for increased agricultural productivity and food security, there are obstacles in putting the policy into practice and accomplishing its goals.

Due to agroecology and plenty of water resources, more than half of Ethiopia's land is suitable for irrigation. Increasing the irrigated agricultural land can contribute to stabilising and increasing food production. As a potential, 56% of the country's agroecology is lowland, where there is vast irrigation land, and an adequate amount of ground and surface water is available (Ulsido & Alemu, 2014a). Irrigated crops like cereals, pulses, vegetables, fruits, cash crops and root crops grow majorly in the country (ibid). From the cultivated area, the estimated total land under irrigation is expected to be 4 to 5%, and irrigation schemes with modern equipped irrigation facilities cover approximately 640,000 hectares (Awulachew, 2010). The irrigated land in Ethiopia is insignificant. Ethiopia needs to increase access to irrigation and modern irrigation infrastructure to better utilise its water resources, achieve higher levels of food security, and fortify the agricultural sector. The country's diverse agricultural output shows opportunities for irrigation development.

Revitalising the existing irrigation system is essential to improve the performance of irrigation schemes. Mwendera and Chilonda (2013) developed a conceptual framework for revitalising SSI and improving performance. The application of this framework and hypothesis improved the understanding of existing schemes. Even though SSI schemes have been shown to have positive effects, more work is still required to strengthen their revitalisation through scientific frameworks. Investigating appropriate irrigation systems needs to consider local constraints.

Construction of new irrigation systems and rehabilitation of existing SSI systems requires the necessary skills and training. Selection of a viable irrigation system based on all agronomy and expansion constraints has always been a scientific and professional challenge for agricultural scientists and practitioners (Jebelli, 2016). Mhembwe et al. (2019) promote the development of agricultural technical skills, the adoption of climate-sensitive irrigation systems by farmers. Moreover, farmers' training to increase the effectiveness of SSI schemes is also being researched (Mwendera & Chilonda, 2013). So, keeping the sustainability of new and existing irrigation systems requires intensive training of rural smallholders. All these actions will help to maximise the benefits SSI can offer smallholder farmers in the future in terms of food security and livelihoods.

Smallholder farmers face numerous obstacles in creating sustainable irrigation systems and efficiently managing water resources. irrigation can be run as a business by encouraging women to participate in irrigation facilities management, ensuring the independent access and use of irrigation land, and providing financial assistance to women to boost their agricultural activities (Mornah, 2011a). In addition, due to inadequate assessment of irrigation systems, poor data are difficult to track their progress and effects, and their sustainability is threatened (Bruce et al., 2019a). Collaboration with agricultural stakeholders is needed to improve productivity, food security in households and the livelihoods of the community (Jason & Francis, 2018). Although strengthening irrigation systems and overcoming the obstacles requires coordinated efforts across various support areas, progress is crucial to improving rural livelihoods and food security through agricultural productivity and water management on a sustainable basis.

Small-scale irrigation systems are crucial for maintaining agricultural productivity and rural livelihoods, but they face several obstacles in terms of efficacy, sustainability, and capacity to satisfy stakeholders' requirements. The selection of irrigation technologies of technical, social, and economic feasibility should also be identified properly (Prosperous, 2019). Moreover, adequacy, dependability and equity in irrigation schemes are critical to improving irrigation efficacy and ensuring the sustainability of irrigation system benefits (Debele & Mohammad, 2016a). However, irrigated agriculture is expensive for both the government and farmers (Haule, 2015a). Large- and medium-scale irrigation schemes (SSIS) are known to function considerably below their potential in many regions of the world, frequently falling short of stakeholders' expectations (Gate, 2010a). Therefore, in rural areas, ambiguities regarding the effectiveness of agricultural interventions are particularly evident (Adeniyi & Dinbabo, 2020a). Tapela (2012) pointed out that the challenge of reducing rural poverty and inequality in SSI systems cannot be solved by existing institutional approaches to agricultural commercialization. Therefore, the whole revitalisation process must be based on learning from experience (historical perspective) and continuous consultation of stakeholders.

Despite the numerous obstacles described above, irrigation agriculture contributes positively to Ethiopia's socioeconomic development, particularly in urban and rural households. Food insecurity affects most rural Ethiopian smallholders. Moreover, food insecurity reduces or makes uncertain the availability of nutritionally appropriate and safe foods, as well as the ability to obtain socially acceptable foods (Hickson et al., 2013). Becoming food insecure can have a serious negative impact on students' academic success, behavioural and social interaction (Cady, 2014). According to the Food Agricultural Organisation and World Health Organisation (2013), in addition to its significant effect on crop production and income of urban and rural households, irrigation development in Ethiopia has shown positive impacts on dietary diversity together with other agricultural activities as a package. In other words, it has shown some improvements in the food security of rural smallholders.

2.2.3 Small-scale irrigation role in food production

In developing countries, agriculture is unable to meet the food needs of rural populations. Seventy-five per cent of the world's poorest people live in rural areas and depend heavily on agriculture to survive (Burney et al., 2014a). Globally, these households produce a large share of the world's food, but they are still the world's most food-insecure households (ibid.). The percentage of poor people in rural areas remains high in Africa. The availability and efficiency of agricultural projects to support the technical problem of rural farmers and food security in rural areas is a challenge (Madzivhandila & Masenya, 2014). Therefore, understanding the context of rural smallholders' food security situations and intervening according to their context is a critical issue. For example, McIntyre and Hendriks (2018) evaluated the participation of members of disadvantaged rural communities in developing a more rooted and local understanding of South Africa's food insecurity. They recognise that the inclusion of people in the joint diagnosis of food security problems creates data on the economic, environmental and cultural conditions that shape the experience of hunger and influence food outcomes that are not always captured in traditional food security analyses.

The systematic review of the literature revealed that several studies have investigated the impact of irrigation on crop production and profitability in different contexts. Usman (2015) reports a significant increase in crop quantity and output yield in Nigeria. It also increases production and productivity (Chazovachii, 2012; Legesse et al., 2018). Additionally, Bruce et al. (2019) evaluated the improvement in rice and pepper production in Ghana. However, crop yield in the Dimbasinia watershed in northern Ghana, which uses shallow groundwater irrigation water, was only approximately 40% of the potential crop production (Worqlul et al., 2018a). Despite this, the resulting profit under irrigation was greater than that of rain-fed agriculture (Bruce et al., 2019b), although the profitability varied depending on the crop variety. They also found that high-value crops such as vegetables are more profitable than cereals. Similarly, Nethononda et al. (2014) report the contribution of irrigation to improving total crop production and household profitability. Jason and Francis (2016) in the Mvomero District of Tanzania assessed the amount of irrigated rice production harvested and monthly income earned from rice production. They found that 32% of users increased agricultural production per unit area, while almost 56.4% of the rice produced was served for food.

The development of irrigation has also contributed to the socio-economic aspect of urban and rural households in southern Ethiopia, especially in Wolaita Zone. It has contributed to the improvement of crop production and income. In Ethiopia, even though SSI is not performing to its full potential, it still ensures a significant contribution to improving agricultural production (Gebrehiwot & Mesfin, 2015a). However, its performance was determined by the structure and perception of rural households of irrigation. Therefore, the availability of adequate and quality food is one of the main problems in the area. To improve the food security and well-being of citizens, Wolaita Zone has wide opportunities such as early intervention of the agricultural extension programme through Wolaita Agricultural Development Unit (WADU), utilisation of improved seeds, access to agricultural inputs, availability of financial services, markets, all weathered roads, ample surface water, groundwater potential, diverse agro-ecology, crop diversity, and the experience of irrigation agricultural system. However, rainfed agriculture does not contribute enough to maintain rural household food security. Most of the mid- and low-lands and even some parts of the highlands have suffered drought owing to rainfall variability, land degradation and low land productivity.

2.2.4 Role of irrigation in food diversity

The role of irrigation in enhancing crop diversity and increasing yields has been widely studied. According to a systematic review of the literature, Issahaku (2018) asserts that irrigation increases the diversity of crops per small farmland. Issahaku (2018) assessed the role of irrigation to increase yields. For Graciana (2011) the crops that users irrigated included maize vegetables and fruits in Swaziland (eSwatini). Changes in crop types occurred in the eSwatini Malibeni community, where water was allocated to fields around residences (Kilel, 2015). eSwatini can grow annual crops twice and produce perennial crops more than twice. Worqlul et al. (2018) found that irrigated vegetables or fodder cultivated in rotation with sorghum is more profitable than maize. Jebelli et al (2016) and Nethononda et al (2014b) suggest that optimising the irrigation cropping pattern for specific crop ranges and the land use of the area would increase food diversity. The evidence highlights the benefits of irrigation on crop diversity, improved yields and profitability.

Previous studies assessed the potential of irrigation to improve dietary diversity. Nadeiwa and Koring (2017) elucidate that the livelihoods of the majority (75%) of farmers belonging to the Perkerra Irrigation Scheme, Baringo County, grew crops for consumption of three meals a day and did not rely on relief food. Irrigation contributed to family food supply through nutritious food from their backyard. On the other hand, Eshetu and Young-Bohk (2017) assessed the livestock and oxen ownership between small-scale users and non-users and found that users have better ownership than non-users. Similarly, Passarelli et al. (2018) examined the association of SSI, as a single agricultural intervention, with dietary diversity and nutrition and indicated a positive association. Irrigation improves the production of diverse crops and animals.

2.2.5 Role of irrigation in food security outcomes

Rural food security depends on the availability of food and the rights of citizens to use resources. This food production and rights depend on access to natural resources like water and land. Water-based food security perspectives, give insights into how to break the low-productivity cycle that leads many small-scale farmers to poverty (Burney et al., 2014a). According to the World Food Summit, attaining food security sustainably comprises multidisciplinary developmental components. Understanding the results of small farmers' food security outcomes needs the unpacking of the concepts and dimensions of food security.

The four dimensions of food security are *food availability*, food *accessibility*, food *utilisation*, and food *stability*. The dimensions are independently defined but are related to one another. Describing the food security outcomes, and the long-term effect of interventions on the food security of rural smallholders is crucial. Various scholars previously employed one or two or more concepts of these dimensions. The role of SSI to the role of food production and food diversity was discussed in the previous section. In this section, the study reviews the role of SSI in food security utilisation, food stability, nutritional food consumption of rural smallholders, health status, income generation, wealth, and livelihood activities under a variable context.

Previous studies used income as an indicator to describe the economic feasibility of SSI for rural households. Balana et al (2020) and Worqlul et al (2018) explored the contribution of SSI to economic feasibility. Their findings indicate that the adoption of SSI technologies increases net farm profits, particularly if appropriate crop types and SSI technologies are combined. By maintaining the right combination, profits from irrigated crops could increase by 154% to 608% compared to the baseline. Bruce et al (2019) found pepper production was more profitable than rice production. M’nabea (2013) in Miriga Mieru East Division of Imenti North District, Kenya, has further related the crop diversity (farmers in the area grew bananas, French beans, and sweet potatoes while few grew watermelons) and income to explain the status of rural household food security. In his study, household income increased, with household members earning between Kshs 20,001 – 30,000 per month. High-value crops like vegetables are more profitable than cereals (Bruce et al., 2019). On the other hand, Graciana (2011) has indicated that SSI schemes that are focused on the household level and the fields around the home contribute to earning an income. Therefore, irrigation has brought a high-level increase in the domestic income of the family (Nadeiwa and Koring, 2017). Moreover, small-scale irrigation schemes have also managed to ensure income generation for the community (Chazovachii, 2012). Therefore, SSI can contribute to generating income at the household and community level.

Studies in Ethiopia have shown that SSI contributed to the improvement of rural household income (Ahmed et al., 2014; Astatike, 2016; Assefa et al., 2019). Eshetu and Young-Bohak (2017) found that the income from irrigated vegetable crops represented 21.38% of the total annual crop income for irrigation users. In addition to these researchers, Ayele et al. (2013) found that households using irrigation had significantly higher mean annual household income by Ethiopian birr (ETB) 3,353 per year. This represents a 27% increase in income for non-irrigating households. Furthermore, households using concrete canal river diversion had higher mean cropping income per household than those using other irrigation types. Hadgu (2020) has found that 44% of non-users and 27% of users' respondents were food insecure and 3,976.95birr higher income than non-user households, respectively. On the contrary, Shumetie and Alemayehu (2019) have discovered that the income of households should increase by 63.34 and 57.56% respectively for the Doba and Goba-koricha districts in Hararge, Ethiopia to lift smallholders out of absolute poverty (Shumetie & Alemayehu, 2019a). Moreover, Ayele et al. (2013), Abebe (2017) and Acheampong et al (2014) indicate that irrigation influences the economic return of a household from a similar land size within a year. Furthermore, access to and use of irrigation water have significantly altered the main sources of income (Kilel, 2015; Legesse, 2018; Chazovachii, 2012), and expenditure on agricultural inputs (Zeweld et al., 2015a). Therefore, SSI serves not only as a source of income for households but also as a source of revenue (Issahaku, 2018). Accordingly, the percentage of agricultural output sold to the market serves as the foundation for market integration (Bocqueho et al., 2015).

The caloric intake of individuals was also used as an indicator to measure the state of food security in the household. Ahmed et al. (2014) have used caloric intake to show the effect of SSI on the food security of rural households. Wondimagegnhu and Bogale (2020) have evaluated the gap in food calorie availability, and the result has shown that there is a high variation ranging from 753-6659 kcal/adult equivalent/day between irrigation users and non-users. Moreover, food-secure households have caloric intake above national standards of 2330 kcal / day / average equivalent increased by 23% (Hussain & Thapa, 2012).

Based on the kilocalorie intake of household members per day, more than 80% and 64% of households in the Doba and Goba-koricha districts in Hararge Ethiopia were food insecure, respectively (Shumetie & Alemayehu, 2019). In addition, Ahmed et al. (2014) have identified that improved income together with enhanced on-farm food production resulted in an almost 20% rise in households' calorie intake. Therefore, this demonstrated how participation in irrigation ensures a significant, positive and robust impact on caloric intake.

Worqlul et al. (2018b) also extended their assessment towards nutritional contribution. They describe that crop types grown, consumed and the available vegetables have improved household nutrition during the dry season because of SSI. Similarly, Balana et al. (2020) confirm that the nutrition levels of rural households have also improved significantly because of the advances in crop yields resulting from irrigation. Furthermore, market-oriented agriculture enhances input use, yields and food security by increasing the dietary diversity of rural households (Ochieng, 2014). Moreover, commercial-oriented farmers have more diverse diets than non-commercial-oriented ones as they can easily purchase other foods to supplement their production. Passarelli et al. (2018) also researched the association of SSI, as a single agricultural intervention, with dietary diversity and nutrition and indicated a positive association. Therefore, it has significantly increased the diversity of the diet of the household and reduced the number of coping strategies adopted during food shortages (Ochieng et al., 2015a).

In contrast to the previous findings Gebru et al. (2019b), discovered that involvement in the vegetable business results in increased food availability and access, but lower food variety and diet diversity ratings. Participation in the vegetable business had a lower impact on per capita kilocalorie consumption and child anthropometric food security indicators (Gebru et al., 2019a). Similarly, Doocy et al., (2017) strengthened this finding and concluded that in a food-insecure context, improvements in agricultural production alone are unlikely to significantly change the health outcome of child nutritional status. A health outcome with a complex, multilevel causal chain (Doocy et al., 2017). Therefore, Tapela (2012) alludes to the role of SSI in commercial agriculture under different contexts needs further study to strengthen or disprove similar results.

The forms of employment available in the research region were examined in the employment situation of rural smallholders. Issahaku (2018) notes in his study how irrigation programmes provide jobs, minimise young outmigration, and ensure asset diversification and livelihood empowerment. Irrigation also has an impact on employment (Chazovachii, 2012). According to de Haas (2017), integrating smallholder farming with cash crops like bananas required fewer labour inputs to maintain a farm income than their grain-farming counterparts and create opportunities for additional income generation and livelihood diversification. Moreover, the SSI schemes have also managed the acquisition of assets such as scotch carts and livestock by farmers in rural communities (Chazovachii, 2012a; Legesse, 2018). Therefore, despite its variability in various contexts, irrigation plays a role in the diversification of livelihood activities and the improvement of food security.

The literature on the health consequences of irrigation appears to be dominated by negative hazards to public health. As a result, it produces varying degrees of debilitation (exhaustion) and disease in both humans and livestock (Asayehegn, 2012). On the other hand, small-scale irrigation schemes have also managed to supply water throughout the year to rural smallholder communities (Chazovachii, 2012a). However, Sinyolo et al. (2018) found that in South Africa, men had greater access to irrigation water than women and that there was unequal access to irrigation water for both men and women. It shows that water access has a significant positive impact on per capita income, with men earning higher benefits than women.

Children and adults' physical and mental health can be related to the quantity and quality of food consumed. The inaccessibility of food produced the limitation of access to food and income affects children and adults physical and mental health (Niemeier & Fitzpatrick, 2019). Furi (2015) also assessed the positive impact of SSI on education level, use of improvised aggregate income per capita, improved standards of living, marketing and distribution, access to credit, non-farming income, membership in water users, extension contact, and average livestock. He has studied the impact of irrigation beyond crop production. In addition, Passarelli et al. (2018) researched the contribution of SSI to income and diversity of food items, and their impact on nutrition. Furthermore, Chazovachii, (2012a) highlights the role of SSI schemes in managing school fees. Apart from this, Nadeiwa and Koring (2017) confirm smallholders possessed skills in farming compared to the time before the irrigation system. Therefore, this indicates that very few scholars have begun to study the driver components of food security outcomes comprehensively.

The impact of small-scale irrigation was not related to the participation and performance of the school children. Johnson and Markowitz (2018) examined the association of food shortage with academic success from a child to adulthood and the socio-emotional development of the household. From the pregnancy period to childhood and the rest of a life period, adequate nutrition is necessary for a healthy and active life of the individual (Prado & Dewey, 1992). Besides, Grimm and Richter (2008) found that irrigation increases and stabilises a food supply during a food crisis. Therefore, adequate and quality consumption has a positive impact on school participation and school performance of children. In conclusion, previously documented literature had a gap in describing the association of SSI with food security outcomes, especially health, socio-emotional skills, and educational performance of children and needs additional studies to clarify the contradicting results of previous studies in developing countries in general and in Ethiopia specifically. Moreover, the role of SSI in food security utilisation and food stability, nutritional food consumption of rural smallholders, health status, wealth, and livelihood activities are under variable context comprehensively.

2.2.6 Rural Smallholder Food Security: Challenges and Constraints

Most people living in rural developing countries experience food insecurity. Globally, 690 million people were undernourished in 2019 (IFAD et al., 2020). According to the FAO report, most people with food insecurity live in rural areas of developing and less developed countries, making it more crucial to study the challenges to food security in these regions. Ataei et al. (2021) identified eight categories as the major challenges to food security: economic, policy, structural, cultural, food access, knowledge information, climate conditions and social challenges. In addition to these challenges, different scholars identified the constraints and factors that affect rural smallholders' food security.

In many developing nations, there are several obstacles and limitations to the Millennium Development Goals (MDGs) and Sustainable Development Goals (SDGs) efforts to end hunger and ensure food security. Food security is one of the MDGs and SDGs, and most developing countries are trying to reduce hunger (Ataei et al., 2021a). However, this effort is challenged and constrained by various issues. In Thailand, land and legal rights over land were the main challenges for agricultural production and income (Charoenratana & Shinohara, 2018). Similarly, in Myanmar, land matters were cited as critical to improving the food security of rural smallholders and landholding households had higher levels of dietary diversity and were more likely to have food security than landless households (Pritchard et al., 2019). Even though developing nations have made progress toward attaining food security and ending hunger, there is still work to be done to address systemic issues like equitable land tenure rights and access to land.

The effectiveness of policy issues and institutional systems vary in different countries. In Sri Lanka, policy responses to the food price crisis, policies and decisions on the nutritional condition of rural dwellers and food security were a challenge to sustainable food security (Weerasekara, 2013). Food security is considered an inseparable component of international development policies. So, developing a nationally effective system to ensure food security while also supporting community nutrition and health, improving the status of the food industry, and increasing production and income levels is critical. The role of government in Rural Development Policy and Community Empowerment was cited as critical to improving rural food security in Indonesia (Dewi & Yustikaningrum, 2018). Establishing innovative rural institutions to improve food security is a challenge that depends on the policy and economy of a country (Zamani-Alaei et al., 2018). Moreover, food security is also challenged by the economy, information and geographic situation of each country (Bashir et al., 2013; Bermeo & Couturier, 2017). The analysts cited improvements in transport infrastructure and access to credit and the market as a challenge in addressing rural food security. Therefore, Achilana et al. (2020) note the importance of policies and strategies to support the improvement and diversification of farm and off-farm incomes in Tanzania. In many cases, the diagnosis of food insecurity lacks the step of contextualising food security data (McIntyre & Hendriks, 2018). Smallholders are challenged to adopt agroecology owing to fresh viewpoints and gathering and combining data from many sources to develop (Wei, 2020). Adapting policies, institutions and programmes to each country's unique economic, geographic and resource conditions can help overcome some of the challenges faced in establishing sustainable rural food security systems. This is to be able to support the livelihoods and nutrition of agricultural communities over the long term, even though coordinated efforts across many sectors are still needed.

Smallholder farmers face a wide range of interconnected supply, demand and resource constraints from agricultural practices and production issues to socioeconomic barriers and market accessibility problems. According to the systematic literature review, additional challenges affecting smallholder agriculture include labour shortages owing to outmigration, lack of skills, professional advice, finance, the low quality of soil, and agricultural land (Merchong et al., 2016). Education, training, access to credit, and location of the household were cited as determining factors for the adoption of technology upgrading (Kattel, 2015b; Takenaka et al., 2013). Constraints to increasing productivity and living standards in the long term include population, rural investments, resource reallocation, and access to agricultural technology (Warner, 2007). Barriers to smallholder market participation include price fluctuations, low yields, inconsistent weather patterns, lack of land, transportation costs, and food wastage or post-harvest losses (Longfield, 2014). Moreover, food production and consumption are influenced by seasonality, locust shocks and drought (Bosch & Zeller, 2019). Therefore, to support improved and sustainable rural livelihoods over the long term through enhancing agricultural productivity, food security and smallholder welfare, coordinated multi-pronged interventions across these domains will continue to be crucial.

2.2.7 Factors affecting rural smallholder sustainable food security.

Food security is a broad concept; it comprises multiple dimensions, multidisciplinary aspects and concepts. It can be affected owing to various issues. Although smallholder farmers are not a homogeneous group, knowing some of the common challenges they encounter might help identify strategies and policies that could more successfully alter the chances of their long-term success (Burney et al., 2014a). In Pakistan, Bashir et al (2013) identified livestock assets, family size, education and income level as factors that influence rural household food security. The study found that livestock assets have a favourable influence on food security in all three regions while family size has a negative impact (Bashir et al., 2013). In northern and central Pakistan, the intermediate and tertiary levels of education boost food security. In the North, the total number of income earners in the family had a positive impact on food security, whereas the age of household heads had an inverse association with food security (Bashir et al., 2013). Similarly, Umaroh and Pangaribowo (2020) investigated the consumption of certain self-produced protein-based food contributions to the food security of rural households in

Indonesia. They also assessed whether the food security of the rural household is influenced by household structure such as education and age of the household head. In Iran, household education, employment status and income are closely linked to food security; social assistance reduces the likelihood of food insecurity in rural households (Mokari-Yamchi et al., 2020). In terms of gender, Murugani and Thamaga-Chitja (2019) found that crop diversification and market-oriented empowerment of women improved farmers' skills in agriculture and contributed to food and nutrition security. The analysts argue that nutrition education and advocacy would also improve household dietary diversity (Murugani & Thamaga-Chitja, 2019). In addition, the factors that contributed to food insecurity in the rural area of Paktia Province, (Ahmadzai & Aryobi, 2021) in Afghanistan were cited as income level, farmland size, household size, food price and internal displacement. Similarly, Ahmed et al. (2017), delineating the factors contributing to food insecurity, revealed that farm households perceived lack of irrigation water, crop diseases, an increase in food prices and health expenses as major livelihood risks. Furthermore, monthly income, family size, debt, and market access (road distance and transportation cost) influenced the food security status of rural households (Ahmed et al., 2017).

Higher socioeconomic status affects the security and quality of life of the household food. Food availability and capacity to access food influence the food security of rural communities (Walsh & Rooyen, 2015). In a study on rural Ghana, Stephen and Samuel (2013) found that expenditure on food, household size, total production, credit access, number of income-generating activities, remittances, and land endowment affect the food security of rural smallholders. In a different study, household food production, financial capacity, household demographics, and food prices were identified as factors influencing variation in food consumption (Limon et al., 2017b). In addition, Sarker and Itohara (2010) note that the level of household head education, household members and farm size, access to extension services and number of cattle were significant for attaining household food security through the adoption of organic farming. Evidence from empirical analyses revealed that independent variables like years of farming experience, farmland size, education level, age, household size, access to the market and belonging to a farm cooperative contributed to systematic variation in the use of agricultural fertilisers and seeds in agricultural production (Gbete & Fengying, 2016b). Therefore, the aforementioned variables are the major factors that influence the food security outcomes of rural smallholders under variable contexts globally and in Africa.

Various studies have also identified the factors that affect rural household incomes, food security and livelihood in Ethiopia. Astatike (2016) reports that the level of household income was affected by irrigation participation, farmland size and livestock holding. Other variables affecting food security were identified as the age of the household (Eshetu & Young-Bohk, 2017; Gebrehiwot & Mesfin, 2015). Analysts such as Eshetu and Young-Bohk (2017) and Gebrehiwot and Mesfin (2015) buttress that factors that influenced food security included investment (purchase value) of pumps and total inputs used. Revenue generated from the sale of agricultural products also influences the food security of rural smallholders (Eshetu & Young-Bohk, 2017; Gebrehiwot & Mesfin, 2015b; Getinet & Lorato, 2020). Furthermore, factors that contributed to rural food security included the level of education of the household, the number of oxen and the size of the cultivated and total farmland (Eshetu & Young-Bohk, 2017; Getinet & Lorato, 2020). With enough household productive resources for the household e.g., availability to irrigation (Gebru et al., 2019a), household size, dependency ratio, proximity of the households to a water source, distance from the market, and crop pest infestation also affected agricultural production and the food security status of rural farmers (Gebrehiwot & Mesfin, 2015; Gebru et al., 2019a).

Households that participated in off-farm activities also had a higher probability of influencing rural food security status (Endiris et al., 2021). Training and extension services, cooperative memberships and farmer participation in the vegetable sector significantly influenced the status of rural household food security and improved the status of rural households in Ethiopia (Gebru et al., 2019a; Getinet

& Lorato, 2020). On the contrary, risk perceptions reduced participation in the vegetable business (Gebru et al., 2019a).

Some articles have identified factors that determine the livelihoods and poverty of rural farmers. Eshetu and Young-Bohk (2017) and Haule (2015b) report that rural farmers' livelihood was affected by access to credits, knowledge and skills related to irrigated agriculture. Furthermore, farming experience and food diversification were also identified as the main factors that influence the likelihood that households are poor (Adeniyi & Dinbabo, 2020b; Ayele et al., 2013). Also, moisture stress had a significant effect on determining household food security and poverty levels. On the other hand, Shumetie and Alemayehu (2019) note that family size had a negative impact on both food security and households' absolute poverty.

2.2.8 Factors affecting the performance of small-scale irrigation.

Government and non-government organisations (NGOs) should include economic recovery programmes in their rural development policies like the modernisation of agriculture. Examples include agricultural extension programmes, irrigation development, etc. SSI development activities could be placed in national development plans to address food security at the household level. Although SSI contributes to agricultural production, income and nutrition, rural smallholders have yet to improve their food security and capacity.

Various factors limit the potential performance of small-scale irrigation and affect the food security of rural households. Factors contributing to the inefficiency of small-scale farmers are demographic, socio-economic and agricultural characteristics, and these characteristics can be used as policy tools to increase production in the best way (Teshager, 2015). Inefficiencies in different African countries have been widely documented (Gate, 2010b; Usman, 2015b). Furthermore, women are not allowed to handle irrigation facilities owing to tradition and norms (Mornah, 2011a). In addition, the policy environment, design, farmer characteristics, expenses, institutional setups, the undervaluation of irrigation water by irrigation authorities, and cultural, communal, and environmental difficulties are the determinants of underperformance and reduced adoption of SSI (Muhoyi & Mbonigaba, 2018).

Different factors affecting the performance of SSI were also discussed by scholars. Assefa (2020) confirms that the distance between the farm and the water source had a significant negative influence on the use of SSI. The constraints affecting the performance and efficiency of smallholder irrigation were cited as sex, education, household labour size, training, frequency of extension contact (Assefa, 2020; Dessale, 2020), lack of capacity to build irrigation channels using own resources, insufficient flow of water, lack of access to other inputs (Dessale, 2020). Some constraints include canal and reservoir sedimentation (Abera et al., 2019; Gurmu et al., 2019), overgrazing, deforestation, soil salinity, poor watershed management, soil acidity, water logging, communicable and non-communicable diseases, soil fertility deterioration, land degradation, and soil erosion (Abera et al., 2019; Ulsido et al., 2013). Furthermore, several other factors were mentioned as limitations, including fewer water user's associations (WUA) committees with expertise in irrigation water management, a lack of clearly defined user rights to water, technical issues with design and construction, infrequent maintenance, and a lack of sanctions against illicit water users (Debele & Mohammad, 2016b; Dessale, 2020).

2.2.9 Concepts to evaluate irrigation, food security, and its outcomes

The definition of food security encompasses multiple components or concepts. After implementing a programme or intervention, various methodological approaches were used to evaluate the impact of the intervention on these concepts. In a systematic review of the literature, scholars have primarily described food security using one or two concepts, with a focus on food availability and accessibility. However, few studies have comprehensively evaluated all concepts of food security, including food availability, access, utilisation, and stability. This subsection of the chapter outlines the concepts identified in the literature during the systematic review.

Review of concepts used to evaluate food security outcomes.

Previous studies used various concepts related to food security. Baiyegunhi et al (2016) used the concept of consumption and Yahaya et al (2018) emphasised the concept of participation. Doocy et a. (2017) underlined the effect of modifications in agricultural production techniques on household food security and children's nutritional status in their farmer field school programs. Rivera et al (2018) investigated the relationship between systems, policy, environmental factors, and this improvement. In a Supplemental Nutrition Assistance Program-Education intervention, low-income Indiana homes with children reported an improvement in family food security. Charoenratana and Shinohara (2018) examined how legal rights and land affect agricultural income and productivity and Richardson et al (2018) assessed food insecurity susceptibility under various investment scenarios for climate change adaptation. Concepts related to food security include participation, change in agricultural production techniques, child nutritional status, policy, environmental factors, household, income, land, legal rights, vulnerability, climate change, and adaptation. The concepts are critical for evaluating food security.

Few researchers investigated the link between agriculture and food security. Leung et al. (2019) have examined differences in dietary intake. The seasonal contributions of market purchases and subsistence farming to food security and nutritional quality in smallholder farming households have also been examined by Sibhatu and Qaim (2017a). Ahmadzai & Aryobi, (2021) have also determined the factors that influence food security in the rural areas of Afghanistan's Paktia Province. Therefore, the main concepts discussed in these journal articles are household food, nutritional security, dietary intake, seasonality, subsistence production, market purchase, dietary quality, and smallholder farms. In addition to the above-summarised concepts, these are also very critical to evaluate and understand the food security situation of the household and community.

The outcomes of food security are the long-term effects of any intervention. To improve conservation and food security outcomes, Addinsall et al. (2017a) have studied the literature on the connections between smallholder participation, tourism, conservation, and agriculture. Furthermore, Sandhu (2014) has initiated a concerted effort to comprehend how India's food security outcomes are impacted by the National Food Security Act. He undertakes a determination to examine the history of the debate surrounding the right to food as well as the reasons why results in food security have consistently failed. Aseres et al. (2019) considered it necessary to look at the outcomes of adopting various sustainable intensification strategies in the context of Ethiopian rural farmers' food security. Conversely, Goshu, (2015) discovered a connection between child nutrition and household food security in Ethiopia's drought prone rural Gubalafto District. Important phrases under this paragraph include drought-prone areas, the discourse on the right to food, and the reasons underlying the ongoing failure of food security outcomes.

Limon et al. (2017a) have evaluated the coping strategies among smallholders. Furthermore, Bashir and Schilizzi (2013) have identified the determinants of food security. In reaction to shocks, the stability of food security outcomes has been studied by Nicholson et al. (2021). In contrast, the case of industrial crop (IC) expansion in SSA smallholder contexts has been examined by Dam Lam et al. (2017). Furthermore, Galeana-Pizaña et al. (2021) determined the relationship between food availability, accessibility, and utilisation and the structure of agricultural systems in Mexico. Additionally, Dompreh et al. (2021) evaluated the effects of certification acceptance on food security outcomes among Ghanaian smallholders growing oil palm and cocoa. Based on important motivating elements, Kasie et al. (2018) evaluated the resilience characteristics of household livelihoods as well. Their evaluation is predicated on the application of contemporary portfolio theory to socio-ecological systems and resilience theory. All the aforementioned researchers have used important concepts like industrial crop expansion, stability of food, coping strategies, resilience property, shock, agricultural system, household livelihoods, and determinants of food security. Therefore, according to the systematic review of the literature, all researchers employed one or two concepts of food security at a time.

Evaluation of relationship between SSI and food security/ outcomes

The impact of small-scale irrigation equipment is assessed using one or two concepts of food security. According to the systematic literature review, Furi (2015) analysed the impact of SSI on the socio-economy of users and non-users. Furthermore, Gebrehiwot and Mesfin (2015) evaluated how SSI helped to advance food security and agricultural productivity. Furthermore, Ohikere and Ejeh, (2012) assessed the impact of SSI technology specific to crop production. In addition, Usman (2015) also identified the effects of SSI technologies on crop yield and factors influencing the adoption and constraints of small–scale irrigation technologies. Gebrehiwot, (2015) also identified problems and challenges in the use of SSI. Adeniyi and Dinbabo (2020b) explored smallholder household types based on three phenomena and identified other factors that affect smallholder typologies. Therefore, the crop production or yield concept discussed in the above literatures are related to the food availability dimension of food security.

Ayele et al. (2013) has evaluated the effect of irrigation on household income. However, Temesgen et al. (2018) have measured the impact of SSI on household income. Gebremariam and Ghosal (2016) have identified the determinants that affect the income from SSI. Legesse et al. (2018) have also exploited participation in SSI and its impact on household farm income. The effects of SSI on income and its implications for the sustainability of rural livelihoods have been studied by Feleke et al. (2020). Similarly, Aseyehegu et al. (2012) and Leza et al. (2020) have identified determinants of SSI participation and the effect of participation in SSI on household income. Furthermore, the profitability of irrigators was explored by Bjornlund et al. (2019). On the contrary, Habineza et al. (2020) have extended their study to assess the profitability of SSI adoption on farmers in the Nasho sector, Kirehe District in Rwanda. Mottaleb and Rahut (2018a) examined the marketing behaviour of paddy rice by small-scale user households and the behaviour of cereal and non-cereal food expenditure of rural smallholders in Bangladesh under rising commodity prices. The impact of irrigation interventions on income generation by Ahmed et al. (2014). Mottaleb and Rahut (2018) analysed the relationship between land allocation for irrigation and household income. Sisay & Fekadu (2013) studied the allocation of land and participation in irrigation with household income as the outcome variable. Mango et al. (2018) also noted the adoption of SSI farming as a climate-smart agriculture technique and its impact on smallholder farmers' income. Finally, research by Passarelli et al. (2018) has examined how SSI may help improve diets and pinpointed the ways by which irrigation influences dietary diversification. Therefore, income, profitability and dietary diversity concepts only got the attention of the mentioned researchers. They are related to the dimension of food access and food security.

The food security status of smallholder farm households and the determinant factors to participate in irrigation were also evaluated by Ahmed et al. (2014). In the same way, Dessale (2020) and Hadgu (2020) estimated the factors influencing irrigation participation and its effects on the state of food security. Muleta (2021) evaluated how SSI affected the level of food security in households. Assefa (2020) determined the factors that influence the utilisation of SSI and how it affects the level of food security in households. Mottaleb and Rahut (2018) examined the relationship between land allocation for irrigation and estimated the barriers to irrigation water usage participation. Mango et al. (2018) looked at the determinant elements that affect the adoption of SSI farming as a climate-smart agriculture practice. M'nabea (2013) also determined the effect of SSI on the status of household food security. Factors influencing resettled farmers' decisions to participate in SSI have been discovered by Astatike (2016) and Shono and Kibret (2020), who have also examined the effects of SSI on the state of household food security. Ochieng et al. (2015) state that the commercialization of staple crops has an impact on rural households' household food security. The methods of adaptation to climate change used by small farmers and their impacts on the status of household food security were also examined by Shisanya and Mafongoya (2016). Furthermore, Wondimagegnhu and Bogale (2020) have analysed the effect of SSI on the food security of rural households. Therefore, food security status as a concept, participation and factors that determine participation in irrigation adoption and determinants of food security were the main concerns of the aforementioned researcher. They did not link to any dimensions of food security.

Adela et al. (2019) identified the effect of irrigation on poverty levels among farmers. Zeweld et al. (2015) studied the impact of SSI on households' livelihood and Getinet and Lorato (2020) measured the food security status of households, livelihood strategies and the factors that affect participation in irrigation agriculture. However, the potential benefits of irrigation in developing countries such as Ethiopia and its impact on food security were not fully explored. Merely, assessing one or two food security concepts would not provide a comprehensive understanding of the potential impact of irrigation. To fully understand the efficacy of this intervention, it is necessary to consider all four dimensions of food security and evaluate its long-term effects.

2.3 CONCEPTUAL FRAMEWORK

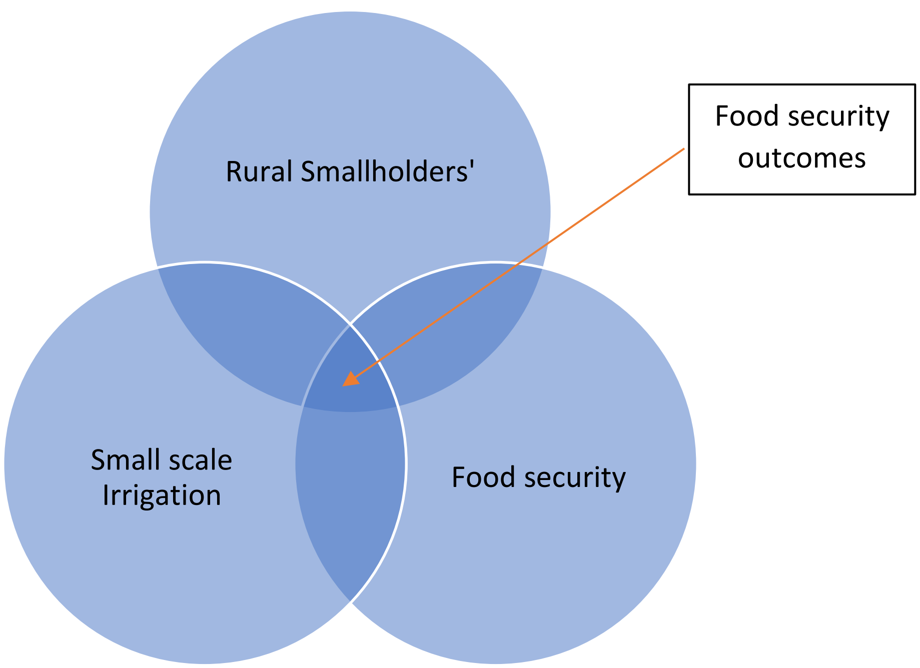
Irrigation: process of applying water to the soil, primarily to meet the water needs of growing plants. Pipes, canals, ditches, or even natural streams are used to pump or allow gravity to move water from rivers, reservoirs, lakes, or aquifers. Watering fields increase agricultural yield in terms of quantity, quality, and consistency (Bjorneberg, 2013). Irrigation is an intensive agricultural system that can generate multiple functions for the development of rural smallholders.

Small-scale irrigation: refers to “intense agricultural activity, small-scale, administered locally and/or mixed with government, carried out using any irrigation technologies or systems to divert water from the source and cultivate below 200 ha” (Mor, 2018:2). The development of SSI schemes is one of the interventions that have been implemented to achieve food security in the household, improve the supply of agricultural products and contribute to the national and individual economy. In this study, it is considered as an intervention that is subsidised by the government to the public to enhance competition, create entrepreneurs and improve the food security of individual rural citizens. Therefore, any SSI technologies, schemes or systems that cultivate below 200 ha and are administered by the community and/or government together are included in the study.

Rural smallholder: The term "implies a restricted amount of available land, 'Resource-poor' farmers who have limited access to inputs, fragmented holdings, low capital (including livestock), and other characteristics" (Chamberlin, 2007). In this study, it has been defined as any rural household that bases its economy on rural farmland size ranging from 0.25 – 2 ha.

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" (Vuppalapati, 2022:1). This study focuses on the role of SSI in adequate and continuous physical and economic access to food, safe and nutritious food access, contribution to dietary needs and food preferences, and active and healthy life of rural smallholders.

Figure 0-1 The conceptual framework of the study



Source: Author

Food security outcome: It is defined as a "comprehensive long-term effect on food availability, food access, food utilisation, and food stability at the household or community level" (Nicholson et al., 2021). Moreover, it refers to the cognitive development and the improvement of socio-emotional skills of individuals within the household in the long run. The multidisciplinary nature of food security outcomes is described in Figure 2.4.

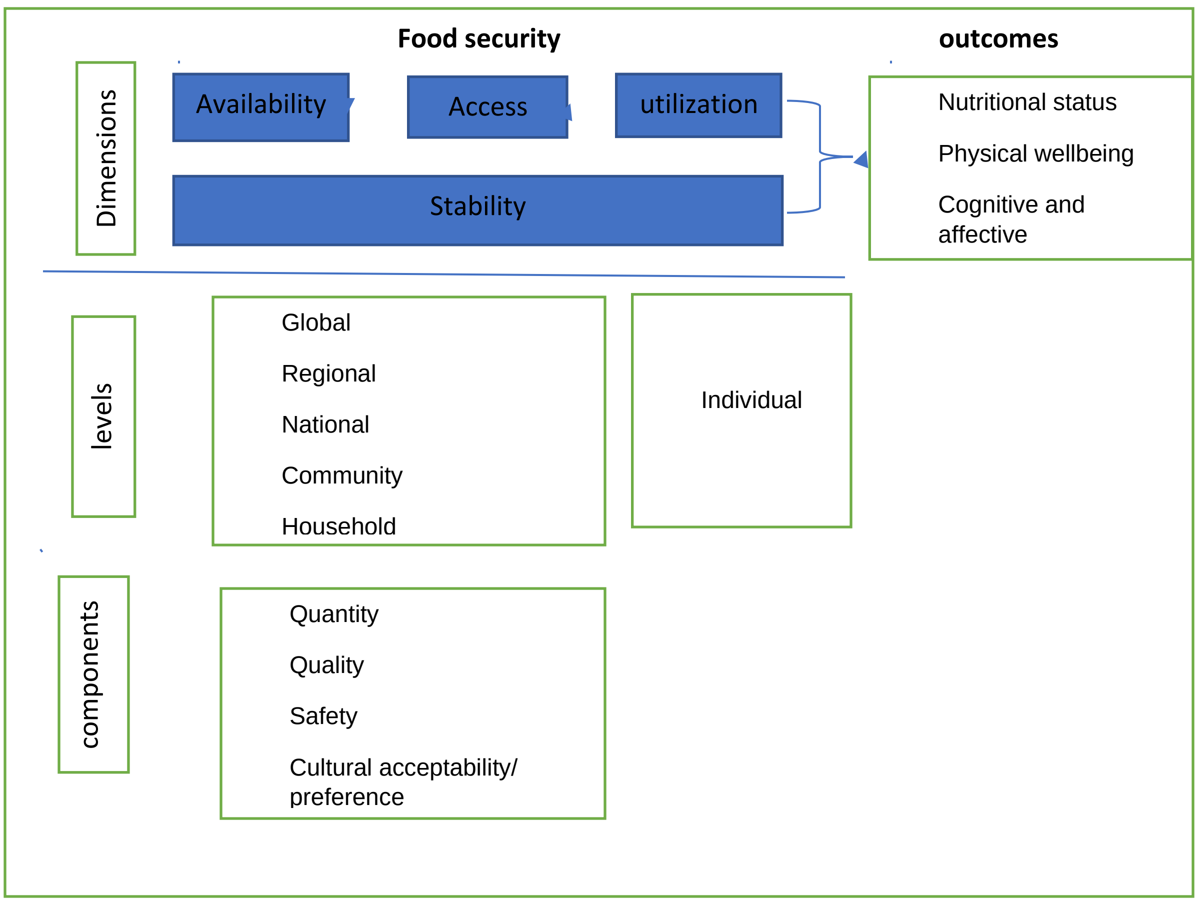
Food availability: refers to “the availability of sufficient quantities of appropriate quality food, whether produced domestically or imported” (Carson & Boege, 2020:7). This study focuses on the increase in household production owing to the application of SSI technology.

Food access: People's ability to acquire resources (rights) that they need to buy the right foods for a balanced diet. Entitlement is defined as ‘the entirety of commodity bundles over which an individual can exercise control due to the legal, political, economic, and social institutions of the community in which they reside (including customary rights like access to shared resources)’ (Vuppalapati, 2022:1). Access to nutritious food is assessed in this study through self-production and purchase (which could be made possible by selling surplus products from irrigation agriculture).

Food Utilisation: utilising “food through a sufficient diet, clean water, hygienic practices, and medical attention to attain nutritional well-being and meet all bodily needs. This emphasises how important non-food inputs are to ensuring food security” (Vuppalapati, 2022:1). The process through which the body absorbs the greatest amount of nutrients from the food is commonly referred to as utilisation. Individuals who receive good care and feeding will consume an appropriate amount of energy and nutrients. Good food preparation, diet variety, and intra-household food distribution all contribute to this. This, along with optimal biological use of the food ingested, establishes the nutritional status of an individual. This study assesses the diversity of food consumed from irrigation farms or purchased based on income generated by irrigation. Moreover, they obtain health and education services (access) owing to participation in irrigation and income generated from the intervention.

Food Stability: A population, household, or individual must always have access to enough food to be considered food secure. They should not lose access to food because of cyclical events (like seasonal food insecurity) or unexpected shocks (like an economic or climatic disaster). As a result, “the availability and access components of food security can both be included in the definition of stability” (Vuppalapati, 2022:1). This study assessed the availability of adequate and quality food for all family members throughout the years owing to irrigated farm production or income generated and assets accumulated owing to irrigation, i.e., from the sale or use of saved surplus crop and animal production, and other home assets.

Figure 0-2 The multidisciplinary nature of food security and its outcomes



Source:- Leroy et al., (2015)

2.3.1 Small-holder rural agriculture

The concepts of household, agriculture, and agricultural household in Ethiopia, according to the Central Statistical Agency (2021), they are explained:

Household: a household may be either

A single individual who provides for their own needs without joining forces with others to form a multi-person household is referred to as a one-person household or a group of two or more people who live together and share expenses for food and other necessities of life. To a greater or lesser extent, members of the group can pool their incomes and establish a common budget. They could be individuals who are connected, unrelated, or a mix of the two. These people are a part of the household.

Agriculture: The process of cultivating land and/or rearing livestock for personal use or commerce.

Agricultural household: When at least one member of the home raises livestock or grows crops alone, either alone or in conjunction with others, the household is classified as an agricultural household.

Holding: Any land and/or cattle kept for agricultural production, whether fully or partially, that is managed as a single legal entity by one person acting alone or in conjunction with others, regardless of management, organisation, size, or location, is referred to as a holding.

Holder: A holder is an individual who has managerial responsibility over the agricultural holding's operations and makes important decisions about how to use the available resources. For the holding, he or she bears major technical and financial responsibility. In the capacity of an owner or manager, he or she may run the holding directly. In traditional agricultural holding, the holder is the individual who manages land and/or raises livestock on their own, either alone or with assistance from others. The holder chooses which areas, when, and how to raise livestock or crops, or both, and can how the products will be used.

Rural household: refers to a one - or multiple-person household that bases their life in rural agriculture and resides under an authorised rural administration area.
Smallholder: a household of one or more people who own farmland that is less than the average land holdings of the national (Ethiopia) and continental (Africa) of 0.84 ha (CSA, 2021) and 2 ha (Hazell, 2017) respectively. Smallholders reside within an authorised rural administration area, exercise management control over the operation of the agricultural holding and make decisions on resource utilisation.

2.3.2 Food security: concepts, evolution, and discourses

The evolution of ideas on food security reflects shifts in policy conceptualisation (Heidhues et al., 2004). The term "food security" was first used in the middle of the 1970s by the World Food Conference (1974), which defined it as guaranteeing the availability and stability of basic foods on a national and international level; adequacy of global food supplies of staple foods at all times to support a steady expansion of food consumption and to offset fluctuations in production and prices (Russell et al., 2011).The FAO analysis on food access, resulted in a definition based on the equilibrium of the supply and demand sides of the equation for food security:' Ensuring that all people have physical and economic access to the basic food that they need' (Vuppalapati, 2022:1).

The term "food security" was broadened to include not only the regional and national levels of aggregation but also the individual and household levels. The temporal dynamics of food insecurity in 1986 were focus of the World Bank study on poverty and hunger (Allen, 1987; Clay, 2002). The study distinguished between transitory food insecurity, linked to times of elevated stress brought on by natural disasters, economic collapse, or conflict and chronic food insecurity, which is connected to persistent or structural poverty and low-income concerns. Sen's theory of famine (1981) and individual rights—that is, labour, production, commerce, and transfer-based resources—on the availability of food (World Bank, 1986). The World Food Summit's (1996) definition of food security considers stability, consumption, availability, and access to food (Shaw, 2007). Concepts of livelihood were popularised by scholars like Chambers et al. (1989). These concepts—vulnerability, risk coping, and risk management—are utilised in emergency scenarios. Food insecurity is a social and political construct as the relationship between food security, starvation, and crop failure weakens (Devereux, 2000).

Food security's ethical and human rights implications have gained attention. The 1948 UN Declaration of Human Rights was the first document to acknowledge the right to food as a fundamental human right. The acceptance of the right to sufficient food in 1996 made the case for a rights-based strategy for ensuring food security. FAO believes that the right to food can be established in 54 nations, and the right to food is guaranteed by the constitutions of more than 40 countries (McClain-Nhlapo, 2004). The Intergovernmental Working Group operating under the FAO Council's developed voluntary guidelines for the gradual realisation of the right to adequate food in national food security (ibid). Although the term has over 200 definitions (Ashley, 2016), most nations have adopted World Food Summit definition:

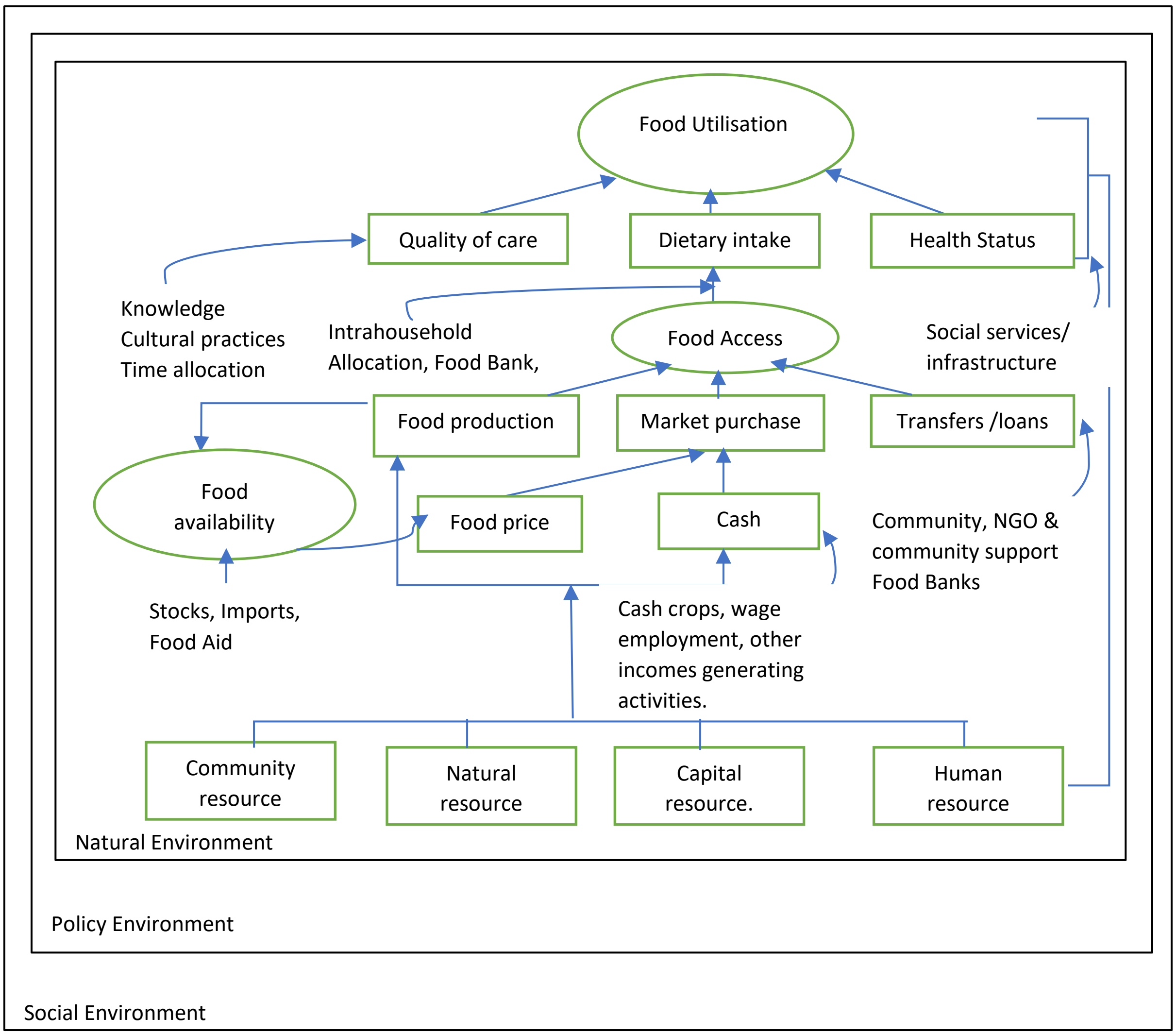
> ‘Food security exists when all people, at all times, have physical and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life’ *(*Vuppalapati, 2022:1*).*

Achieving food security, requires physical food supplies available overall, households access to the food supplies through the production, the market, or other sources, and the food supplies must be used appropriately to meet each person's unique dietary needs (Riely et al., 1999). In 1994, Human Development Report of the UN Development Program examined human security as an evolutionary notion. Human rights brought up the issue of food security, which at the time was a part of the larger social security framework. Adding a social focus, expanded the concept of food security (FAO, 2014). 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.

2.3.2.1 Dimensions of food security

The notion of food security has led to the identification of four dimensions: food availability, food consumption, food access (financial and physical), and food stability (vulnerability and shocks) (Peng & Berry, 2018). Their influence on rural smallholders' food security depends on the natural, and policy environment.

Figure 0-3 Conceptual Framework of Food Security



Source: - Riely et al., (1999)

2.3.3 Typologies of Irrigation

The primary definition of irrigation is providing plants with the necessary amount of water at the necessary intervals. It is essential for farming as well as for raising farm yields. Irrigation not only provides water but also enhances soil fertility, appropriate growth and development, and the moisture needed for seed germination. There are two types of irrigation techniques: traditional and modern irrigation techniques (Mengesha, 2018).

Modern methods: The more efficient irrigation systems of today were created in the last several decades. We can use water more wisely and waste-free thanks to contemporary irrigation techniques. Being cost-effective, modern irrigation increases crop productivity per unit of land, improves financial gains from increased competition from other water users, and increases the reliability of water delivery, allowing farmers to properly schedule cropping cycles and maximise the use of other inputs. They improve people's ability to manage systems through better system monitoring, by enhancing knowledge and understanding, and by enhancing the use of institutions and governance structures. They a increase delivery flexibility, giving farmers more control over what they grow and when to apply water. The modern irrigation methods of irrigation include sprinkler irrigation, drip irrigation and pot irrigation methods.

Traditional irrigation methods: The oldest irrigation techniques still in use today are traditional techniques, which are also more economical and effective than contemporary techniques. Even now, some of these irrigation techniques are in use. Among the conventional irrigation techniques are the following: Check the drain and drain technique. Based on the area of irrigation, irrigation schemes and technologies are classified into three major types. They are small-, medium-, and large-scale irrigation.

Small-scale irrigation: This study refers to intense agricultural activity, small-scale, administered locally and/or mixed with government, carried out using any irrigation technologies or systems to divert water from the source and cultivate below 200 ha (Mor, 2018: 2).

Medium-scale irrigation: an irrigation scheme, technology, or system that cultivates irrigation farms from 200-300 hectares and is administered by government or private investors (Mor, 2018: 2).

Large-scale irrigation: an irrigation scheme, technology or system that can cultivate greater than >300 hectares and administered by government or private investors (Mor, 2018: 2)

2.4 THEORETICAL FRAMEWORK

2.4.1 Interventionism

Interventionist theory promotes improving the competitiveness or capacity of individuals and groups that cannot be achieved in a free market system. In a free market economy, the authority is not limited to keeping the interchange of goods and services from being disrupted. The government interferes in the operation of the market through interventions (Dunne, 2014). Rural smallholders are unable to compete and build their capacity under free-market conditions. State intervention is required for a certain period to enhance the capacity of individuals and groups without competition and the challenges of the market. SSI schemes in rural areas are among interventions implemented by the government to improve the capacity of rural farmers (community) to make them competitive in local and national markets.

2.4.2 Capability Theory

The 'conversion' problem—that is, the idea that income, wealth, and commodities (IWC) should be distributed efficiently to maximise well-being—is considered by capability theory, which advances our knowledge of well-being (Sen, 1997; Drèze & Sen, 2003). IWCs are transformed into functions (beings and acts) that subsequently play a role in potential lives that individuals 'might have caused' to desire. The social, cultural, and environmental elements known as conversion variables enable an individual to transform their IWCs into functional ones (Robeyns, 2005). The focus of this research is capacity connected to nutrition. A skill is related to nutrition only if it can be improved by eating more or better food. There is a distinction between "undernutrition" and "undernourishment." While the latter is viewed as an undesirable state of being, undernutrition refers to food intake deficit. Undernourishment refers to the state of humans, whereas undernutrition relates to commodities (less food, or less variety of food than specified nutritional standard would demand). Undernutrition is associated with commodities (specifically, food). This study evaluates the role of SSI technologies in generating income, wealth, agricultural commodities, and change in their behaviour/skill/knowledge in enough and quality food production, consumption and social interaction, the utilisation of socioeconomic institutions and the understanding of environmental conditions.

2.4.3 Human Development Theory

Whether in infancy, childhood, adolescence, adulthood, or late adulthood, the human development theory, also known as the relational development systems (RDS) model, frames contemporary research in human development and encourages investigation of variation both within time and across people in their trajectories of individual-context relations using person-centred and change-sensitive methods. RDS theories suggest, methods for bringing everyone closer to living on a more "level playing field" may be discovered through the malleability of individual context relations (Lerner et al. 2015). The theory gives the study ground to understand the effect of adopting SSI technology towards economic, behavioural, social, and cultural variations that occurred after the introduction of SSI within a long-term implementation period.

Socioemotional skills: contains “changes to one's personality, feelings, perspective on the beginning, social skills, and interactions with family and friends on a personal level” (Kuther, 2017). These depend mainly on the individual's cover of income, wealth, commodity, training, knowledge, and social interactions. These skills could be obtained owing to activities, programmes and services provided to enhance the performance of SSI in the area over time.

Cognitive development: involves “the development of our mental processes and the instruments we employ to learn new things, become conscious of the world around us, and find solutions to issues” (Kuther, 2017). These depend on the individual's cover of income, wealth, commodity (especially consuming adequate and quality nutritional food all the time and maintaining a healthy life), training, knowledge, and social interactions.

2.5 Summary of concepts and theoretical perspectives

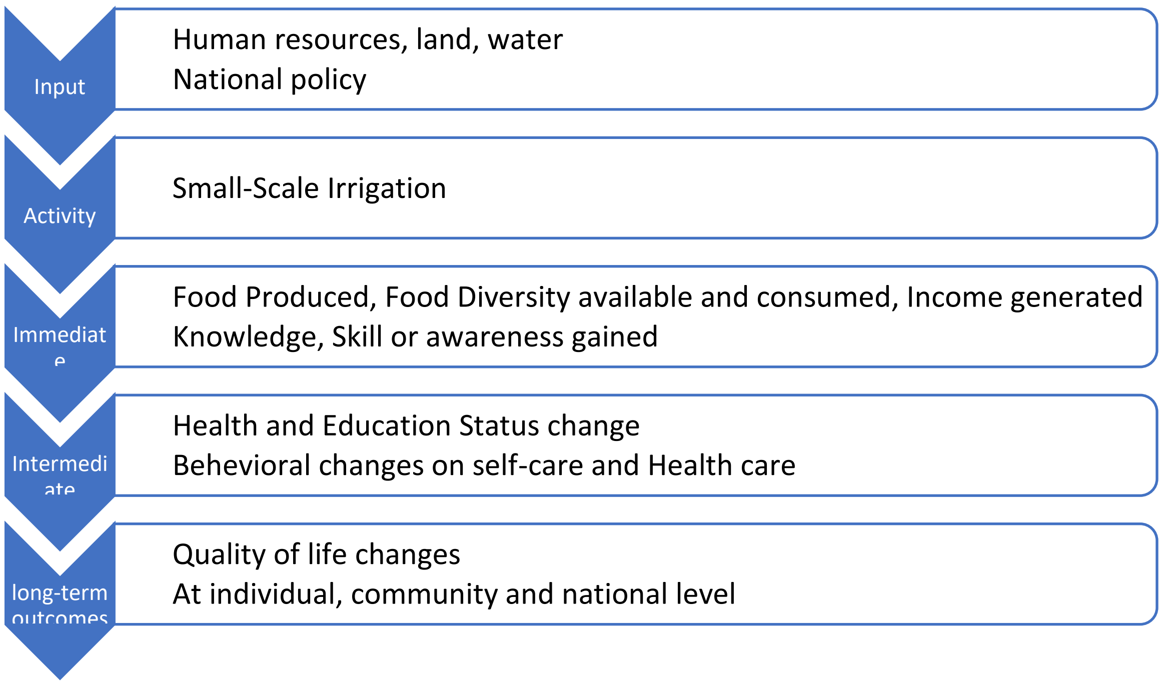
The food security of rural smallholders could be improved by intervening in development interventions that can improve the capacity of rural smallholders and reduce the causes of food insecurity. The following are some additional concepts summarised under programme theory.

Intervention: According to the Merriam Webster dictionary (1828), intervention is defined as 'the act or fact of taking action about something to affect its outcome' (Paula Spencer, 1828:1).

Outcomes: Outcomes describe the benefits that the engagement is designed to deliver. They often relate to changes in levels, are localised in terms of scale, might be quantitative or qualitative, and often take place over a slightly longer timescale (e.g., over the lifetime of a project, rather than immediately after a single engagement activity) (INTRACT, 2017: 2).

A programme theory is composed of a series of assertions that characterise a certain program, explain how, why, and under what circumstances the program effects happen, forecast the program's results, and outline the prerequisites required to produce the intended program effects (Sharpe and Bay, 2011). Program activities or inputs planned outcomes or outputs, and the mechanisms by which the intended outcomes are achieved are the three components that program theory modelling utilises to explain the program (Rogers et al., 2004). The elements of the program, how they are delivered, the strength or quantity of treatment needed to induce the desired result, and the necessary elements essential to achieving the desired results are all defined in a description of the critical inputs (Sedani & Sechrest, 1999). Then list the necessary elements essential to achieving the desired results (Sharpe & Bay, 2011). The procedures that come after the inputs and on which the result depends ought to be explained (ibid.). The components, connections, and stages of the anticipated transformation process are covered, alongside implementation concerns, in the process or mechanisms of the program theory (Rogers, 2008; Sedani & Sechrest, 1999). The result should outline the type of change, anticipated time frame, side effects, the pattern of change, and how the various outcomes relate to one another (Sedani & Sechrest, 1999; Wholey, 1987). The relation between inputs, activities, and outcomes of this study is described in Figure 2.4.

Figure 0-4 Adopted simplified logistic framework for assessing the role of SSI.



Sources: Rogers et al., (2004); Sidani & Sechrest, (1999); Sharpe & Bay (2011)

This study uses interventionist theory, capability theory, human development theory and programme theory to attain the specific objectives of the study and construct the theoretical framework of the study. By operationalizing food security concepts under human development and capacity theory, the study intends to understand the effect of SSI intervention on the development of human, financial, social, and environmental capacity of rural smallholders, and food security outcomes under the framework of programme theory.

2.5.1 Operationalisation: Human Development and Capability Theory

Variable approaches to food security analysis have been employed in the past (Burchi & Muro, 2016), including the food availability approach, the basic needs approach, the income-based approach, the sustainable approach, and the entitlement approach. However, the human development and capability approach was developed later, in 1989, by Jean Drèze and Amartya Sen in their ground-breaking book Hunger and Public Action. Furthermore, this approach was suggested as a comprehensive approach to evaluate important long-term concepts such as vulnerability, sustainability, and coping strategy. Food utilisation is related to the concept of vulnerability. Food stability is seen similarly in the concepts of sustainability and coping strategies.

Three stages were involved in the analysis of irrigation's impact on small farmers' food security outcomes using a human development and nutrition capability approach: Three analyses presented include: (1) entitlements to food; (2) fundamental capacities for ensuring food security; and (3) the capacity to ensure food security.

The initial stage of the entitlement analysis process involves gathering data on the endowments, exchange conditions, and production possibilities—the three main components of food entitlements. Fundamental capabilities are analysed in the second phase consider aspects other than dietary entitlements. These are environmental and institutional conversion variables, largely out of individual control. Institutional conversion factors are the laws, standards, and practices that permit, the conversion of a specific amount of money into enough food. A woman will not be able to utilise her money to purchase food, for example, if she is prohibited from "going to the market alone". Environmental conversion factors influence, how food farmers convert food output into actual food (for subsistence agriculture) or income (for food sold in the market), given the productive potential and exchange conditions. Examples include climate change and natural disasters. Environmental conversion variables can be acquired at the community level by ad hoc qualitative/participatory processes (e.g., focus groups or "life stories") or from basic national or worldwide sources.

In the third stage: A more thorough assessment of fundamental abilities, including good health, education, and the capacity to engage in household decision-making and community life, is necessary because food security cannot be fully understood based solely on one's ability to obtain food. To perform this analysis, the following data must be gathered or located: (1) school enrolment, educational attainment, literacy, participation in adult literacy courses, and other non-formal education programs; (2) health care services accessibility, sanitation, major disease morbidity, and self-reported health status; and (3) the ability to make decisions jointly or independently within the household on matters like food allocation and budget (empowerment-type). The ability to acquire food relies on how the "basic capabilities" interact with one another. In this instance, the former serves as the basis for the latter based on the "basic" and "more complex" skills. The "ability to be adequately nourished" as (Drèze and Sen (2003) is similar to the "capacity to be food secure." FAO (2014), defines food security as "a situation that exists when all people, at all times, have physical, socioeconomic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life." Thus, human development and capability theories help to understand the role of irrigation in rural smallholder food security outcomes.

2.6 SUMMARY

This study aims to understand the role of irrigation in the food security outcomes of rural smallholders under the framework of human development and capacity theory. The study focuses on the development of human, financial, social, and environmental capacity, contribution to dietary needs, food preferences, and active and healthy life of rural farmers. The study is based on a three-phase analysis of food entitlements, basic capabilities for food security, and the ability to be food secure. The analysis was carried out through: (1) analysis of entitlements and access to food; (2) analysis of basic capabilities; and (3) analysis of the ability to be food secure. Human development and capability theories were the dominant theories used to analyse the impact of irrigation intervention on the food security outcome of small farmers. The study operationalises the concept of food security in the context of programme theory.

CHAPTER 3

MACRO-ECONOMIC AND INSTITUTIONAL CONTEXT

3.1 INTRODUCTION

This chapter presents the underlying theoretical conceptualisations that have shaped the Ethiopian economy and the macroeconomic context of rural smallholders. The chapter examines the global socialist command economies and the free-market economic policies. The chapter explores Ethiopia's political and macroeconomic policies and their implications for various sectors and the country's overall economic performance. It describes the rural development policies and institutional contexts in general and specific to Ethiopia.

3.2 GLOBAL SOCIALIST OR COMMAND ECONOMY

The socialist economy bases its economic thought on Marxist philosophy. Karl Marx (1818-1883) was the founder of scientific socialism (Sharma, 2013). Lekachman (1966), Marxism as philosophy, sociology, history, and economics. The English economic thought was influenced by Marxian thought of socialism (Sharma, 2013). The vertical mediation of horizontal relationships between firms has been a significant characteristic of communist economies. The mega-hierarchy is where this mediation occurs in the conventional system (Chavance, 1995). Although the centre's effect on actual developments is significant, it cannot lead to the latter controlling the economy (ibid.).

The socialist economic system has three common features in all countries, from 1930 in the USSR until it collapsed in 1989-90, from Eastern Europe to China and Cuba (Myant et al., 1996). Initially, the entire economy was under the authority of one party, which is why it was named communism. Second, collective ownership of the primary means of production served as the foundation for the economic institutions. Coordinating mechanisms constituted the third mandatory central planning mechanism, with a growing but ancillary role allocated to market instruments. The state owned everything, people had no property, and that all economic decisions were dictated by the government (Delville, 1991; Myant et al., 1996). Socialists do not favour individual rights and freedom. The socialist ideal economic distribution of resources cannot be attained in practice, and perfect competition cannot be realised for every individual (Lerner, 1938). The goal of socialist economic systems was to encourage collective ownership of resources and state control to theoretically achieve more equitable outcomes. Most command economies failed due to the inherent challenges of large-scale, centralised coordination in the absence of individual incentives or market signals, and the lack of flexibility and adaptability to changing circumstances.

There are different types of movements that can be seen along the two-way path that separates anarchy from complete state control, or, between the minimal and maximal states. These include slow progress in one direction that ends at a specific point, alternating, nearly cyclical movements back and forth. The "maximal state" is neither final nor irrevocable. The functions of the state such as stabilisation, full employment, and economic connections with the outside world require active government macro-policy; preventing negative externalities and supply of public goods and income redistribution for social justice to assist the weak and impoverished. Where state operations are limited to support at least one of these three purposes is referred to as a "justifiable medium state." Kornai, (1988), notes social justice, welfare (and the increase in physical production, efficiency, and productivity that goes along with it), and liberty are l essential ideals.

The standard of living and quality of life are indicators of social welfare, which is shaped by institutional, cultural, historical development-predetermined economic, social, environmental, and environmental elements. Achieving greater social well-being should be the goal of each country. Thus, it is intriguing to explore theoretically why various nations achieve varying degrees of social welfare under similar starting circumstances (Slukhai & Borshchenko, 2019). Under socialist/command economy, it was challenging to distribute financial resources, and opportunities for the development of a welfare state and individual.

There were valid arguments in favour of striking the ideal balance between social welfare, individual liberty, and state intervention is difficult. Moderation and flexibility are essential for creating political and economic structures that can adjust to shifting conditions while upholding justice and freedom. Although equality can never be fully realised due to the complex interplay of institutional, cultural, and economic factors that shape national well-being, equitable access to basic needs, freedoms, and opportunities that enhance the quality of life for all citizens remains an aspiration worth pursuing. This is because the ideal level of social welfare varies depending on the values and priorities of each society. The development and evolution of market-based systems that distribute decision-making among economic actors was aided by the reliance on a single governing authority to allocate resources efficiently, although socialist economies sought to achieve equitable economic outcomes through central coordination and public ownership.

3.2.1 Global Food Security

Food security exists at any level 'when all people, at all times, have physical 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, 2009). Describing these concepts make it easier to understand food security. 'All people' explains the adequacy and quality of food available at household levels, i.e., children, women, youth, and elders in the household. It also refers to all individuals living in various contexts, that is, developed and developing countries, urban and rural, rich, and poor. 'All times' indicates the availability of enough quality food every day and at the required times throughout the year. Furthermore, 'physical and economic access' signifies the production and financial capacity of the household to get enough quality food to all members of the household in various contexts. This aspect could be achieved by other means such as aid, remittance, and others. However, this is beyond the autonomy of the household. In other words, it will be affected by other external factors. 'Sufficient, safe and nutritious food' implies the amount and quality of food required at various individual ages. 'Dietary need' describes the amount and quality of food required at various ages to obtain the macro and micronutrients required. 'Food preference' suggests the autonomy of individuals to consume food items according to their or family members' interests. However, this would be influenced by the norms, cultures, policies, and political situation of the area. Finally, an 'active and healthy life' depends on the quantity and quality of food consumed, age, health care and sanitation service that family members use before, during and after getting sick. Therefore, describing the food security situation could be based on one, two or more components of the aforementioned factors.

Food security mentioned, it can be described in terms of four dimensions: food availability, food access, food use, and food stability. Nicholson et al (2021) note that previous research has focused on the availability of food globally in terms of food supply and demand, quantity and quality of food necessary on a global, regional, and national scale. Access measures can provide insights since the indicators respond differently to output shocks, demand increases and production subsidy schemes. Food security situation has not been widely assessed for access, utilisation, and stability at the household level in various contexts.

The prevalence of undernourished people has been used to describe the food security situation of regions and countries. From 2.6 billion in 1950 to 7.6 billion in 2017, the world's population has grown by over 200% in the last 70 years (Grosso et al., 2020). Projections indicate population growth will continue, with over 8 billion people on Earth by 2030 and over 9 billion by 2050 (Grosso et al., 2020). Ten years after the Rome World Food Summit (WFS) in 1996, the global undernutrition rate remained high. FAO indicated there were 854 million undernourished people globally in 2001-2003: 820 million in poor countries, 25 million in transition countries, and 9 million in developed countries (Skoet et al., 2006).

Determining the dietary energy intake has also been used to describe the state of food security, in addition to the availability of food. In terms of dietary energy consumption, the FAO reported in 2014 that over 800 million people are undernourished. Approximately 2 billion people suffer from micronutrient deficiencies, another sign of undernourishment. The fact that every year over 3 million children pass away from malnutrition before turning five is regrettable (Ashley, 2016). In addition, since 2014, the number of hungry individuals worldwide has been rising rapidly. Nearly 690 million people, or 8.9% of the world's population, were undernourished before the COVID-19 pandemic, according to the most recent projections for 2019 (FAO et al., 2020). Approximately 750 million people globally, or almost one in ten, experienced severe food insecurity in 2019 (ibid.). Two billion people, or 25.9% of the world's population, either went hungry or did not have regular access to enough food that was both nutritious and sufficient in 2019 (ibid.). Food insecurity affects people's health in several ways, including how well women's and children's diets are prepared (ibid.). Low-income nations rely more on basic foods and less on fruits, vegetables, and meals derived from animals than do high-income nations. However, there are only enough fruits and vegetables available for human consumption in Asia, and usually in upper middle-class nations, to meet the FAO/WHO recommendation of 400 g per person per day (ibid.).

The availability and consumption of healthy diets at the community, household, and individual levels can be influenced by the economic status of nations and regions. According to FAO et al. (2020), over 3 billion people globally were unable to buy a nutritious meal in 2017. Among these, millions reside in Latin America and the Caribbean (104.2 million), North America and Europe (18 million), Asia (1.9 billion) and Africa (965 million) are home to most of these people (FAO et al., 2020). Basic foods in low- and lower-middle-income countries include cereals, roots, tubers, and plantains. There was minimal change in the availability of staple foods worldwide between 2000 and 2017 (ibid.). More than 60% of the food that was available in low-income nations in 2017 was made up of cereals, roots, tubers, and plantains (FAO et al., 2020). Foods derived from animals contribute differently depending on the nation's income level. According to FAO et al. (2020), it is lowest in low-income countries (11%) and higher in high-income countries (29%) than in upper and lower-middle-income countries (20%). Therefore, there may be a correlation between household income and the availability and consumption of crop and animal foods in homes.

The global fight against hunger conceals regional differences. Since the baseline WFS period, there has been a decline in the frequency and prevalence of undernutrition in both Asia and the Pacific and Latin America and the Caribbean. However, the average rate of decline in both regions has not kept up with the necessary pace to cut the number of undernourished people in half by the year 2015 (Skoet et al., 2006). There were around 48 million (7.4%) undernourished people in Latin America and the Caribbean in 2019, which was lower than the global 8.9% prevalence. The number of undernourished people in the region rose by 9 million between 2015 and 2019, with notable variations between subregions, indicating a rise in hunger in recent years. While conditions in Central and South America have gotten worse, the Caribbean has shown some slight improvements (FAO et al., 2020). Some Asian nations have reported improvements in the state of food insecurity (ibid.). Therefore, lowering hunger still takes careful thought and preparation.

More than half of the world's malnourished people live in Asia (FAO et al., 2020). Governments in South Asia have traditionally prioritised combating food insecurity. Between 2016 and 2018, the percentage of undernourished people in South Asia's overall population decreased dramatically from 23.9% in the early 1990s to 14.9% (Mughal & Fontan Sers, 2020). India accounts for a quarter of the world's total food insecurity (Sandhu, 2014). In South Asia, one in seven individuals (194 million or 14.5%) remains food insecure and one in three children under five years of age manifests stunted growth (Mughal & Sers, 2020). The 1.25 billion people in India are expected to receive food grains at subsidised prices. The implementation of the National Food Security Act (NFSA) in 2013, addressed food insecurity in a way that represented a paradigm change from a welfare-based to a rights-based approach (Sandhu, 2014). After this Act, agriculture-related inputs like seeds, fertiliser, irrigation, machinery, and tube well electricity were subsidised. Subsidised credit and cash rewards were given to small farmers. The average daily calorie consumption in South Asia in 2017 ranged from 2,090 kcal in Afghanistan to 2,673 kcal in Nepal (FAOSTAT, 2019). Individuals in Bangladesh, Nepal, and Sri Lanka primarily get their calories from rice, whereas individuals in Afghanistan and Pakistan primarily get their calories from wheat (Mughal & Sers, 2020). In Asia, undernourishment is prevalent in 8.3% of cases in 2019. It has demonstrated a drop from 14.4% in 2005 to 6.1%. Additionally, from 574.7 million in 2005 to 381.1 million in 2019, fewer people are undernourished (FAO et al., 2020). Despite and policy interventions needed, southern Asia and India made improvements in food security due to government intervention and subsidies to smallholders.

Africa has the second-largest number of undernourished individuals worldwide and the highest prevalence of undernutrition. Africa accounts for 36.4% of the world's undernourished individuals (FAO et al., 2020). The percentage of undernourished individuals in Africa increased from 17.6% in 2014 to 19.1% in 2019, or about 250 million people (FAO et al., 2020). The number of undernourished persons increased in both the Near East, North Africa and SSA (ibid). This has been visible throughout SSA for three decades. Strides have been made in SSA to lower the prevalence of undernourishment (Skoet et al., 2006). The percentage of undernourished individuals in the region decreased for the first time in multiple decades, falling from 35% in 1990-1992 to 32% in 2001-2003, following a peak of 36% in 1995-1997 (Skoet et al., 2006). To meet the WFS target, the number of undernourished individuals must decrease to 85 million by 2015, from 169 million to 206 million (ibid.). Despite positive development, the region still challenges.

People in SSA suffer from undernourishment. The only region where the percentage and quantity of undernourished people have increased between 1990 –1992, albeit from a relatively low base, is the Near East and North Africa (Skoet et al., 2006). Since 2015, the sub-Saharan subregion has had the greatest undernourished population (>32 million) in all of Africa (FAO et al., 2020). Since 2014 the greatest increases in hunger have been in the Eastern and Western subregions and Central Africa, where the percentage of the population suffering from hunger reached 29.8% in 2019 (FAO et al., 2020). The prevalence of undernourishment in Ethiopia fell from 39.2% in 2004 to 19.7 % in 2018. However, prevalence of moderate and severe food insecurity increased from 56.2% in 2015 to 58.3% in 2016 (World Bank, 2021). Food insecurity rose at a slow rate until the end of 2017 to 59.4% (ibid.). However, the trend started to decrease to 57.9 in

2018 (World Bank, 2021). In East Africa, and specifically Ethiopia, planning to reduce food insecurity should receive critical attention.

Variables that pose the security of food supplies in a world are complex and unpredictable. Several global change processes, such as climate change, rapid urbanisation, and population ageing, as well as unanticipated shocks, such as natural disasters, financial crises, and political upheavals, and the unexpected reactions of food systems to these processes and events, are among them (Tendall et al., 2015). Particularly at risk are communities and small-holder farmers whose livelihoods directly depend on their capacity to produce food. Moreover, nations experiencing rapid population growth and restricted access to healthcare and education tend to have higher rates of hunger (FAO et al., 2020). This establishes definite connections between population health, food security, and nutrition, all of which have an impact on economic growth and development opportunities (ibid.). Furthermore, reaching food security is at risk due to climate change, especially in the areas with the highest levels of food insecurity (Richardson et al., 2018b). Therefore, analyses of rural smallholders from different dimensions of food security would benefit individuals and nations in Africa in general and Ethiopia specifically is critical.

3.2.2 Global Rural Smallholder Agriculture

The agricultural system of small farmers has been in place since the creation of a human being. Since then, it has started on a small scale by planting crops and raising small domestic animals. About 4 million individuals worldwide lived as hunter-gatherers before agriculture was introduced (Cohen, 2017). However, lately, the agricultural system has shown incredible development and reach to the current situation. Six billion people are fed by modern agriculture worldwide (Tilman et al., 2002). The modern agricultural system in developed countries has been transformed and has significantly contributed to the lives of their citizens. However, in developing countries, it has not yet been developed and has not been able to support the food demand of each country.

The agricultural system of smallholder farmers in developing countries is dependent on rainfall and tradition. The production of food in underdeveloped nations is especially susceptible to climate change. The two primary factors influencing crop growth—rainfall and temperature—also have an impact on animal productivity. The global data collection also shows that food insecurity is pervasive, with 80% of households reporting food insecurity for at least one month (Niles & Brown, 2017). Smallholder farmers are essential to achieving food security goals while also considering sustainability (United Nations Conference on Trade and Development, 2015). On the other hand, improving the productivity and resilience of smallholder agricultural systems is a huge undertaking that will call for substantial and continuous political, financial, and technical support as well as action at the local and national levels (Harvey et al., 2014). Smallholder participation in international trade has been hindered by fragmented value chains and intense competition among nations. Nonetheless, big farms also manage product certification and supply chain integration better than small ones, which are increasingly standard procedures in global trade (UNCTAD, 2015). Therefore, although the smallholder agriculture system has started earlier since the creation of humanity, it is, however, still traditional and has many challenges in developing countries.

Rural smallholder farmers account for a sizable portion of the global population (450–500 million) and 85% of all farms (Harvey et al., 2014). Moreover, it is believed that they account for half of the world's hunger and likely three-quarters of those in Africa (ibid.). Nonetheless, these farmers provide around 80% of the food consumed in Asia and SSA in addition to providing roughly 70% of Africa's total food needs. Furthermore, most of the primary agricultural exports from several emerging nations are produced by smallholders. Smallholders have, meanwhile, been largely ignored by governments, research and development departments, and the global community despite their significant contributions (UNCTAD, 2015). The sustainable development of smallholder food security was challenging in developing countries. Crop production on individual household plots continued to suffer crop losses owing to drought (Kilel, 2015). Therefore, many countries particularly in Africa and especially in Ethiopia reduced the complete control of the state and free market with selected intervention to improve the capacity and competitiveness of smallholders.

Climate change is a major challenge for the smallholder agricultural system. Changing climatic situations (Pereira et al., 2014) and the need to produce adequate and quality food for direct consumption and trading in rural markets has increased dramatically. Thus, governments are looking for development ideologies, interventions, policies, and agricultural strategies that could improve rural smallholder agricultural production sustainably (John, 2013; Mazunda, 2013). Currently, food and water security has become a world issue, and addressing the challenges related to this concern requires new thinking (Sinyolo et al., 2018). Furthermore, in rural areas, different access issues to institutions, farms, and non-farm resources, agricultural inputs affect the food production process (Misselhorn & Hendriks, 2017). Therefore, rural smallholder households continue to face structural, social, and cultural barriers that prevent equal access to resources with potentially adverse impacts on food security (Nawrotzki et al., 2014).

Therefore, later different global governments, international organisations, and NGOs were highly concerned with supporting the traditional agricultural system. Various scientific and research activities were conducted to improve the traditional smallholder agricultural system. Meeting global food demands and eliminating poverty in rural regions were crucial aspects in the architects' vision of a world society that could provide freedom from hunger and insecurity to all people. The development of national agricultural research systems has been a crucial tool for supporting poor countries in fulfilling domestic food needs, according to agencies such as the United States Agency for International Development and the World Bank. Moreover, external aid has played an important role in the building of robust national agricultural research systems in several countries. William Gaud later, at a 1968 Society for International Development meeting in Washington, DC, coined the term "Green Revolution" to characterise the developments brought about by US and philanthropic funding for fertiliser, irrigation, improved hybrid seeds, state support, and credit (Patel, 2013). It has been implemented in various countries around the world and an increase in production was registered. Therefore, this strategic change has contributed to a significant change in the food production of smallholders in some countries.

The Green Revolution has created surplus production in developed countries. Much of the success was owing to the mix of high rates of investment in crop research, infrastructure and market growth (1966-1985), as well as proper regulatory backing (Pingali, 2012). In a similar vein, food systems in poor nations have undergone significant transformation since the Green Revolution (Dawson et al., 2016). It has also improved the food production system of southern Asian countries during the 1960s to 1970s (Dawson et al., 2016). In Moldova, many smallholders—of whom a tiny percentage shifted to entrepreneurial agriculture employing fertiliser, irrigation, improved seeds, official support, and credit—turned to entrepreneurial agriculture during the collapse of socialist agriculture in post-Soviet nations (Piras et al., 2021). Moreover, resource-poor coffee growers in the Himalayan hills of Nepal offer their organic coffee as specialty coffee on the international market. Education, training, bookkeeping for coffee-related operations, and credit availability all served to help them (Kattel, 2015b). Therefore, although the smallholder agricultural system has shown a significant contribution to the improvement of every rural agricultural household in developing and some developing countries owing to the Green Revolution, it is not significant in Africa.

Although smallholder agricultural systems have shown incredible improvement in recent decades, they have also faced critical challenges. Samsudin et al. (2016) have identified challenges that hinder the adaptation of small farmers in the rural area of Kampung Merchong located in Pekan District, Pahang State, Malaysia. They reviewed challenges such as labour shortages owing to outmigration, lack of skills, professional advice, training and finance, and low quality of soil and agricultural land. Furthermore, Mottaleb and Rahut (2018) indicate the variability of commodity prices is a challenge. Therefore, owing to these challenges and others, the agricultural production system of small farmers in developing countries, especially in Africa, should be investigated more.

Development of global irrigation agriculture

Irrigation has a similar history to agriculture (Fereres et al., 2003). Crop domestication occurred 10,000 years ago in the region that is now known as Potamos, the tributaries of the Euphrates and Tigris rivers, Assyria, Phoenicia, and Lower and Upper Egypt. This region was formerly known as Mesopotamia (the name Mesopotamia is derived from the Greek words meso and potamos). The Tigris and Euphrates, which were considerably smaller than the Nile, provided water to Mesopotamia (Bazza, 2007). Ancient water infrastructure and irrigation systems that date back to 2000–5500 BC can still be discovered in various parts of the region as ruins or historical vestiges (ibid). As early as 5000 BC, it is thought that complex irrigation systems and water diversion constructions were created and utilised in Egypt and Mesopotamia (by the standards of the time) (Bazza, 2007). Furthermore, farmers recognised as early as the Stone Age that additional water application to the land may mitigate the effects of drought (Fereres et al., 2003). Therefore, the origin of irrigation also occurred there, just after the beginning of agriculture to reduce the effect of climate change and drought.

The thinking of earlier human beings was to divert water from its source and use it during drought seasons in arid and semi-arid areas. During this earlier period, they used traditional and some structured designs to divert water. The traditional method was simply to dig and form some soil embankments by aligning the waterways from their source to the farmland. But later, they have started to develop some structures more advanced than the previous one. Therefore, even at an earlier time indigenous (not structured) and traditional (structured but not modern) irrigation systems were described in literature.

Irrigation agriculture was developed to reduce the occurrence of drought and the effect of weather-related risks. Puy and Balbo (2013) discovered that the Iberian Peninsula's irrigated terraces are connected to Al-Andalus, the name given to the area following the arrival of Arabic Berber tribes that started to migrate across the

Strait of Gibraltar in 711 AD. In the west Mediterranean, a few of these farming zones still exist today. Furthermore, White (1957) illustrated in his review that while the Rhine, Ohio, and Thames flows have long been vital to the industrialised populations along their banks, the Nile and Tigris-Euphrates Valleys cradled the early civilisations of the eastern Mediterranean and continue to support their basic irrigation agriculture. Moreover, Ryan and Pitman (1998) specified that essential irrigation tenants have been understood since at least the Sumerian civilisation over 6000 years ago: getting water on the ground, maintaining it there as long as needed, disposing of it when no longer needed, and keeping undesirable water away. Similarly, around 7000 years ago, early farming and stock-breeding societies arose in China during the mid-Neolithic period (Angelakis et al., 2020). Furthermore, agriculture was also developed in Crete and adjacent islands in southern Greece during the Minoan era (around 3200-1100 BC) to support a rapidly rising population (Angelakis et al., 2020). Therefore, irrigation and drainage of agricultural regions became particularly significant throughout the Neo palatial period (ca. 1750–1450 BC) (Angelakis et al., 2020). Water and irrigation management, which included the expansion and renovation of all pre-existing irrigation systems, contributed to the Abbasid Dynasty's prosperity in the early Islamic era. The Abbasid Dynasty had its capital in Baghdad and ruled from 762 to 1258 AD (Bazza, 2007). In addition to tank irrigation in southern India, the Harappa and Mohan-Jodaro civilisations around 2500 BC carried out much of the early irrigation development in the Indian subcontinent (Rao, 2000). Therefore, all this research has confirmed that the development of a traditional irrigation system on the riverside was to sustain cropping and farming in low-lands areas.

At least two physical modifications to the stream's flow are implied by the development of irrigation. One way to control water availability is to manage land, store water, or divert it so that it doesn't depend on daily, seasonal, or annual variations in the natural flow. Utilising water to maximise benefits from other resource use is the other (White, 1957). Taiwan's public sector irrigation system began to take shape during the Dutch colonial era (1609–1661) (Levine et al., 2000). The only times Taiwanese people designed and managed irrigation systems were during the Ming-Chung and Chin dynasties (1662–1895) (ibid.). Taiwan's irrigated area rapidly increased under the Japanese occupation (1901–1945) (Levine et al., 2000). Around 1900, the US saw a surge in irrigation development due to an increase in food production brought on by population growth (Fereres et al., 2003). In British India, there were around 29 million acres of irrigated land in total by 1900 AD. Of these, 16 million acres were public works, with 10 million acres coming from extensive irrigation schemes (Rao, 2000). The area covered by significant public irrigation projects increased quickly in India between the 1950s and the 1970s (Mukherji, 2017). A large portion of India was thought to be at imminent risk of falling into a Malthusian trap of rapid population increase and low agricultural production, which would cause widespread food crises and famines. This worry led to the catastrophic food crisis of the 1960s, which prompted this development. Farmers have made more and more investments in groundwater pumps and wells since the 1970s (Mukherji, 2017). But in response to the great famines of the 1960s and 1970s, governments and international organisations later made significant expenditures on fertiliser, improved crop types, and irrigation Burney et al. (2014). Therefore, according to Burney et al. (2013), the Green Revolution was a development plan that involved both contemporary crop technology and water.

The Green Revolution has favoured agricultural intensification in small areas using irrigation systems. Hydraulic theory, as it was applied in the 1960s, showed a simple adaptational linkage: in dry settings, agricultural intensification owing to population increase demanded irrigation development (Earle, 1987). From 1921 to 1930, there was a considerable change in Taiwan's irrigation system and improved (Ponlai) rice varieties were introduced, resulting in increased fertiliser use (Siebert et al., 2000). There was an early emphasis on careful water management during Japanese control in Taiwan (1895-1945) when Taiwan was turning into a significant rice exporter to Japan (Street & Britarn, 1977). Humans started growing rice in lowland areas near rivers and lakes in Hemudu, Yuyao Chekiang Province, China. This led to the development of rudimentary irrigation and drainage engineering techniques (Angelakis et al., 2020). Although Japan is a "green archipelago" with a rainy season, other areas of the country have a dry environment and few perennial rivers, and these areas have traditionally used reservoir irrigation systems for rice agriculture. Ponds, tanks, and tiny reservoirs are among Japan's oldest irrigation infrastructure. They were most likely introduced from China in the fifth century, partly through Korea. In Japan, this period is known as the 'Ko-fun' period (the third to sixth century AD). Archaeologically many minor ponds have been discovered to have been constructed during this time (Mogi, 2011).

Much of the food in the world, including most fruits, vegetables, and other high-value crops, is still produced by irrigation (Turral et al., 2010). Governments were the main source of funding for the construction of extensive irrigation systems in colonial India, Central Asia, the western United States, and emerging Australia in the late 19th century (ibid.). The Chinese government has been the main investor for millennia (Turral et al., 2010). In the United States, agriculture contributes less than 3% of the gross national product (GNP), and approximately 2% of the population is directly employed in the farming industry. In contrast, in India, the farm sector accounts for approximately 30% of the GNP, and approximately 70% of the population is directly employed in it (Rao, 2000). According to Rao (2000), the average farm size in the United States is over 400 acres, while the average farm size in India is approximately 2.5 acres. Therefore, densely populated, developing countries have small land holdings and they base their national and individual economy on the agricultural sector.

Twenty percent of all cultivated land is used for irrigated agriculture, which also provides forty percent of the world's food production (World Bank, 2020). According to FAOSTAT (2019), equipped irrigated agricultural land covers 419.8 million hectares. More than 50% of the global irrigation area is located in India (70.6 million ha), China (75.2 million ha), and the United States (26.9 million ha)

(FAOSTAT, 2019) (Table 3.1.). According to Siebert et al. (2013), the largest contiguous areas of high irrigation density are located along the Mississippi-Missouri river basin, in parts of California, along the Nile River in Egypt and Sudan, in North India and Pakistan along the Ganges and Indus rivers, and in the Hai He, Huang He, and Yangtze basins in China. Additional regions with significant irrigation density and regional significance can be found in the northwest of the United States along the Snake and Columbia rivers, in central Chile, along the western coasts of Mexico and Peru, in the rice-growing areas along the Brazil-Uruguay border, in the Euphrates-Tigris basin in Iraq and Turkey, in the Aral Sea basin, in the Amu Darya and Syr Darya river basins, in the Brahmaputra basin in China and Bangladesh, in the Mekong delta in Vietnam, in the plain surrounding Bangkok in Thailand, on the island of Java in Indonesia, and in the Murray-Darling basin in Australia (Siebert et al., 2013). Furthermore, as Siebert and his group, nearly every populous region on Earth has smaller irrigation areas.

Table 0-1 Countries with greater equipped irrigation land in each region.

Regions	Rural population (2018)	Agricultura land (in thousends ha) (2019)	Agricultural land per rural population	equipped Irr. land (in thousends ha) (2019)	% share of total equiped irr. Land to agri land (in thousends ha)
World	**3,413,025,999**	**4,752,110.71**	**0.0014**	**341,585.13**	**7.19**
china	583,199,631	528,509.20	**0.0009**	**75,238.27**	14.24
Africa	**740,318,336**	**1,118,601.27**	**0.0015**	**16,443.01**	**1.47**
Egypt	56,938,212	3,835.97	**0.0001**	3,823.00	99.66
Americas	**190,836,828**	**1,127,759.80**	**0.0059**	**55,975.51**	**4.96**
USA	57,980,034	405,810.35	**0.0070**	26,916.00	6.63
Asia	**2,279,002,514**	**1,667,953.59**	**0.0007**	**239,602.39**	**14.37**
china	583,199,631	528,509.20	**0.0009**	**75,238.27**	14.24
Europia	**189,736,785**	**462,609.07**	**0.0024**	**26,267.82**	**5.68**
Russia	36,807,854	215,494.00	**0.0059**	4,300.00	2.00
ocenia	**13,132,183**	**375,186.98**	**0.0286**	**3,296.39**	**0.88**
Australia	3,465,207	362,477.00	**0.1046**	2,546.00	0.70

Source: - FAOSTAT, (2018 & 2019)

Irrigation investment grew at a rapid pace throughout the 20th century. Throughout Asia, communities have invested cooperatively in SSI for generations and still, management methods have evolved. The extensive rise of private groundwater extraction, which has become India's primary mode of irrigation and provides considerable contributions, has been a characteristic since the early 1980s (Turral et al., 2010). An approximately 500 km wide and 2500 km long stripe through central North America, Brazil, the north-eastern region of Argentina, the northern and western regions of India, the north-eastern region of China, large portions of North Africa, western Europe, the entire Arabian Peninsula, the eastern and central regions of the Islamic Republic of Iran, and the provinces of Punjab and Balochistan in Pakistan are home to areas that are primarily irrigated by groundwater (Siebert et al., 2013). On the other hand, surface water is mostly used by the irrigation industry in Eastern Europe, the former Soviet Union's republics, Southeast Asia, the southern portion of China, SSA, the northwest of the United Republics, Oceania, and the majority of Southern America (Siebert et al., 2013). This is because irrigation is widely used in agriculture worldwide and growing demands are placing increasing pressure on surface and groundwater resources.

Securing land tenure, expanding access to better agronomic and irrigation information, with a focus on female-provided education, and strengthening market and transportation links (to ensure that crops meet market demand and attract higher prices) should be part of policy facilitation (Bjornlundet al., 2019). The latter maintain that the experience of the rural economic transformation in China, the development of irrigation accompanied by the provision of improved varieties, fertilisers and substantial investment in agricultural research played a major role under a small landholding community to improve the economy of the country in general and the population mainly (Samuel, 2006). Furthermore, SSI can improve the production of nutritionally rich crops, livestock production from available crop residues, and fishery from the harvested water for irrigation (Sangeetha et al., 2013). Nowadays, the world's river systems run with very little of their overall volume being used for human benefit (White, 1957). Nonetheless, it is critical to improve food security through external support, information access, and farmer-to-farmer knowledge (Ville et al., 2016). Therefore, rural smallholders in developing countries could improve using the available water potential and improving the policy issues.

3.2.3 Rural Smallholder Agriculture in Africa

Green Revolution initiatives are now being pursued again in Africa to stimulate agricultural growth and eliminate poverty. When the Asian Green Revolution began in the 1960s, Africa was becoming independent from former colonial masters (Ejeta, 2016). A large portion of the institutional and human resources needed for an agricultural revolution were either non-existent or lacking in Africa (ibid.). The discovery of miracle crop types in wheat and rice, two globally significant crops, but not in sorghum, millets, maize, or cassava, which are essential crops for Africans, ignited the Asian Green Revolution (Ejeta, 2016). Food production in Africa has not kept up with population growth (Frankema, 2014). Agricultural production increased in absolute terms, but this was primarily owing to an increase in the number of smallholders who brought more land under cultivation (Otsuka & Larson, 2012).

The Green Revolution initiatives introduced in Africa boosted the production of smallholders. The policies encourage farmers to switch from a traditional polyculture system that supported subsistence and local commerce to modern seed types, inputs and finance to specialise in marketable crops and boost productivity and income (Dawson et al., 2016). After the Green Revolution, African leaders were committed to supporting agricultural research and development in the region. They have also placed agriculture on their agendas, committed 10% of their national budgets to food security and agricultural-led growth (Comprehensive Africa Agricultural Development Programme, 2020). Only the wealthy minority complied with modernisation, and policies increased landlessness and inequality for poorer rural residents (Dawson et al., 2016). Subsistence practices were disturbed, poverty was aggravated, local knowledge, trade, and labour systems were harmed, and land tenure security and autonomy were reduced for the majority of households (ibid). To improve rural smallholders, the agricultural system and equitable use of resources in Africa, policy makers and researchers must understand the context of the agricultural system of each.

The policies, strategies, and programmes designed improved the agricultural system of small farmers and food security in Africa. These trends were at odds with local experiences, although the programs have been judged effective in increasing yields and poverty rates have declined (Dawson et al., 2016). Training was provided to improve the experience of rural smallholders. Participation training program in sustainable agricultural intensification practices (SAIPs) demonstrated consequences for food security, the rural economy, and farmers' lives (Yahaya et al, 2018). However, the income that rural smallholders in Mali, West Africa, receive from indigenous horticulture crops (IHCs), which include vegetables, herbs, and non-timber forest products (NTFPs), is relatively low (Takenaka et al, 2013). Because smallholder farmers typically have limited access to capital, establishing an organisation of producers or implementing a microfinance system could increase market competitiveness (Takenaka et al., 2013).

However, financial services among small farmers in rural areas of Africa face many challenges. As an illustration, Uronu (2018) states that the following are the primary obstacles to financial services in Tanzania's Dodoma and Morogoro regions: most smallholder farmers seldom repay loans acquired through wholesale borrowing; the groups play a significant role in enhancing smallholder farmers' access to financial services. When interest and penalties raise the loan amount, defaulting on a loan puts more financial strain on the borrower. As a result, frightening group sustainability and collaboration exacerbate smallholder farmers' poverty. It was also noted that a subpar group lending implementation structure was the primary cause of the low loan payback Uronu (2018). To improve the agricultural system of smallholders, financial and other rural agricultural services should receive policy support.

Specifically, the smallholder agricultural system is also a backbone for the economy of sub-Saharan African countries. For instance, the cash crop industry, which was centred on smallholders, became the mainstay of Uganda's colonial economy. However, following the initial adoption of cash crops, farm characteristics remained relatively unchanged (de Haas, 2017). Despite the low profitability of cash crops, smallholders were nonetheless able to maintain living conditions well above the subsistence level, and their cultivation offered a steady stream of revenue. Compared to their peers who farmed grains, smallholders in Uganda's banana districts needed fewer labour inputs to sustain a farm income, which opened possibilities for further income creation and livelihood diversification (de Haas, 2017). In the same way, row planting technique adoption in rural Ethiopia has a favourable and noteworthy effect on crop income per hectare as well as per capita consumption (Fentie & Beyene, 2019). Thus, by increasing household income and food security, scaling up the technology will greatly increase farmers' resilience to the negative consequences of climate change (Fentie & Beyene, 2019). According to Dawson et al. (2016), a thorough impact evaluation should be conducted instead of the Green Revolution in SSA being pro-poor or even of a comparable kind. Smallholder agriculture continues to be essential to many SSA communities' means of subsistence, food security, and economic growth. However, to ensure the sector's long-term sustainability and its capacity to fortify itself against climate threats, specific policy support, investments, and innovations that advance the productivity, profitability, and diversification of farmers' production systems in an equitable and environmentally responsible manner are needed.

Development of irrigation in Africa

The development of irrigation in Africa has started in Egypt along the Nile River. Archaeological evidence indicates that at about 5000 BC, the first irrigated agricultural areas in the Near East emerged along Egypt's Nile riverbanks (Bazza, 2007). Because the Nile River flooded frequently in ancient Egypt, early agriculture consisted of sowing seeds in soils that had just been covered and treated with floodwater and silt deposits (ibid). Irrigation projects were carried out on a local or regional basis and were important during low Nile floods (Hassan, 1997). Irrigation techniques and water management are ancient knowledge in North Africa, especially in Egypt, Iran, and Iraq. About eight centuries before Christ, during the Carthaginian (Phoenician) Empire, irrigation in North Africa extended from Mesopotamia and Egypt to the Mediterranean, and then during the Roman Empire (146–439 BC) to the south (Bazza, 2007). The region's Romans concentrated on managing the water supply by using pre-existing sources and gathering rainfall. After the Iron or Stone Age time, there remain remnants of indigenous pre-colonial irrigation systems throughout southern Africa, including the eastern highveld of South Africa, Nyanga in Zimbabwe, the Limpopo River Valley, and Mpumalanga, as has been widely documented in the literature (Tempelhoff, 2008).

Irrigation was dependent on natural forces until the 19th century when a perennial system was introduced. It is possible that certain artificial canals were utilised as early as the Early Dynastic period (3000-2700 BC), but no evidence of a state-run irrigation system has been found. It is surprising to learn that, according to the lever notion, water-lifting devices like the basic shaduf were not used until the New Kingdom, circa 1550–1070 BC (Hassan, 1997). However, under conditions considerably different from those of Mesopotamia, Egypt, India, and China's early dynasties, farmers in dry and semi-arid regions depended on permanent springs and seasonal runoff (Angelakis et al., 2020). In Africa, however, an irrigation system under governmental supervision was later established. Voluntary smallholder irrigation systems, for instance, were set up in Zimbabwe in 1913 to alleviate the famine and later to relocate black farmers who had been forced from lands allotted to white commercial farmers (Rukuni, 1988). A determined government programme to reduce reliance on rainfed agriculture was implemented in response to the terrible drought of 1982-1984 (ibid). In 1928, the colonial administration launched a programme to support existing smallholder schemes while also assisting in the development of new ones (Rukuni, 1988).

The development of irrigation in came after a 20-year break following the irrigation industry's underwhelming performance in the 1970s and 1980s (Woodhouse et al., 2017). Pan-African agricultural investment initiatives, like CAADP, prioritise improving the reliability of water control for agriculture due to the continent's persistently low productivity in agriculture and its food supplies' susceptibility to growing volatility in global commodity markets (Woodhouse et al., 2017). Irrigated farming has been identified as a key strategy in global attempts to ensure food sufficiency by expanding the production of staple crops. The development in Sub-Saharan Africa (SSA) has been gradual, despite various investments in irrigation by governments (colonial and postcolonial), multinational donor organisations and private investors (Ofosu et al., 2014).

As a component of New Partnership for Africa's Development (NEPAD), the African Union (AU) developed CAADP. 'Expanding the area under sustainable land management and reliable water control systems' is the first of the program's four pillars (NEPAD, 2003). Although African leaders made policy adjustments and designed initiatives such as CAAD and NEPAD, which encourage the development of irrigation infrastructures, coverage is low (Table 3.2).

Table 0-2 The Agricultural land and irrigation land equipped of the Africa sub-regions.

Regions	Rural population (in 2018)	Agricultura land (in thousends ha)	equipped Irr. land (in thousends ha)	Agricultural land per rural population	% share of total equipped irr to agri land
World	3,413,025,999	**4,752,111**	**341,585**	0.0014	0.07
Africa	**740,318,336**	1,118,601	16,443	0.0015	0.01
Eastern Africa	**312,327,611**	**333,394**	**3,323**	0.0011	0.01
Somalia	8,354,510	44,125	200	0.0053	0.00
Ethiopia	85,207,113	37,903	858	0.0004	0.02
Madagaskar	16,495,525	40,895	1,086	0.0025	0.03
Middle Africa	**85,054,645**	**166,689**	174	0.0020	0.00
Angola	10,612,667	56,952	86	0.0054	0.00
North Africa	**114,140,510**	**173,090**	9,876	0.0015	0.06
Sudan	27,131,309	68,186	1,855	0.0025	0.03
Egypt	56,938,212	3,836	3,823	0.0001	1.00
southern Africa	**24,003,742**	**164,377**	1,735	0.0068	0.01
South Africa	19,311,652	96,341	1,670	0.0050	0.02
western Africa	**204,791,828**	**281,051**	1,336	0.0014	0.00
Nigeria	97,264,436	69,123	331	0.0007	0.00
Mali	11,014,386	41,201	380	0.0037	0.01

Source: - FAOSTAT, (2018 & 2019)

Sustainable management of water resources could have been achieved if it had participated in the local community or user groups and considered their view (Rizvi, 2012). More importantly, digging a micro-pond, implementing physical and biological soil and water conservation activities, clearing the silt from the headwork and canal, managing, and maintaining the crop schedule sustain the availability of water resources. Furthermore, it maintains the watershed sustainably and enhances the sustainable benefit of SSI schemes (Dejene, 2007). Proper management of irrigation systems such as farms, crops, rivers, and waterlogging effects would decrease the following of farmland, improve land management and fertility of irrigable farmland; therefore, it enhances agricultural productivity (ibid.). These participatory resource management practices and participation in developmental activities also capacitate and change the behaviour of the household in understanding, observing and participating in the challenging issues that affect their progress and livelihood (Chanie et al., 2018).

3.3 THE ETHIOPIAN SOCIALIST / COMMAND ECONOMY

Ethiopia adopted different developmental ideologies to improve the economy and the wealth of citizens. Through Emperor Haile Selassie's period (1930-1974), the feudal-capitalist system (ancient class system and a landed aristocracy like the free-market economy) was implemented to improve the economy. The country during this period has made half-hearted attempts at economic development (Tesfaye, 2017). Furthermore, the expansion of large-scale farms and agribusiness was the pillar strategy to improve agricultural production and industry (Gurmessa, 2016). Next, during the period of the "Derg" regime (1974 - 1991), the country executed a state-controlled economic and political system that has the ideology of socialism. The institutions and modes of production are determined by its control over the means of production. However, the question of political and economic freedom persisted as the most contentious one, largely ignoring individuality (Sharma, 2013).

Several policy documents aimed to address the issue of hunger and malnutrition in the nation were created following the political-economic systems of each regime (Chanie et al., 2018). Small farmers who use traditional technology and low input/low output production systems make up the majority of the country's agricultural workforce (Welteji, 2018). Therefore, smallholder farmers were not properly and adequately subsidised to improve their agricultural system.

The agricultural policy designed and implemented during the emperor period has adopted a national economic policy which is pro-feudal and capitalist. The driving force of this policy was the market. Although three to five years of development plans are documented, peasants or small land-holding households were socially and economically under the domination of landlords. Educated elites control the production, income, and land tenure system of smallholder rural households (ibid). This authoritarianism made rural households not use their land and produce what they needed. Improving coffee cultivation is a key component of the first five-year plan's emphasis on increasing foreign exchange revenues (Samuel, 2006). In 1960s, food scarcity forced the government to concentrate on agriculture, and as a result, the second and third development plans ignored the grain produced by subsistence farmers in favour of large-scale commercial farms (Bogale & Ba, 2015). Large irrigation projects planned in the Awash Valley in the 1960s to produce food crops for internal use and industrial crops for exports, were seen as a smart approach to national economic development (Yihdego et al., 2015). The policies did not encourage rural smallholders or provide the freedom to produce what they needed.

After the collapse of the emperor's regime, "Derg" took the position to administer the country. It gave smallholder farmers the right to use land and redistributed rural farmland, which was privately owned by emperor landlords, elites, and churches, to peasants and farmworkers of the landlords (Welteji, 2018). "Derg" adopted its economic policy from socialist ideology. All private and public economic activities were controlled at the centre, all private undertakings were nationalised, and a national capital ceiling was imposed for private operators. 'Derg' granted the right to use, but the ownership of the rural land was under the control of the state. Due to the principles of the political system, rural smallholder households did not have the right to produce the required amount and type. They did not have the right to decide what type, number of agricultural inputs to use, and which crop types to consume and sell (Bogale & Ba, 2015). All the economic activities of rural households were under the control of the institution called the "Agricultural Marketing Corporation" which oversaw the production and sale of agricultural outputs at the national level. Furthermore, the policy did not favour foreign direct investment, incentives, and competition. Individual farmers were negatively impacted, as agriculture only benefited state and collective farms (Gurmessa, 2016). Thus, neither the small rural farmers nor the private sector supported raising household incomes or ensuring food security.

The distorted macroeconomic policy in the 'Derg' regime caused political unrest. The regime implemented massive villagisation and settlement programmes to address policy gaps. However, the villages and settlement programmes did not contribute enough to rural development as intended in policies (Bogale & Ba, 2015). The socialist ideology of the regime was primarily aimed at reallocating wealth and confirming public possession of means of production. In the socialist economic system, the central government decides the type of production, the use of resources, its distribution, and the prices of production. However, this socialist's collective production had its limitations on a country's economic and citizen development. It does not promote competition and provides incentives to stimulate individual citizen's economic activity (Gurmessa, 2016). Therefore, the "Derg" regime changed the economic and political-economic system to a mixed type and tried to establish socio-economic institutions to boost the economy from stagnation (Welteji, 2018). So, the socialist economic system or the Marxist ideology in the “Derg” regime did not grant freedom and subsidies to rural smallholders or improve the citizens' ability to participate in a competitive free market.

Both regimes, i.e., Emperor and Derg, developmental interventions were implemented for the interest of the central government. The irrigation schemes were medium to large-scale and produced crops which were decided by the central government to support the young industries. The economic activity of citizens and institutions was influenced by the state and undermined individual freedom. The agricultural development and economy of the country during these two regimes were stagnant (Tesfaye, 2017). To boost agricultural development, small farmers need policy support and play their part in rural development in the country.

3.4 FREE MARKET ECONOMY

The end of the 20th century a shift occurred in global socialism. Socialism was put to the test in terms of its ability to renew for creating an economy flexible and responsive to advances in science and technology, society's ever-changing needs and combining efficient production with a system of inherent values and ideas (Abalkin,1990 In the socialist governments of the Soviet Union and Eastern Europe, centrally regulated command economies were dismantled in 1989 and 1990 (Pieterse, 2010). These nations' economic development became so sluggish in comparison to Western European nations that they perceived the centrally planned economies to be inferior to those based on private enterprise (Qayum, 1992). Consequently, the leaders and decision-makers of these once-communist nations began to transform their centrally planned command economies into decentralised free market economies (ibid.).

The transition from a socialist economy to a free-market economy was challenging. Neo-institutionalists argue that the shift to a market economy should be accompanied by incremental institutional reforms that include both planned and unplanned characteristics (Ngo, 2018). They believe that traditional institutions should be preserved to "guide the operation of the old sector," while new institutions should oversee the growth of the private sector (ibid). Furthermore, the structures and processes that have been in place for more than half a century to run a planned command economy cannot be undone overnight (Qayum, 1992). Citizens' attitudes and behaviours about employment and income stability, as well as the entitlement to free education and health services, are difficult to change (ibid). Therefore, they did not immediately change their economic system to the free market and need further improvement.

Socialist governments gradually privatised centrally managed institutions. However, western Europeans were already liberalised directly without engaging in a socialist economic system. They liberalised the institutions. The characteristics of a market economy are at odds with those of a command economy (Sharma, 2013). In a market economy, decision-making is coordinated through markets and private ownership and control of resources, while the command economy is characterised by state ownership and control of resources and centralised decision-making (Sharma, 2013). The free-market economy liberalises institutions, and the economic system is determined by the market. Practically the free-market economy does not favour citizens equally. The gap between individuals remains wide and ignores individual's equal resource use rights. Both socialist and free market economy systems do not equitably and perfectly improve the economic development of citizens and the state of developing countries.

3.4.1 Free market economy in Ethiopia

The free-market economy system started in Ethiopia during the end of the 'Derg' regime. To boost the stagnant economy, “Derg” has finally implemented a mixed economy. This mixed economy system had mixed some concepts of a free market economy with a socialist economic system. However, it does not last long. After “Derg”, the Ethiopian People's Revolutionary Democratic Front (EPRDF) started to rule the country. During the EPRDF period, a unity of ethnic-based organisations established a federal political system. The party has been governed by a combined ideology of socialism (from the success of East Asian countries) and capitalism at the other end (Tesfaye, 2017). It has also encouraged the economic system to be of mixed type, liberalism and control of major interventions that could affect the economy (socialism) at state, corporate private and rural smallholder household levels (Gurmessa, 2016).

Ethiopian People's Revolutionary Democratic Front has proclaimed that rural land ownership is under the state and has given households the right to use rural land, improve their income and food security (Welteji, 2018). Furthermore, great attention has also been paid to improve the agricultural sector and rural households in comparison to the previously mentioned regimes. Agriculture-based policy, strategy, programmes, and five-year plans have been designed and implemented. Among the key policy documents are the Food and Agriculture Policy, the Agricultural Development Led Industrialization Strategy, the Participatory and Accelerated Sustainable Development to Eradicate Poverty Program, and the two successive growth and transformation plans (GTP I and II). Furthermore, by enhancing smallholder production via the use of an information and technology strategy developed through research, it contributes to national efforts to achieve food self-sufficiency (Welteji, 2018). As a result, as a package strategy, several actions could boost the supply to industry, export, citizens and ensure the rehabilitation and conservation of natural resources.

Like other developing countries, Ethiopia has also adopted different economic models and neoliberal ideology from developed economies around the world. Neoliberal ideology promotes large corporations to dominate the national economy, and it is against the poor (smallholders). This neoliberal ideology was severely criticised for its aspiration of having a weak state (Gurmessa, 2016). Therefore, the country has begun to transform its politics and economy. The party then liberalised the economy to a pro-capitalist and market-oriented (Tesfaye, 2017). Owing to market imperfection and inefficiency of neoliberals, the latter of EPRDF has developed its ideology called "revolutionary democracy". The ideology of revolutionary democracy mixes the essential components of liberalism (capitalism) and socialism, which are essential for the economic development of the citizens as well as the nation.

The preferences of developmental theories and strategic policies are different from country to country (Tesfaye, 2017). The country had adopted its economic development model based on the experience of different countries. Among global countries, the economic development experience of East Asian countries has attracted the Ethiopian government during the EPRDF period. Therefore, Ethiopia has adopted the development state economic model, which these countries use (Gurmessa, 2016).

Ethiopian People's Revolutionary Democratic Front (EPRDF) has preferred Keynesian economic theory to the culture, ethnicity, and economic status of the country of lower-income citizens, including small rural landholders. Keynesian economists promote a mixed economy, that is, private sectors perform their economic activity under the follow-up of the government (ibid.). However, currently, the Prosperity Party has shifted its development ideology to centrism which could be categorised as interventionist. The notion of a developmental state is intimately linked to the swift progress of industrialization and the transformation of society through substantial government engagement in the economy (Bayeh, 2019). The progressive state is not a socialist or capitalist regime from an ideological standpoint. Instead, it is positioned halfway between a command economy run by the central government and a free-market capitalism economy (Bolesta, 2007). It preserves the positive aspects of both systems while eschewing their drawbacks. Therefore, both the EPRDF and Prosperity Party have allowed some features of the free market system, with a selected state intervention to protect low-income citizens, enhance their competition and correct the imperfection of the free market system.

However, different scholars have studied the shortcomings of the development state economic system in Ethiopia during the EPRDF. For example, Bayeh (2019) said:

> Even though the developmental state has brought an observable level of economic growth, it has also caused several detrimental effects in other spheres: eroding the value of pluralism; endangering human rights; infesting a single-party authoritarian rule; leading to rampant corruption; intensifying arbitrary intervention in the life of citizens. In implementing the model, the focus was on economic growth, while the political aspect of it was sidelined. As a result, the researcher suggests that economic growth and political transformation (democratisation) should be valued equally and pursued side by side, not in tandem (Bayeh, 2019:1).

Although the correct reason for shifting the ideology from Revolutionary Democracy to Centrism is not justified, the aforementioned shortcomings would be the reason.

3.4.2 Rural Development and Food Security

Governments design and implement variable policies, programmes, and strategies according to the political ideologies and context of their countries. Their economic growth as a state, public and individual citizens was based on these political ideologies and theories. The development of every country's policy was totally or partially administered by the central government. When all developments are governed from the state (centre), every policy, strategy, programmes, reform, and plans are developed and implemented from top to bottom. However, if it is governed partially, the government provides some autonomy to the free market and intervenes on some issue which could not be accessed by every citizen under the free market system, and favours equity and computations or capability of smallholders. Mixing the two will keep the right of citizens to all developmental activities and resources. Therefore, every citizen, especially the marginalised, in any country would have the right to utilise any resources and develop their economy equally, at the household level.

Policies and programmes help low-income populations receive food support and improve their dietary intake and food security. The nutritional promotion component of Supplemental Nutrition Assistance Programme (SNAP), known as the Supplemental Nutrition Assistance Programme-instruction (SNAP-Ed), helps low-income Americans increase their dietary intake and decrease food insecurity by providing nutrition instruction (Rivera et al., 2019). To guarantee the nutritional security of Indians, Sandhu's research has led him to suggest that the National Food Security Act (NFSA) should be reviewed to go beyond the provision of subsidised food grains (Sandhu, 2014). As part of a comprehensive strategy to promote food security, physical health, and overall well-being among vulnerable populations, policymakers would be well-advised to continue strengthening food assistance programs through measures that improve access to nutrition education, healthier food options, and coordinated social services, given the ongoing challenges associated with malnutrition.

Farmers decision-making and crop choice are current issues of rural development policies. According to Mazarura (2014) farmers in Zimbabwe agreed that SSI schemes were managed centrally before, but not today. Although there are local officers, it is evident that farmers make their own independent decisions as to which crops to grow and when to grow them. It was widely accepted that the decision of farmers to choose the right variety and the quality of the seed was particularly important.

Gender inequality and technology adoption were also the major concerns of rural smallholders' development policies. However, although many countries provide equal rights for all citizens to use any natural resource and participate in any development activities, women are still not treated equally. So, gender inequality has been shown to affect household income levels in Namibia under government-funded irrigation schemes (Zuwarimwe et al., 2016). Not all farmers adopt and utilise technologies equally. Therefore, understanding intrahousehold control over technology will help campaigns support technology adoption for women's empowerment and agricultural development and avoid considering technology adoption as a goal (Theis et al., 2018).

Smallholder suitability for markets and policy implementation should be low-income countries' concern. Ncube (2017) has also shown in his research that not all South African smallholders are suitable for every kind of market, and not all farmers can successfully market their produce. Thus, connecting smallholder characteristics to markets and implementing policy tools that permit cohabitation individuals to share control over technology is essential.

Water security, on the other hand, is a new idea that has gained traction over the last five years (Naidoo et al., 2013). Owing to its importance in household use (domestic), small-to-large-scale and homestead agriculture (agricultural), industrial and other service use, water is essential for sustainable urban and rural livelihoods and household food security. African countries have reformulated and incorporated the sustainable use of water in their policies and programmes. As of

Chazovachii (2012), Zimbabwe has made institutional reforms to administer the use of water for irrigation and other purposes. Nevertheless, there are now issues with the administration of irrigable areas and the management of these smallholder irrigation systems. Decentralised community organisations like the Water Users Associations were founded to guarantee the efficient administration of irrigation water and SSI programs to address this issue (Akudugu, 2013).

Land and water reform programmes were also implemented in South Africa to address equity and promote rural development (Saruchera et al., 2010). Furthermore, different activities and approaches were also implemented under various projects to improve the farmer's skills. In South Africa, land suitability assessment methodologies and approaches are often targeted at commercial professional farmers with superior expertise and technology means for crop production. Land appropriateness for certain crop ranges was generated for SSI schemes using dynamic land suitability recommendations (Nethononda et al., 2014).

Furthermore, irrigation has been pushed as a means of enhancing livelihoods and lowering poverty in Southern Africa. Within SSI schemes, household livelihood options have grown more varied and sophisticated. The income from off-farm sources is becoming more and more important in strategies that rely on livestock and rain-fed and irrigated cropping for farm income. The ability of the household to decide how to use its labour, money, land, and water resources will determine if these tactics are successful (Bjornlund et al., 2019). Thus, even while it is vital to link land reform to water reform, the ineffective application of water reform continues to be a barrier, impeding the growth of agriculture and rural livelihoods. Additionally, it appears that the land or water reforms must be connected to more comprehensive agrarian reforms that consider market access, support services, and the various, frequently multiple, livelihood strategies that characterise rural areas to effectively address equity and promote rural development (Saruchera et al., 2010).

Competition for variable use water supply was identified as a serious threat (Naidoo et al., 2013). Therefore, governments have begun to implement and incorporate some water-sustaining policy issues in their development activity. Some activities are planned and practised to their benefit. However, although these reforms have positive effects on sustainable water use, they do not contribute enough to their potential. Therefore, different organisations and scholars were interested in why rural farmers do not get enough services or benefit from these reforms and conducted variable research on institution- or reform-induced challenges and opportunities that affect the performance of SSI schemes. Chazovachii (2012) has evaluated how the commercialisation of water, that is, water pricing, has negatively impacted agricultural productivity in the scheme. He found that it was owing to the reduced performance of the scheme arising from farmers abandoning the scheme, disputes over water allocation, deterioration of infrastructure, indiscriminate water cuts, low incomes, and farmer dissatisfaction with the budget-straining water charges out of reach for peasant farmers in the scheme. As a result, people who suffer limited water access have fewer opportunities for both present and future water use due to these complex challenges.

One major problem that hinders access to water is policy knowledge gaps and a lack of awareness of water management mechanisms (Naidoo et al., 2013). Therefore, one of the policy tools to address the issue might be the revitalization of SSI schemes and the decentralisation of water and scheme administration and management. As a result, the creation of an official water user association was largely adopted as a solution. A conceptual framework was developed by Mwendera and Chilonda (2016) to revitalise SSI projects that are failing or have partially collapsed due to a confluence of institutional, physical, social-economic, and governance problems. The foundation of the framework is the notion that an irrigation scheme consists of four interrelated systems: the social-organisational system, the physical system, the crops system, and the economic system. The conceptual approach consists of two main parts: developing the technique for revitalization and putting the revitalization process into action. The method is characterised by performing diagnostic studies to look at the irrigation system, socio-organisational structure, market conditions, and water availability of the scheme. To sustain the resurrected system, farmers and extension agents must be trained, physical infrastructure must be repaired, and a framework for tracking and evaluating the program's performance must be built (Mwendera & Chilonda, 2013).

The Water Users Association (WUA) established to administer water management of the schemes has positive and negative impacts to agricultural production and use rights of landholders. According to Akudugu (2013), the WUA no longer has authority over the management of the irrigable lands, and in some of the villages, they have even seemingly stopped existing. As a result, other landowners have emerged and are now taking up the WUA's land allotment responsibilities. In addition to preventing people from using small-holder community irrigation schemes to access irrigable land, this situation exacerbates tensions and may lead to conflicts that may be challenging to resolve soon. In addition, irrigators frequently experience unpredictability in irrigation water supply, unequal water distribution and lack of timeliness in water distribution. All the schemes analysed revealed a lack of organisation for the administration of the irrigation system. Moreover, WUAs lack specific laws/by-laws and strategies for directing small and large canal operations and maintenance (Ulsido & Alemu, 2014).

3.4.3 Rural institutions and smallholder farming

Rural institutions and smallholder farming in Ethiopia need integration. Agricultural institutions are the major sector. Rural smallholder farming is directly related to these institutions. The total land area reported for private peasant holdings was estimated at more than 22.81 million hectares and operated by more than 19.23 million agricultural households and about 23.19 million are agricultural holders (CSA, 2021). According to the report of the CSA (2021) agricultural survey, among the agricultural land holdings of small agricultural holders, about 71% were covered by temporary (annual) crops. In other words, about 19.52 million and 14.59 million agricultural households were reported to grow temporary and permanent crops, respectively, for the 2020/21 (2013 E.C) production year (CSA, 2021). Thus, the development and strengthening of economic institutions in a rural area of Ethiopia should get government attention to enhance the capacity of rural smallholders.

The Ethiopian government has currently understood the proportion and contribution of rural smallholders. The government has provided several agricultural package programs as part of the development agenda to boost smallholder farmers' production and enhance the welfare of rural residents (Teka & Lee, 2020). Therefore, especially since the EPRDF, the government has paid the necessary attention to boost social, economic activity and contribution to the rural smallholder household specifically and to the country in general.

To improve the state's and its residents' economies, several development policies, programs, strategies, plans, and interventions have been created and put into action. Before 1991, no policy or plan execution established a steady and equal transfer of wealth to individuals, particularly smallholders. The rural development policy was developed in 2002 to completely address smallholders and the development of rural communities (Ministry of Finance Economic Development, 2003). To support the implementation of this policy, strategies were also designed. Programs for rural development focused on agriculture were also implemented to help achieve the nation's and the people's goal of economic development (ibid). The most well-known and long-lasting economic policies that have been implemented since 1991 include the Sustainable Development and Poverty Reduction Programme (SDPRP), the Agricultural-Led Industrialization (ADLI), the Participatory and Accelerated Sustainable Development to Eradicate Poverty (PASDEP), and the Growth and Transformation Plans I (GTP I) and GTP II (Welteji, 2018). The rural development strategy in the country is based on rural and agricultural development. It views development that is centred on agriculture and rural areas to guarantee quick economic growth, improve benefits to the populace, terminate the nation's reliance on food aid, and encourage the growth of a market-oriented economy (MoFED, 2003). As a result, since 1991, the nation has adopted several agricultural policies, including market liberalisation and structural adjustment, to increase agricultural productivity (Shikur, 2020). All the policy documents mentioned emphasise the improvement of smallholder agriculture, their competition, and their contribution to the national economy.

The backbone of the Ethiopian economy is agriculture. The process of agricultural economic growth is significantly influenced by agricultural policy (Shikur, 2020). The primary policy to start agricultural transformation and raise rural residents' incomes is a shift in agricultural productivity (Ngai & Pissarides, 2007; Urgessa, 2020). The government has not offered any price support or agricultural subsidies since 1991 (Shikur, 2020). A program of structural adjustment reduces the government's power over the distribution of resources and strengthens the position of supply and demand in the Ethiopian economy. By increasing agricultural productivity and output, all these policy initiatives have helped to lower poverty and food insecurity (ibid). Furthermore, various rural institutions and sectors were integrated into the rural development policy (MoFED, 2003). To improve agricultural productivity policy issues like land utilisation, subsidising smallholders with agricultural inputs, technologies and farm implements, finance and credit services, health and education services, improvement of road and transportation and market channels, etc., should be integrated to boost the competitional capacity of smallholders to the principles of free market.

3.4.4 Rural Development and Water Resource Management

Ethiopia's economy relies on agriculture, which also contributes significantly to GDP and jobs. There is a history of rural development initiatives in Ethiopia. The nation's program packages for rural development policy have been assessed over the course of the last three administrations. Due to erroneous governmental priorities, institutional factors, and technology limitations, there were gaps in access, utilisation, and coverage (Welteji, 2018). SSI programs and small-scale rainwater harvesting technology development were adopted in Ethiopia and other developing nations to reduce food scarcity and alleviate poverty. Donors and non-governmental organisations fund the development of irrigation systems, particularly SSRWHT (Small-Scale Rainwater Harvesting Technology) and PSSIS (Participatory SSI Schemes). Out of Ethiopia's 5.3 million hectares of potentially irrigated land, only 5 to 10% are cultivated (Tadesse & Baihilu, 2017).

Ethiopia has many large surface and underground water resources (MoFED, 2003). There is no denying the critical role that water plays in agriculture, which would be nearly impossible without it. Typically, crops account for 60% of the sector's output, followed by animal production (27%), and other sources (13%) (Welteji, 2018). To make the best use of these resources, appropriate water policies and regulations are required. The federal government has already issued this policy and is currently being implemented. Although the majority of the work has already been done, there is still more that can be done to enhance the policy (MoFED, 2003).

The lack of infrastructure, financial capability, highly skilled workers, and foreign investors in the areas is the main obstacle to building large-scale irrigation dams. Moreover, using available water resources diplomatic issues to get foreign loans, grants, and enhance technical capacity e.g., a hydrologist and other trained university professionals was also a problem. However, with some domestic financial sources, water resource development master plans and water institutes have become real in the country. Then, the water resource management policy was designed for the first time and in an integrated manner with other related rural development policies. Then afterwards, professionals have been assigned to the kebele and have started to support water conservation programmes at the kebele level. However, none of the initiatives necessary to improve our utilisation of water resources can completely alleviate the sector's capacity limitations.

Consequently, the plan raises the amount of money available for small-scale water resource development. It addresses the capacity issues in the water industry. The policy then replaces labour with capital in all development initiatives. For this reason, labour-intensive procedures received special attention in the growth strategy. The policy then began by improving the agronomic techniques of the farmers so that agricultural operations embrace greater use of water. It encourages methods that will allow farmers to manage and conserve rainwater. The use of runoff and flood water for irrigation will also be encouraged by promoting straightforward technology that farmers can themselves develop. Another possibility is to build a medium dam and divert the river. By providing people with some technical and financial help through credit services, it is possible to mobilise people and develop water resources. Moreover, the existing policy promotes the construction and profitable operation of hydroelectric dams by private investors. A similar approach to policy stimulates and promotes private involvement in irrigation dam building. As a result, there aren't many issues with the current government strategy because it attracts private investment.

The water resources management policy has been designed independently and is extracted from the rural development policy. It consists of three primary policy sections: water supply and sanitation, irrigation, and hydropower. The policy aims to strengthen and promote all national efforts to maximise the effective, egalitarian, and optimal use of Ethiopia's existing water resources for considerable socio-economic growth in the long term. It is important to understand that the development, use, preservation, and conservation of water resources are interdependent and guarantee that related activities, hydraulic structures, watershed management, drainage, irrigation, and sanitation, as well as water supply and sanitation, are coordinated.

The objective of the irrigation policy, which falls under the category of water resource management policy, is to maximise the potential of irrigated agriculture to sustainably and efficiently produce food crops and the raw materials required for agro-industries, all the while maintaining the fertility of the production fields and the foundation of water resources. The policy aims to support the nation's large-, medium-, and small-scale infrastructure development and distribution in an environmentally sustainable, equitable, and efficient manner. The policy offers integration with the nation's goals for socioeconomic growth, especially the Agricultural Growth Led Industrialization (ADLI) Strategy. Irrigation policy is created within the domain of water resource management since it is acknowledged as an intrinsic part of the water sector. Irrigation technology development, promotion, distribution, and administration were controlled by other sub-policies.

Although the irrigation policy encourages the creation of suitable and reasonably priced technology for the planning, building, implementing, running, and maintaining of irrigated schemes, its full potential has not yet been realised. The policy did not receive the necessary attention, even though it encourages the development of suitable institutional structures for the management of irrigated agriculture as well as the development of capacity in the areas of human resources, new technologies, engineering, and financial management. Water must also be readily available, accessible in the proper quantities, and available when needed. For agriculture to develop rapidly and independently, a dependable supply and management system for drinking and irrigation water is required. To date, policymakers and aid organisations have placed emphasis on using modern farm technologies as Ethiopia's only source of agricultural growth (Welteji, 2018). Technology is expensive and fewer farmers can afford it (Welteji, 2018). Emphasis has been on drinking water supplies, sanitation, and hydropower policies. Irrigation does not receive attention about its potential and contribution to the national and household economy. The policy should be treated independently and include detailed issues such as how to subsidise rural smallholders with modern irrigation and farm technologies. In addition, the Ethiopian government implemented policies that aim to increase access to education, health and improve the livelihoods of rural smallholders. These policies seek to promote sustainable development and reducing poverty in the rural area of the country.

3.4.5 Irrigation in Ethiopia

Ethiopia has practiced traditional irrigation for more than 2000 years (Gebul, 2021). However, publicly funded medium- and large-scale irrigation projects have only been underway over the past thirty years (Gebul, 2021). Irrigated agriculture is still unimportant in Ethiopia's heavily populated highlands, even though it likely existed before the Axum dynasty. Traditional irrigation was practised in the country's highlands before the 1950s (Ethiopian Ministry of Agriculture, 2011). The 1950s saw the advent of sophisticated irrigation methods. The government-sponsored SSI program was beset by civil war, the villagization and resettlement programmes, insecure land tenure, inadequate water-use legislation, and a lack of interest from peasants in government-sponsored projects, even though it increased production in certain producer cooperatives. Since the famines and droughts in the 1970s and 1980s, SSI projects centred on peasant farms received more attention as a means of enhancing agricultural output and achieving food self-sufficiency. Consequently, the Upper and Middle Awash River Basin—one of the most highly developed basins in the nation—has seen the emergence of medium- and large-scale commercial irrigated farms (Gebul, 2021).

Irrigation was developed through cooperative concessions with foreign companies. Through a bilateral agreement between the Ethiopian government and a Dutch corporation, Hangler Vondr Amsterdam (HVA), the irrigated sugarcane plantations and factories in Wonji (5,000 ha) and Metahara (11,000 ha) started operating in 1954 and 1965, respectively (Gebul, 2021). Private companies established large-scale irrigation projects in the Awash Basin after the Koga Dam was completed in 1960. In 1961–1962, Seignior Tiliota Santo (Italian) built a 1,638-hectare farm surrounding Merti and Jeju (Gebul, 2021). Throughout the Emperor and Derg periods, medium- and large-scale irrigation facilities were implemented (Table 3.3).

Table 0-3 Medium and large-scale irrigation schemes commenced operation from 1654 to 1997.

No	Irrigation scheme Name	Starts operation in	Farm Size (in ha)	Crop types grown	Region	Remark
1	Wonji	1954	5000	Sugarcane	Oromia	
2	Methehara	1965	10000	Sugarcane	Oromia	
3	Merti and Jegu	1961/62	1638	cotton	Oromia	Later, fruits in 1975
4	Amibara	1980	10000	cotton	Oromia	
5	Nura	1983		Horticulture crops	Oromia	
6	Meki Zewai	1967		Horticulture	Oromia	
7	Fincha	1997		Sugarcane	Oromia	
8	Sille farm	1957		cotton	SNNP	Later cotton & fruits
9	Bilate Tobacco Monopoly	1962		Tobacco	SNNP	Wolaita Zone

Source: Gebul, (2021).

Ethiopia has ample water resources. The country has 12 river basins (Table 3.4.), from this surface water, it has a potential of 122 billion m^3 (Bm^3) from annual runoff and 2.6 - 6.5 billion m^3 of water from groundwater. Potentially, 3.7 million hectares of land can be irrigated using different water sources and irrigation technologies (Awulachew et al., 2007). In southern Ethiopia, three potential river basins like Omo- Gibe, the Rift valley and Genale Dawa basins are available. Among these river basins, all administrative districts in the Wolaita Zone are covered by two river basins, Omo-Gibe and Rift Valley (ibid).

Table 0-4 Twelve river basins and their irrigation potential in Ethiopia

No	River Basins	Area (km^2)	Runoff (Bm^3)	Potential Irrigable land (ha)	Estimated ground water potential (Bm^3)
1	Tekeze	82,350	8.2	83,368	0.2
2	Abbay	199,812	54.8	815,581	1.8
3	Baro-Akobo	75,912	23.6	1,019,523	0.28
4	Omo-Ghibe	79,000	16.6	67,928	0.42
5	Rift Valley	52,739	5.6	139,300	0.1
6	Mereb	5,900	0.65	67,560	0.05
7	Afar/Denakil	74,002	0.86	158,776	NA
8	Awash	112,696	4.9	134,121	0.14
9	Aysha	2,223	NA	NA	NA
10	Ogaden	77,121	NA	NA	NA
11	Wabi Shebelle	202,697	3.16	237,905	0.07
12	Genale Dawa	171,042	5.88	1,074,720	0.14
	Total	1,135,494	124.25	3,798,782	3.2

Source: - Awulachew et al., (2007)

In addition to these 12 river basins, Ethiopia has four crater lakes, eleven fresh and nine salinised lakes, and over a dozen notable wetlands or swamps (Awulachew et al., 2007). Most of the lakes are in the Rift Valley Basin. Ethiopia's lakes, both man-made and natural, cover about 7,500 km2 of surface area overall (ibid.). Fish are abundant in most Ethiopian lakes (Awulachew et al., 2007). In SNNPR, ten lakes such as Hawassa, Abaya, Chamo, Chew Bahir, Rudelf, Chofore, Deno, Monsu, Shesha, and Boreda are available (BoFED, 2019). Among these, Abbaya is in Wolaita, Gamo Gofa and Sidama zones. It covers 1160 km^2 and is used for irrigation using SSI pumps around Gamo Gofa Zone (ibid.). Rainfall and temp data currently vary to a specific place and time. However, although the southern part of Ethiopia has irrigation potential and has its swamps or wetlands, its coverage and use have not yet been studied and documented well.

Following the EPRDF, the country built some small, medium, and large-scale irrigation facilities throughout the country. The country has developed an ADLI plan (Ohno, 2009) to stimulate the construction of SSI systems to sustain rural smallholder food security and drive the country's economy toward industrialisation. For the sake of planning and development, the nation has divided irrigation systems into three groups: small-scale (200 hectare), medium-scale (200-3000 ha), and large-scale (> 3000 ha) irrigation (Gebul, 2021; Awulachew et al., 2004). The entire estimated area of irrigated agriculture in the nation is 107,265.65 hectares, of which 20,038.39 hectares are small-scale, 30,291.26 hectares are medium-scale, and 56,936 hectares are large-scale, according to the database of Awulachew et al. (2007). However, there are currently about 107 irrigation schemes available in SNNPR. Modern irrigation networks have helped cultivate about 7,931.5 hectares of land, benefiting 38,230 households in total. Awulachew et al. (2007) state that 3,560 hectares are from the middle scale and 4,371 hectares are from the small scale. However, even though irrigation is an essential agriculture intervention, it has not yet done well in a rural community and contributes to agricultural growth as a country and at the household level (Ethiopian Ministry of Agriculture, 2011). Moreover, its potential, contribution and actual coverage per each scale are not well documented in the public or well researched in the country.

According to the Annual Abstract Bulletin of the Wolaita Zone Finance and Economic Development (WZoFED), the Wolaita Zone has ample water resources that indicate the irrigation potential (WZoFED, 2019). The zone has an average rural small landholding size of 0.25 ha (WZoFED, 2019), which is below national (0.8), and Africa (<2ha) (CSA, 2021) and the world (2ha) (Hazell, 2017). Although the initial period of traditional irrigation is not documented, a modern irrigation system has started around the Bilate River. In 1962, the Ethiopian government established a Bilate Tobacco Monopoly factory around the current Duguna Fango District, at Bilate Charicho kebele (Gebul, 2021). Similarly, to support this factory, a modern irrigation scheme and farm have been built and started to produce tobacco for the factory. It was the second irrigation farm next to the Sille Farm that was established earlier in the SNNP region (Gebul, 2021). Later, another state farm like the Bilate State Farm was also established on this river to produce cotton and fruits. According to meteorological data, the trend of rainfall decreasing in the study area has not yet been carried out. The mean annual rainfall in the zone ranged from the lowest 800 mm around the Bilate area to the highest 1200 mm around Wolaita Soddo (WZoFED, 2019). The nature of the rainfall in the zone is unpredictable and variable. The mean annual maximum and minimum temperature ranges from 15.2 0^c to 31.4 0^c (ibid.). According to the Wolaita Zone Department of Water, Mines and Energy (WZDoWEM), 2021 Annual Inventory Report on water resources, there are a total of 17 seasonal and perennial rivers in Wolaita (WZDoWEM, 2021). Beyond the potential of groundwater, all the mentioned rivers can be used for irrigation using various irrigation technologies. Therefore, the zone has the potential to expand irrigation development by integrating activities of natural resource management. According to the Wolaita zone of finance department, 2018/19 Annual Statistical Abstract, the total equipped irrigated agricultural area is 3,874 hectares, of which 2,546 hectares are small-scale and 1, 328 hectares are medium scale. Therefore, although irrigation has a significant contribution to the Wolaita Zone, the development of equipped irrigated land and the harvest of the potential for irrigation in the study area has not yet been carried out.

3.5 SUMMARY

This chapter outlined the theoretical conceptualisations, rural development policies and institutional context in Ethiopia. Small-holder irrigation schemes (SSIs) were implemented to curb food scarcity and alleviate poverty in Ethiopia). The lack of effective implementation of water reform was developed as part of the water resource management policy, with the goal of developing the potential of irrigated agriculture to produce food crops and raw materials required for the agro-industries. The policy aims to strengthen and promote effective, egalitarian, and optimal use of Ethiopia's existing water resources for socio-economic growth.

CHAPTER 4

METHODOLOGY

4.1 INTRODUCTION

This chapter on methodology reviews previous research, including design, study population, sample size, data types, and data collection methods. The study instruments, their relevance and data analysis methods, are discussed. This chapter presents an overview of the methodological components used in the study on the role of SSI on the food security outcomes of rural smallholders.

4.2 SYSTEMATIC LITERATURE REVIEW

To collect and analyse relevant data for the thesis, the research employed a systematic review of the literature as a qualitative data analysis method. This approach enabled the researcher to identify gaps in previous work related to the topic of this thesis. The systematic review of the literature can include an analysis of the published and grey literature analysis (Ndinda et al., 2018). The systematic review was done in two parts. First, it was necessary to categorise all journal articles whose titles contained words like "SSI schemes", "SSI technologies"," SSI", "SSI interventions", "irrigation and food security", "SSI and food security outcomes". The second stage was to categorise journal articles with the terms "rural smallholders", "smallholders and food security", "rural food security", "smallholders and food security outcomes", or "food security outcomes" in the title.

4.2.1 Inclusion and Exclusion Criteria

Identifying published articles with parts like "SSI schemes", "SSI", "SSI technologies", "SSI interventions", "irrigation and food security", "SSI and food security outcomes", and other similar phrases with all the words forming parts were the main criteria for including articles in the review process. Furthermore, if all the words were phrases, publications with the term's "smallholders", "food security", "smallholders and food security", "food security outcomes" and similar terms in the title of the article were also included. Only journal articles published between 2010 and 2021 were selected.

Several exclusion criteria were used to guarantee the quality and relevance of the articles included in the review. Articles on large- and medium-scale irrigation were excluded, as well as those that were not published or were not published in English. Additionally, books, reports, conference proceedings, bills, duplicated citations, duplicated journals, and unpublished works were not considered for review. The last step was to screen published journal articles based on their titles and abstracts, excluding those that did not discuss SSI, smallholder, their connection to food security, or other related topics. Only published journal articles that had a direct bearing on the thesis title were included in the study.

4.2.2 Search Strategy

An electronic search was performed using the Google Scholar database to perform relevant articles search. The University of South Africa (Unisa) was entered into the search engine and processed. The Unisa library and Unisa-ProQuest Full-text databases were also selected and saved before starting the search process. To find relevant journal articles, the researcher used a mixture of single and compound keywords, including the single keywords "irrigation," "food," "security," "technology," "schemes," "intervention," and "rural," as well as compound keywords like "small-scale," "smallholder" and "outcomes." These terms were typed into the Google Scholar search engine and the time range was limited to 2010-2021, while the search options were changed to look for articles using all the words in the title. Key terms such as SSI schemes, small-scale technologies, small-scale interventions, SSI, SSI and food security, SSI and food security outcomes, rural food security, food security outcomes, rural smallholders, smallholders and food security, and smallholders and food security outcomes were used as keywords in the search.

The records identified based on the keyword category were saved accordingly. After applying the inclusion and exclusion criteria, the search results were as follows: "SSI" (n=649), "SSI schemes" (n=98), "SSI interventions" (n=3), "SSI technologies" (n=18), "rural smallholders" (n=19), "rural food security" (n = 141) and "food security outcomes" (n=35). In the second search, using all keywords in the title of the article, the results were as follows: "SSI and food security" (n=28), "SSI and food security outcomes" (n = 0), "smallholders and food security" (n = 73) and "smallholders and food security outcomes" (n=0), resulting in a total of n = 10,64 records identified. Of these, n=202 journal articles were isolated for final screening and eligibility (Table 4.1).The identified journal articles were imported into Mendeley library using the Mendeley web importer extension tool and saved in a separate folder based on their combined keywords for ease of searching.

Table 0-1 Journal articles excluded and included for systematic literature review.

No	Key words used for searching	Identified records	Excluded records during screening and eligibility process			Included records
			Citations	Duplicates	Eligibility	
1	Small-scale irrigation	649	175	78	312	84
2	Small-scale irrigation Intervention	3	0	0	2	1
3	Small-scale irrigation schemes	98	18	3	47	30
4	Small-scale irrigation Technology	18	1	3	8	6
5	Small-scale irrigation AND Food security	28	14	0	8	6
6	Small-scale irrigation AND Food security outcome	0	0	0	0	0
	Sub-Total	**796**	**208**	**84**	**377**	**127**
1	Rural smallholders	19	2	0	7	10
2	Rural Food security	141	9	8	87	37
3	Food security outcomes	35	3	3	13	16
4	Smallholders AND Food security	73	25	2	34	12
5	Smallholders AND Food security outcomes	0	0	0	0	0
	Sub-Total	**268**	**39**	**13**	**141**	**75**
	Total	**1064**	**247**	**97**	**518**	**202**

Source: SLR, (2021)

4.2.3 Screening Process

The primary screening of journal articles was done according to the established inclusion and exclusion criteria. Then it was reviewed by the supervisor. Duplicate articles were identified using the Mendeley reference tool and merged. Next based on their title and abstracts, the remaining articles were screened. As the combined keywords "SSI and food security outcomes" and "smallholders and food security outcomes" did not produce results, they were excluded from further screening (Tables 4.1 and 4.2). The systematic search revealed a research gap in the relationship between SSI, smallholders, and food security outcomes. Only 139 of 202 journal articles relevant to the thesis and suitable for analysis were screened in the primary stage. Finally identified 139 journal articles were further categorised into two based on the keywords. The first category includes all journal articles that have the key terms “small-scale irrigation” and “food security” as a single or compound word in their title. The second category includes all journal articles that have the key terms “rural smallholder” and “food security” as a single or compound word in their title (see Table 4.2)

The systematic literature review revealed a research gap in the relationship between SSI, smallholders, and food security outcomes. No results were found during the systematic literature review search on the impacts of SSI on food security outcomes among smallholders, using the combined keywords "SSI and food security outcomes" and "smallholders and food security outcomes" in the title of the journal (Table 4.1). Food security outcomes are multifaceted and can be understood by evaluating food availability, food accessibility, food utilisation and food stability concurrently; this gap in the literature is important. Therefore, more studies are required to fully understand the connections between smallholders, food security outcomes and SSI.

Table 0-2 Articles Excluded and included in the final screening stage.

No	Keywords used for searching	Identified at the initial screening stage	Excluded at secondary screening Stage	Included in the final analysis
	Category 1			
1	Small-scale irrigation	84	44	40
2	Small-scale irrigation Intervention	1	0	1
3	Small-scale irrigation schemes	30	16	14
4	Small-scale irrigation Technology	6	1	5
5	Small-scale irrigation AND Food security	6	1	5
	Sub Total	**127**	**62**	**65**
	Category 2			
1	Rural smallholders	10	0	10
2	Rural Food security	37	1	36
3	Food security outcomes	16	0	16
4	Smallholders AND Food security	12	0	12
	Sub Total	**75**	**1**	**74**
	Grand Total	**202**	**63**	**139**

Source: SLR, (2021)

4.2.4 Data Synthesis

The data extracted from journal articles that met the inclusion criteria and passed the screening process was analysed using Microsoft Excel. The articles were exported from the Mendeley library to an Excel sheet as an XTML file. Additional columns were added to capture missing information in the Excel sheet, such as region, country, objective/purpose, research design, research methods, data analysis method, data collection instrument/tools, sample size, sampling procedures/techniques and findings. The data were summarised and interpreted in a narrative report format. Descriptive statistics were used to analyse the distribution of journal articles by geographical location (i.e., regions and countries) and all methodological components. A graph was used to visualise the articles reviewed in the systematic literature review.

4.2.5 Analysis of selected works

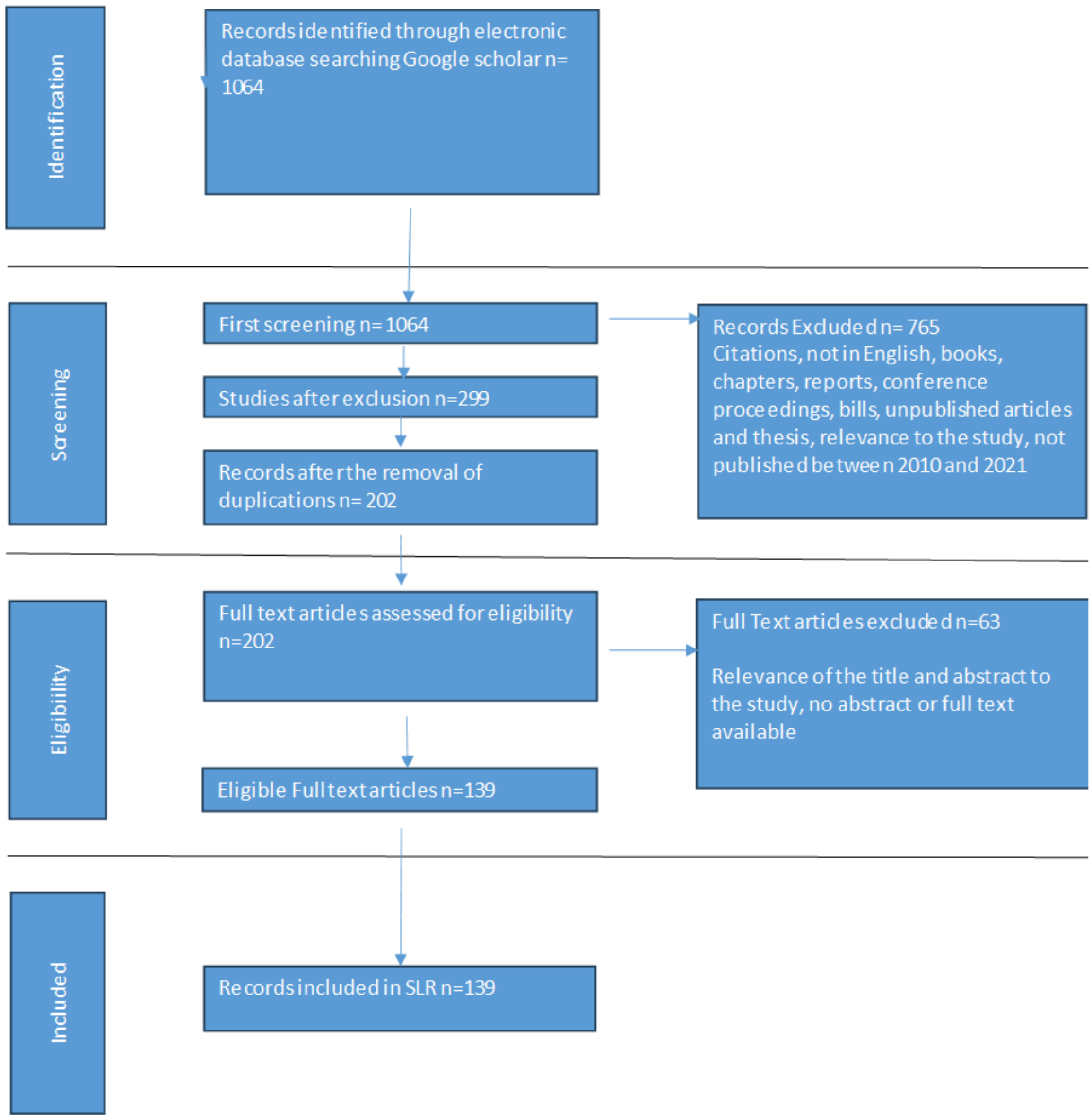
Descriptive statistics were used to analyse the selected studies. Charts, tables, percentages, and counts were used to interpret the findings of the literature review. Before analysing the research methodology components of these include previous research works, the geographic distribution and year of publications were analysed using descriptive statistics. The systematic literature review process was summarised in a flow chart (Fig. 4.1).

Table 0-3 Summary of included journal articles by region.

No	Region	Count of articles under category 1	%	Count of articles under category 2	%	Total count of articles	%
1	Africa	61	93.85	43	58.11	104	74.82
1.1	Ethiopia	35	53.85	7	9.46	42	30.22
1.2	Ethiopia plus	1	1.54	3	4.05	4	2.88
2	Asia	2	3.08	19	25.68	21	15.11
3	South America	0	0.00	3	4.05	3	2.16
4	North America	0	0.00	2	2.70	2	1.44
5	Australia	1	1.54	1	1.35	2	1.44
6	Europe	0	0.00	1	1.35	1	0.72
7	Africa and South America	0	0.00	1	1.35	1	0.72
8	Africa and Asia	0	0.00	1	1.35	1	0.72
9	Asia and North America	0	0.00	1	1.35	1	0.72
10	Global	1	1.54	2	2.70	3	2.16
	Sum	**65**	**100.00**	**74**	**100.0**	**139**	**100.00**

Source: SLR, (2021).

Figure 0-1 Flow chart of the systematic literature review process.



SLR= Systematic Literature review

4.2.6 Geographic distribution

The geographic distribution of the identified 139 journal articles was analysed based on the mentioned two categories. The first category consisted of journal articles that included the combination of key terms "SSI and food security" (n=65). The second category consisted of journal articles that included the combination of key terms "rural, smallholder and food security outcomes" (n=74) (Table 4.2). This categorisation allowed for a more detailed analysis of the results based on the specific key terms used in the journal articles. Journal articles identified in each category and total journal articles were analysed into regions (Table 4.3).

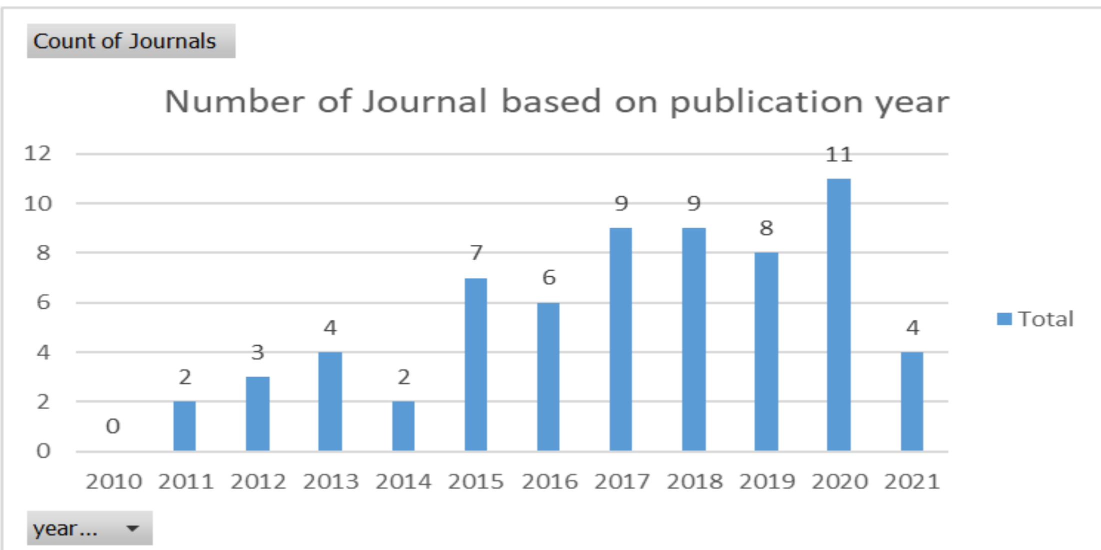
Creating sustainable availability and consumption of adequate and nutritious food remains a challenge in developing countries. Most studies focus on how food can be sustainably produced using irrigation technologies in developing countries. About 93.85% of the research conducted in the first group of journal articles (n=61) was carried out in Africa (as shown in Table 4.3). Fewer journal articles were published on the connection between SSI and food security in Asia (n=2) and Australia (n=1), with n=2/65 (3.08%) and n=1/65 (1.54%), respectively. This suggests that most Asian countries have already addressed the issue of food security for small farmers in rural settings using irrigation agriculture, and the researchers were not interested in further exploring this topic. The search yielded no studies in Europe, North America, or South America between 2010 and 2021 (n=0), suggesting that research in these areas has paused. To identify the issues and improve the viability, accessibility, and consumption of nutritious food at the household and community levels in Africa, more research is still required. This emphasises how critical it is to conduct additional studies to address the problems of sustainable food production in Africa.

Rural smallholder food security remains an important issue in Africa and Asia (as shown in Table 4.3) and is reflected in most journal articles (n=74) for analyses, of which 87.84% were from Africa and Asia (43 articles from Africa and 19 from Asia). Some studies compared the situation among smallholder farmers in different regions, including Africa and Asia (n=1), Africa and South America (n=1), and Asia and North America (n=1), as the concept of food security is multidisciplinary. This suggests that food security for rural smallholders remains a research concern in developing regions like Africa and Asia. In Europe (n=1), Australia (n=1), North America (n=2), and South America (n=3), few publications were recorded in the database. Sustainable availability and consumption of nutritious food at the household and community level is a concern for governments and researchers in Africa and Asia. SSI, smallholder farmers and food security are relevant topics in these regions.

4.2.7 Publication year

The first review group comprised 65 journals published between 2010 and the end of April 2021. The trend of publications on the selected key terms is increasing, with the highest number of publications recorded in 2020 (Figure 4.2). This suggests that research interest in the relationship between SSI (SSI) and food security is growing and that efforts to produce enough food to meet global demand and overcome production challenges are improving.

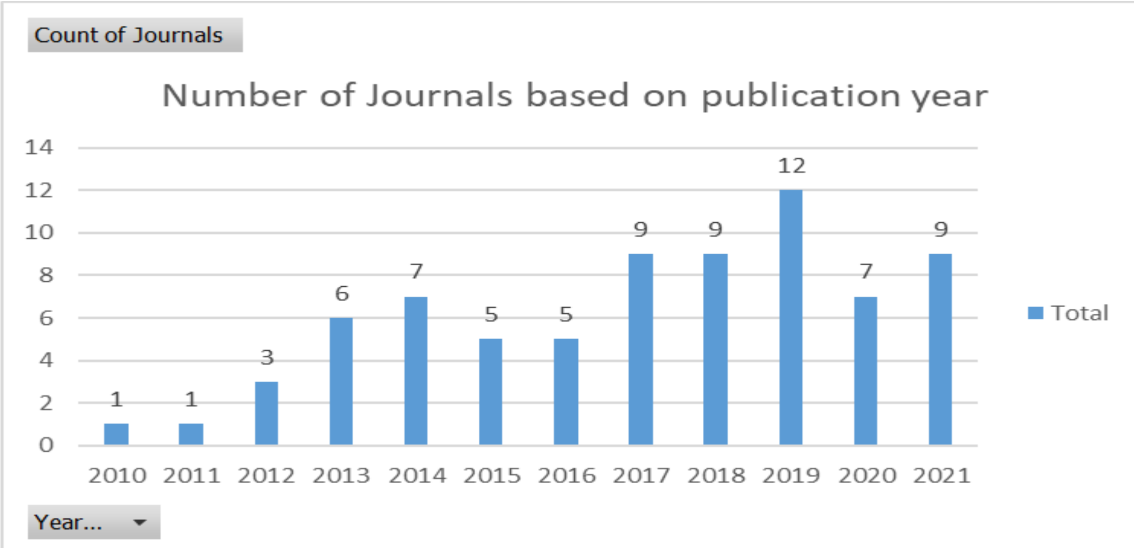
*Figure 0-2 Year of publication f*or the combined Small-scale irrigation and food security keywords.



Source: SLR, (2021)

For the combined key terms "rural, smallholders, and food security," there was a significant increase in publications since 2011 (as shown in Figure 4.3).

Figure 0-3 Year of publication for combined rural, smallholders, and food security *keywords*



Source: SLR, (2021)

4.3 RESEARCH DESIGN, METHODS, AND APPROACH

4.3.1 Design, method, and approaches.

The methodologies used in the 139 journal articles were recorded in an Excel spreadsheet and analysed in two separate parts of the thesis. The first part described and analysed all methodologies used to examine the relationship between SSI and food security (outcomes). The second part assessed methodologies that examined the relationship between rural smallholders and food security (outcomes). The gaps in previous methodologies were identified to understand the relationship between irrigation, rural smallholders, and food security outcomes. This research methodology was suggested to address these gaps.

The concept of irrigation is vast and can be described at three different levels: large, medium, and small scale. Studies choose one or two of these scales as a representative sample to assess the impact of irrigation and generalise a broader context. Articles analysed using qualitative, quantitative, and mixed methods were included in the analysis. Studies have used various research designs and methods to understand how irrigation affects food security variables. In the first category, cross-sectional (47.69%), case studies (10.77%), mixed cross-sectional and survey (7.69%), and review of the literature (6.15%) are the most used research methods to evaluate the effect of irrigation on food security (Table 4.4). For example, Mornah (2011) employed a case study approach to examine the impact of irrigation in two SSI schemes (Sankana and Daffiama) located in the Nadowli District of the Upper West Region of Ghana.

Table 0-4 Review research design findings for category 1 (*small-scale irrigation and food security key words)*

Research Design identified	**Count of Journal articles**	**%**
Case Study	7	10.77
Case Study and Social Survey	2	3.08
Cross-sectional and survey research	5	7.69
Cross-sectional and case studies	2	3.08
Cross-sectional	31	47.69
Experimental	5	7.69
Experimental and survey research	1	1.54
Exploratory	1	1.54
Literature review	4	6.15
Longitudinal	1	1.54
Narrative	1	1.54
Quasi-experimental	1	1.54
Systematic literature review	2	3.08
Exploratory and survey research	2	3.08
Grand Total	65	

Source: SLR, 2021

In the second category, 74 journal articles were examined to identify the research design used. The analysis revealed that mixed case study, cross-sectional, and survey research, cross-sectional, literature review, and exploratory designs were used at rates of 15 (20.55%), 10 (13.7%), 9 (12.33%), 9 (12.33%), and 8 (10.96%), respectively. Therefore, according to both categories, case studies, cross-sectional, cross-sectional, and mixed surveys, literature review, experimental, and exploratory designs were used higher.

Table 0-5 Review research design findings for category 2 *(Rural Smallholder and food security keywords)*

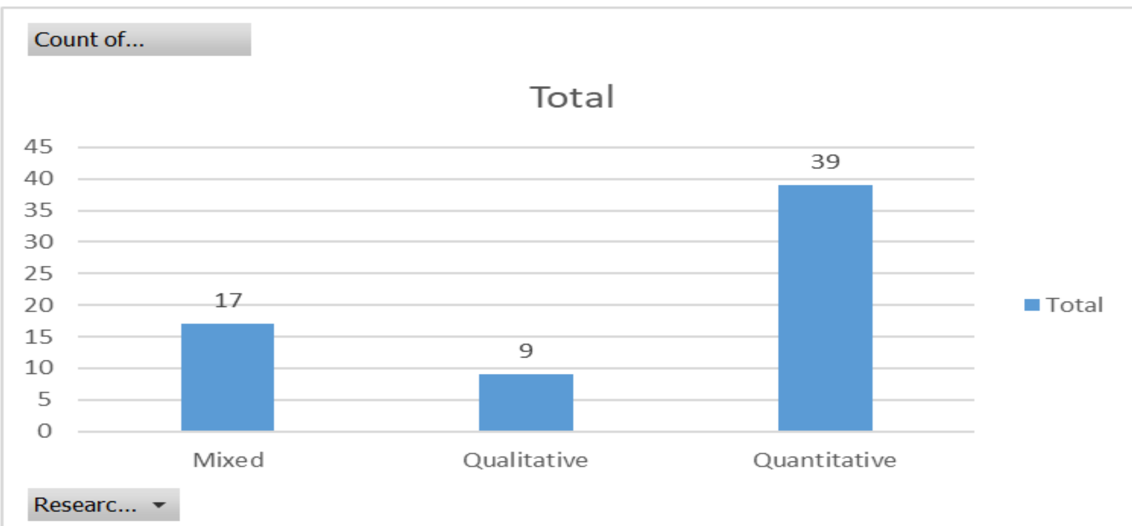
Research Design identified	Count of journal articles	%
Case Study	15	20.55
Cross-sectional	9	12.33
Cross-sectional and survey research	10	13.70
Experimental	2	2.74
Exploratory	8	10.96
Literature review	9	12.33
Narrative	1	1.37
Non-experimental, cross-sectional & Case study	1	1.37
Quasi-experimental	1	1.37
Longitudinal, case study, and survey research	1	1.37
Cross-sectional and case study	3	4.11
Literature review, exploratory and survey research	1	1.37
Exploratory and survey research	2	2.74
Exploratory, case study and survey research	1	1.37
Survey research and case study	6	8.22
Experimental and Case Studies	1	1.37
Systematic literature review	1	1.37
Longitudinal, and survey research	1	1.37
Grand Total	**73**	

Source: SLR, (2021)

The researchers implemented single or mixed designs and methods. Qualitative, quantitative, and mixed methods were used for the analysis according to their intention. For example, Mhembwe et al. (2019) used qualitative methods to examine the status of irrigation schemes, assess the need to rehabilitate, evaluate initiatives toward their revival, determine benefits for smallholder farmers, and discuss challenges faced in running SSI schemes in rural areas. Furthermore, Samsudin et al. (2016) conducted a qualitative study to gain an understanding of the agricultural sector as a source of livelihood worldwide.

Some researchers, like Wondimagegnhu and Bogale (2020), utilised only the quantitative method. However, others combined it with qualitative data collection tools. Adela et al. (2019) triangulated survey results with focus group discussions and key informant interviews. Adjei and Anlimachie (2020) also employed a mixed-method research design, combining qualitative and quantitative methods and primary and secondary sources of data. Gebru et al. (2019) used a mixed-method approach to identify determinants of participation in the vegetable business and its impact on food security. Furthermore, Chazovachii (2012), Gebrehiwot and Mesfin (2015) and M'nabea (2013) used a combination of quantitative and qualitative methodologies to investigate the impact of SSI schemes on rural livelihoods and food security. From the systematic review of the literature for the first category of journal articles, 39 (60%), 9 (13.5%) and 17 (26.15%) identified journal articles using quantitative, qualitative, and mixed methods, respectively (Fig. 4.4).

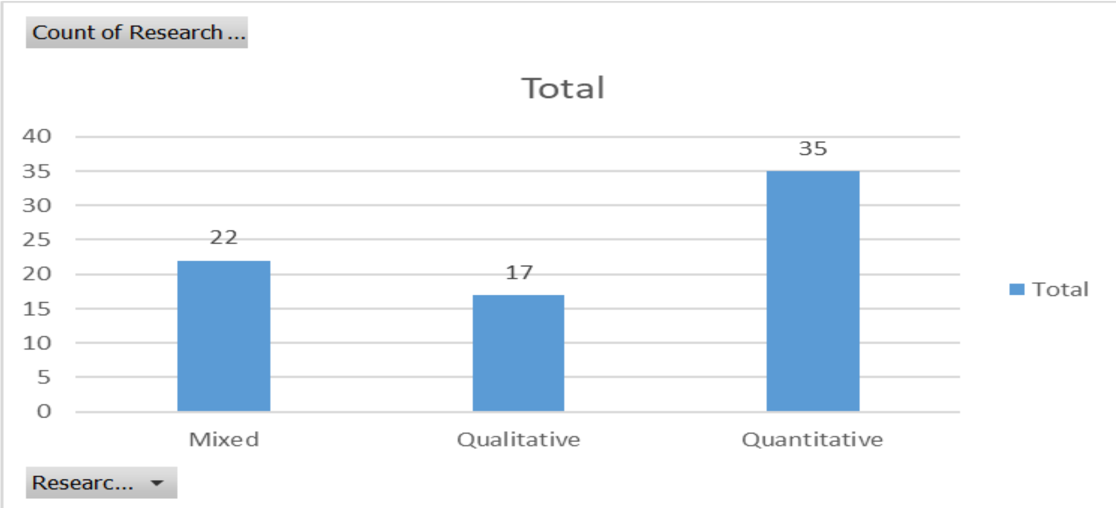
Figure 0-4 Review of research methods findings for category 1 *(small-scale irrigation and food security key words)*



Source: SLR, (2021)

For the second category, 35 (47.3%), 17 (22.97%) and 22 (29.73%) journal articles were done using quantitative, qualitative, and mixed methods, respectively (Fig 4.5). Therefore, from both categories 139 journal articles were published, 74 (53.24%), 26 (18.71%), and 39 (28.06%) were quantitative, qualitative, and mixed methods, respectively.

Figure 0-5 Review of research methods findings for category 2 *(Rural smallholders and food security keywords).*



Source: SLR, (2021

4.3.2 Application of research design, method, and approaches

This study used a mixed methods research design that involves the collection of quantitative and qualitative data from various interdisciplinary stakeholders. The assumption of the mixed method approach is to collect various types of data, providing a more comprehensive understanding of the research problem than relying solely on quantitative or qualitative data (Creswell, 2013). It also identifies effective practices and areas for improvement (Tomasi et al., 2018). In addition, this design encompasses philosophical assumptions that use of both qualitative and quantitative methodologies, and the integration of these approaches in a study gives comprehensive understanding of the intervention (Creswell, 2009).

Different research designs, including qualitative, quantitative, and mixed methods, are underpinned by paradigms that reflect the underlying beliefs of researchers about how information is generated and how change can be achieved. The issue of paradigm-method fit has prompted discussions about the philosophical foundations of mixed methods research and whether philosophical paradigms and research methodologies are aligned. This issue emerged in the 1960s and 1970s with the rise of qualitative research and the recognition of philosophical links between traditional post-positivist and naturalistic research (Migiro & Magangi, 2011; Revez & Borges, 2018)

Post-positivism is an approach that balances positivism and interpretivism, which were developed owing to the inadequacies of positivism as a paradigm (Creswell, 2009). Positivism assumes that there is only one objective reality that can be measured and understood without the influence of personal values (Panhwar et al., 2017). In contrast, interpretivism recognises humans as unique in producing greater depth in meanings and focuses on in-depth variables associated with a context (Alharahsheh & Pius, 2020). Post-positivism aims to incorporate the experiences of the majority and to announce conclusions that are deemed acceptable. Although post-positivism is more suited to quantitative research, interpretivism is more concerned with qualitative research (Park et al., 2020).

According to Creswell (2009), social constructivism is a qualitative research approach that is predicated on the idea that people try to make sense of the world and create subjective interpretations of their experiences. These meanings are varied and complex, and researchers should aim to explore multiple views instead of narrowing them down to a few categories or ideas (ibid.) According to this approach, learning occurs through experiences and reflection rather than solely through traditional classroom lectures (Dickson et al., 2019). On the other hand, objectivism, which holds that there is only one right way to understand any subject and that learning is characterised as a change in behaviour or cognitive processes, is the foundation of traditional approaches to learning and teaching that are based on behaviouristic and cognitive theories (Vrasidas, 2000). Most conventional methods of teaching and learning operate under these presumptions (ibid.).

In quantitative research, theory is used to explain or predict the relationship between variables, typically by evaluating an established theory through deduction. In contrast, qualitative research, such as ethnographies, also uses theory as a comprehensive explanation but emphasises theory creation "from the data" through induction. Mixed-method researchers, on the other hand, have the option of using theory inductively in qualitative research or deductively in quantitative research (Creswell, 2009; Heyink & Tymstra, 1993).

Qualitative data involves selecting and creating linguistic or visual material to understand social phenomena, experiences, and meaning-making processes. It is also used to describe structures and processes in routines and practices (Flick, 2017). However, quantitative research involves working with statistics or numerical data to quantify phenomena and determine relationships between variables (Stockemer, 2019).

The pragmatic paradigm is a philosophical basis for mixed-methods research that rejects rigid methodological frameworks and instead focuses on obtaining the necessary data to answer research questions using appropriate methods (Revez & Borges, 2018). Moreover, pragmatism asserts that individuals actively construct their world and that the meaning they derive from their experiences is the result of a complex relationship between received ideas and present experiences. The mixed methods approach, which looks to several methodologies for data collection and analysis rather than adhering to a single manner, is in line with pragmatists' rejection of the idea of absolute unity in the world (Maddux & Donnett, 2015). Furthermore, mixed methods studies may incorporate a postmodern turn that reflects social justice and political aspirations, since pragmatists acknowledge that research always takes place in social, historical, political, and other settings (Creswell, 2009). Therefore, the pragmatic paradigm, therefore, gives researchers the freedom to mix reflections obtained from respondents and generalise them by mixing appropriate methods.

In this study, mixed methods were employed because, as noted by Byrne and Humble (2007), each data gathering approach has limitations that can be mitigated or eliminated by combining them. It's also possible that each technique's advantages complement one another (ibid.). Due to their complexity, social phenomena require a variety of approaches to completely understand the situation (Byrne & Humble, 2007). Similarly, the role of irrigation in achieving food security outcomes is multidisciplinary and could vary in different contexts. Evaluating food utilisation and food stability dimensions comprehensively using only the quantitative method is difficult. Mixed methods allow the researcher to simultaneously answer confirmatory and exploratory questions and explain seemingly contradictory results that occur from diverse methodologies (Byrne & Humble, 2007). Therefore, the mixed-method approach enables a better understanding of both food availability and food access beyond quantitative assessment.

This research employs a mixed methods approach to analyse the role of irrigation in all dimensions of food security outcomes and fill the previous research gaps. The research employed a convergent parallel design, meaning that the quantitative and qualitative components were carried out concurrently, the methodologies were given equal weight, the two components were independently analysed, and the results were interpreted jointly (Demir, 2018). The case of participating and not participating in SSI is used to infer the improvement of rural smallholder food security outcomes of small-holder farmers. The study also utilises cross-sectional data for quantitative analysis and longitudinal data from the last ten years for qualitative analysis. Therefore, it mixes the longitudinal and cross-sectional research designs. The nutritional capability approach is used to analyse the role of SSI in the food security outcomes of small-holder farmers.

4.3.3 Sampling Procedure, Techniques, and Sample Size

4.3.3.1 Theoretical basis

Sampling is the process of picking a representative subset of a population to obtain consistent, unbiased estimates of the population status for research purposes and to save the researcher time and effort (Sapsford & Jupp, 2006; Showkat & Parveen, 2017). The research question, the study methodology, the size, and knowledge of the population of interest, the degree of similarity or difference for individual cases within the population, and time and/or financial constraints are some of the factors that need to be considered when choosing a sampling strategy (Elfil & Negida, 2019; Shorten & Moorley, 2014). As a result, non-probability sampling procedures can only be used to answer qualitative research questions;

probability sampling techniques can only be used to answer quantitative research questions (Berndt, 2020).

Probability and non-probability sampling techniques are further subdivided into other subsampling techniques. Probability sampling, also known as random sampling, provides the same chance of being included in the sample for every item in the population (Etikan & Bala, 2017). It includes multistage, cluster, systematic, stratified, and simple random sampling methods (Showkat & Parveen, 2017). Multistage, stratified, and simple random sampling are commonly used for quantitative household surveys (Elfil & Negida, 2019). Multi-stage sampling is used when constructing a sampling frame is difficult owing to the population size. If the population is heterogeneous, stratified random sampling is a helpful technique for gathering data (Singh & Masuku, 2014). This approach divides the whole heterogeneous population into several homogeneous groups, or strata, each of which is homogenous within itself. Units are then randomly selected from each stratum (ibid.). Furthermore, simple random sampling is where all elements have an equal chance of inclusion (Dixon & Leach, 1977). When the population of interest is large, probability sampling techniques are most effective, and sampling errors can be detected by choosing suitably large samples (Berndt, 2020).

Non-probability sampling is a sampling technique that does not offer a way to determine the likelihood that certain components of a population will be included in a study sample. Purposive sampling and expert sampling are two methods of non-probability sampling. Purposive sampling involves the researcher selecting participants who are most likely to provide the best information for the study's objectives (Berndt, 2020; Ebeto, 2017). However, within purposely chosen samples, probability methods can still be used, as in the case of place case studies (Dixon & Leach, 1977). Expert sampling involves the researcher gathering information directly from individuals or groups who are experts or have specialised knowledge in the study. Moreover, the sample is assembled based on the expertise or experience of the participants (Etikan & Bala, 2017).

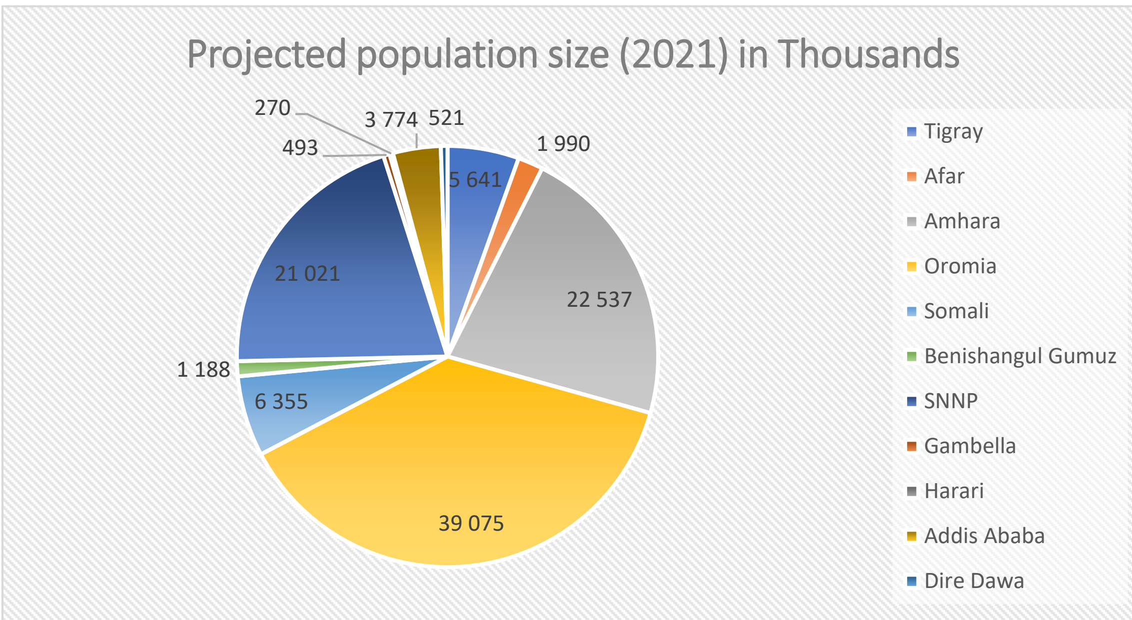
The reviewed studies (139) utilised sampling procedures and techniques, including multistage, two-stage, purposive and simple random sampling, etc. For instance, 25 (17.98%) studies have employed multistage sampling procedures, combining techniques such as purposive, stratified, cluster, convenience, and simple random sampling to select sample households (Gebrehiwot Yihdego, 2015; Sisay & Fekadu, 2013; Shono & Kibret, 2020). Eight others (5.76%) used two-stage sampling techniques, mixing random, stratified, systematic, proportional, and objective methods to select the sample. A two-stage Hackman sampling approach has been used in two out of eight research to choose peasant associations and then sample respondents (Aseyehegu et al., 2012; Mottaleb & Rahut, 2018). Simple random sampling, sometimes combined with purposive or stratified techniques, has been used to identify the final respondents in 34 (24.46%) studies. Purposive sampling, combined with random and stratified sampling, has also been used to select study areas, projects, and key informants in 44 (31.65%) studies. Stratified sampling (7.2%), with proportional, cluster, random, purposive, snowball, and systematic techniques, was used to differentiate strata or groups. Cluster random sampling (1.44%) was implemented to group similar categories into variable clusters. Three-stage sampling (2.16%), systematic sampling (6.5%), randomised control trial (0.72%), snowballing (0.72%), discrete sampling (0.72%), and randomised complete block design (0.72%), were also employed. Most studies combine non-probability and probability sampling techniques to collect data.

4.3.3.2 Application: Sampling procedure, techniques, and sample size

This study employed a mixed methods research design. Consequently, it involved both probability and non-probability sampling procedures. For the quantitative aspect, respondents were selected using multistage, purposive, simple random stratified, and sampling techniques. On the other hand, for sampling of study areas, selection of SSI schemes and qualitative respondents (FGD, KII and participatory observation), purposeful, snowball and expert sampling procedures were employed.

According to CSA (2007), Ethiopia is made up of nine administrative regions and two city administrations. However, in 2020, Ethiopia's government declared the Sidama Zone in the administrative zone of SNNPR as an autonomous region, and the western Ethiopia region (in 2021) was also separated from the SNNPR, bringing the total number of regions to 11. The number of city administrations remained the same. The SNNPR is now one of the 11 autonomous administrative regions in the country. The SNNPR was purposefully selected due to its potential for irrigation, population density per square kilometre and food security situation.

Figure 0-6 Population size of Autonomous Regions and city administrations in Ethiopia.



Source: CSA (2013).

In 2020, the country made changes to the other administrative zones and special districts of the SNNPR. The region had 13 administrative zones and 11 special districts during the 2007 census. Since 2020, some special woredas have been elevated to zonal administration status, while a few special woredas have been merged into existing zones. The number of zonal administrations and special woredas was reduced to 11 and 6 respectively. The Wolaita is one of these zonal administrations of the SNNPR, which was purposefully sampled among other administrative zones of the SNNPR owing to its potential for irrigation, high population density per square kilometre compared to the national average, very low average landholding (0.25 ha) compared to the national average (0.84 ha) and its reputation as a green famine (it refers to the situation when rural smallholders do not have food to eat even the area looks green) area (CSA, 2021; Rahmato et al., 2013; WZoFED, 2020).

In 2020, the number of administrative districts and municipal administrations in the Wolaita Zone was changed. Before 2020, Wolaita had 12 administrative districts and three town administrations, but it has now increased to 16 administrative districts and six town administrations. Five districts were selected from each agroclimatic zone (highland, midland, and lowland) based on the year of construction of the existing SSI scheme, the potential for irrigation, population density, and food security situation (Table 4.6). The study was conducted in five districts – Boloso Sore, Damot Gale, Damot Woyde, Abela Abaya and Humbo - out of 16 districts.

Table 0-6 Administrative districts, their area, and the demography of the Wolaita zone

No	Name of Administrative Districts	Administrative Districts			
		Area in sq. km	Population size	Population Density/km ^{2}	Number of kebeles
1	Boloso Sore	270.3	224,103	829	28
2	Damot Gale	216.7	152,968	706	26
3	Damot Woyde	203.7	123,411	606	20
4	Humbo	285.4	71,310	250	22
5	Sodo Zuria	168.0	118,341	705	16
6	Kindo Koysha	461.3	119,540	259	18
7	Ofa	308.5	107,174	347	14
8	Boloso Bombe	266.7	126,455	474	17
9	Damot Sore	173.4	120,571	695	21
10	Kindo Didaye	315.1	104,040	330	15
11	Damot Pulasa	167.2	152,780	914	22
12	Duguna Fango	433.3	139,847	323	26
13	Abela Abaya	465.4	56,081	121	14
14	Hobicha Abaya	216.0	55,044	255	9
15	Kawo Koisha	116.5	77,060	661	10
16	Baira Koisha	104.7	61,631	589	9

Source: - CSA (2007) and Wolaita Zone Finance and Economic Development Department 2018/19 Statistical Abstract (2019).

Small-scale irrigation scheme was selected from each sample district based on its construction year, as well as five peasant associations from each district. Peasant associations serve as the lowest level of government administration responsible for policy implementation. A kebele, or lower administration level, was purposely chosen from each selected district based on the existence of a small-scale communal irrigation scheme constructed by the government that has served the community for five to ten years. The available irrigation schemes were categorised into large, medium, and small scales before selecting the scheme (Table 4.7). For convenience in planning and development, the country has classified irrigation schemes into three categories: small-scale (<200 hectares), medium-scale (200–3000 ha) and large-scale irrigation (> 3000 ha) (Awulachew et al., 2004; Gebul, 2021). Therefore, in this research, SSI schemes refer to those cultivating a total command area below 200 ha, according to this categorisation.

To determine the sample size for quantitative research, researchers typically use formulas such as the Cochran and Yamane formulas, as well as sampling tables and calculators. On the contrary, for qualitative analysis, the determining factor is the point of data saturation. Data saturation is the state in which an appropriate sample size has been reached when no new problems or insights are found while the data are being collected and the data start to repeat (Hennink & Kaiser, 2022). The sample size for home surveys in quantitative research is calculated by a formula; nonetheless, the sample size grows at a decreasing pace with population growth and stays comparatively constant at little more than 380 instances (Krejcie & Morgan, 1970). Therefore, in both quantitative and qualitative research, data saturation is used to maintain a specific point in the study.

Table 0-7 Available irrigation schemes in Wolaita Zone Districts

No	Name of Districts	Name of Irrigation scheme	Year of construction	Command Area (in ha)		Irrigation Type		
				Designed	Actual	Large scale	Medium scale	Small scale
1	Boloso Sore	Ethana	2012/13	60	50			x
		Woybo	1993/94	90	95			x
		Soke	1998/99	90	173			x
2	Damot Gale	Damte	2006/07	80	43			x
3	Damot Sore	Bitite	1997/98	62	110			x
4	Damot Woyde	Bisare	1998/99	183.58	100			x
		Bedesa	1999/00	80	28.1			x
5	Duguna Fango	Bilate Eta	2005/06	586.62	627.77		x	
		Bilate Chericho	2001/02	859.17	701.64		x	
		Fango Bijo	2012/13	120	106.19			x
6	Boloso Bombe	Magera	1994/95	150	3.56			x
		Woybo	1993/94	190	10.5			x
7	Offa	Busha	2006/07	200	7			x
		Manisa	2000/01	200	50			x
		Moyo	2011/12	150	0			x
8	Kindo Koisha	Ongoto	2003/04	70	50			x
		Balia	2002/03	100	0			x
		Lefia	1996/07	500	0			x
9	Sodo Zuria	Kotegent	2007/8	60	10			x
		Chare Hamessa	2002/03	25.18	18.16			x
		Tando	2002/03	35	35			x
		Busha	2006/07	25	20			x
		Tekecha	2001/02	150	0			x
10	Humbo	A/Bisare	2012/13	300	0			x
		Ela	1993/94	180	200			x
		Lintala	2006/07	90	90			x
		Bosa	2006/07	100	100			x
		Lasho	1993/94	190	200			x
		A/Faracho	2007/08	0	100			x

Source: - Department of Finance and Economic Development of the Wolaita Zone 2018/19 Annual Statistical Abstract (2019).

The systematic literature review revealed that of the 139 included records, 27 journal articles on survey research used stored databases, online surveys and national census data for analysis, the maximum and minimum sample sizes were 68,323 and 408, respectively. For household surveys, the maximum sample size identified was 404 rural households (Mokari-Yamchi et al., 2020), followed by 402 respondents (Bjornlund et al., 2019). The maximum and minimum number of journals or documents reviewed by the systematic review were 115 and 1, respectively. Furthermore, the maximum and minimum number of key informants interviewed were 120 and three, respectively, while the maximum and minimum number of focus group discussions conducted were 15 and 1, respectively. Forty (40) studies reviewed were peer-reviewed (Bashir & Schilizzi, 2013), 40 involved smallholder interviews (Samsudin et al., 2016), and three rounds of interviews were conducted with a panel of experts composed of 27 academic faculty members in the fields of food security, agriculture, rural development, and executive staff (Ataei et al., 2021). Most of the research reviewed focused on one or two SSI schemes and one or two study areas to better understand the influence of irrigation on rural small-holder food security.

The goal of sampling theory is to create a subset of a population where each case has an equal chance of being chosen, which will correctly represent the population's variation (Yu, 2019). Statisticians have created mathematical theories, such as the classical and Bayesian theories of inference, for concluding information about a large population from a sample of data (Edwards et al., 1963). The theory of distributions and the principle of stable estimation are two of the tools used in Bayesian statistics (Edwards et al., 1963). Precision and confidence/risk level are significant factors considered for sample size estimation, which can be estimated using standard error and represents the difference between the sample estimate and population parameters (Nanjundeswaraswamy & Divakar, 2021). The degree of variability in the population determines the required sample size for a given precision level, with larger sample sizes needed for more heterogeneous populations and smaller sample sizes sufficient for more homogeneous populations (ibid).

The study used the Yamane formula to determine the sample size for a quantitative household survey. The Yamane or Slovin formula was used widely by researchers to determine the quantitative sample sizes for finite populations (Madow, 1968).

$$n=\frac{N}{1+N(e)2}$$

$$n=\frac{361,408}{1+361,408\,(0.05)2}$$

$$=\frac{361,408}{1+361,408\,(0.0025)}$$

$$=\frac{361,408}{1+903.52}$$

$$=\frac{361,408}{904.52} = 399.56 \cong 400$$

Where: -

n = the number of sample households (user and non-user) required per selected peasant association,

N = the total number of rural households (user and non-user) that reside in the Wolaita Zone,

e = precision level (95%) or sampling error (0.05).

Based on the calculation of the sample size, the study determined that a total of 400 participants are needed for the household survey. The simplified Yamane formula was used, assuming a confidence coefficient of 95%, a population proportion of 0.5, and a sampling error of 0.05 (Adam, 2020). Researchers generally prefer Slovin's formula, which has some limitations, and the Yamane formula was deemed appropriate for this study (Ryan, 2013). The total population for the sample size calculation was taken as the number of rural households in the Wolaita Zone, which was determined to be 361,408.

The Cochran formula was used to determine the sample size for a confidence level of 95% and a marginal error of 5% for an infinite population size, which is 385 (Cochran, 1977). For a finite population using the same parameters, the Cochran formula and sample size calculator determined that the sample size should be 384 (Oakland, 1953). Other studies have also suggested similar sample sizes, such as Krejcie and Morgan (1970), who determined that a sample size of 384 is appropriate for a total population of 1,000,000. Yamane also indicated that a sample size of 400 is suitable for populations larger than 100,000. Therefore, the maximum sample size for infinite and finite populations using the Cochran and Yamane formulas is 385 and 400, respectively (Uakarn, 2021). This means that data saturation can be achieved with a sample size of 384 to 400 for quantitative household survey studies in a homogeneous community. Therefore, for the study population of 5,817 and 361,408 rural households, the sample size was determined to be 384 and 400, respectively, which is the maximum limit for data saturation.

To determine the sample size for each sample kebele of the study, the percentage share of households in each kebele was calculated based on the total number of households in all kebele. Then, the total sample size of 400 was divided proportionally among the households in each kebele. These households were further divided into two strata: SSI users and nonusers. Then, a proportionate stratified random sampling was conducted to select the sample households for each group, as described in Table 4.8. To identify these households, the researcher obtained a list of households in each peasant association from the kebele administration office through an official request letter, and a list of small-scale beneficiaries was obtained from each water user association.

Table 0-8 Sample size distribution of selected districts and Kebeles

		Kebele HH	% share	User HH	Sample size distributed		
					Total	User	Non-user
1	Boloso sore						
	Gurumo Koisha	1828	31.43	95	126	63	63
2	Damot Gale						
	Buge	478	8.22	83	32	16	16
3	Damot woyde						
	Adecha	1425	24.50	63	98	49	49
4	Humbo						
	Ampo koisha	1267	21.78	224	88	44	44
5	Abela Abaya						
	Abela Mareka	819	14.08	194	56	28	28
	Total	**5817**		**659**	**400**	**200**	**200**

Source: - Department of Finance and Economic Development of the Wolaita Zone, Annual Statistical Abstract (2019) and WZoWID (2020)

The study included sample households from both SSI users and nonusers using a simple random sampling technique. According to Showkat and Parveen (2017), simple random sampling is a technique for choosing a sample in which each element and every combination of components in the population has an equal probability of being chosen. One popular method is to number each element and choose samples of elements using a random number generator (Dattalo, 2009). The simple random sampling was conducted separately for users and non-users, and households with permanent government employment were excluded. This method ensures the reduction of bias in sample selection and enhances robustness by giving every individual an equal chance of being selected. In the study area, all households have equal access to rural socioeconomic services, except for the size of the landholding and the employment of the government. They share similar culture, language, policy privileges, infrastructure use, and autonomy to participate in developmental activities.

4.3.4 Data collection

4.3.4.1 Data Collection Process and Procedure

Household surveys, focus group discussions and key informant interviews were used to collect data. To fully understand the multifunctional nature of irrigation and its impact on food security outcomes, qualitative and quantitative data were simultaneously collected in the field, independently analysed, and then integrated. The gap could be solved by using more than one data collection method.

Data were gathered from primary and secondary sources, both quantitative and qualitative. Primary data was obtained from rural SSI users and non-users living in five selected kebeles. Secondary data was acquired by examining various articles in the journal and authorised survey reports in the sector. To compare the differences between users and non-users, cross-sectional data from the year before the data collection year were employed. As the year during which the field data were gathered, 2022 served as the reference year to calculate the cross-sectional data year. On the other hand, for qualitative analysis, data was collected using qualitative data collection tools from the start of the intervention until the data collection period. Structured and open-ended questionnaires and checklists were designed to collect quantitative and qualitative data. To ensure comprehension and correct interpretation of the questions, an officially certified organisation translated the questionnaire from English to Amharic and the local language, Wolaitigna. Before conducting the actual data collection, a pilot questionnaire was conducted to assess the understanding and precision of the responses of local farmers. During this pilot test period, certain words such as "vitamin food" and "micronutrient-rich foods" were identified as difficult for local farmers to understand. To address this, these keywords were translated by describing the available vitamins and micronutrients in the area. Furthermore, the term "food security" was found to be technically confusing for locals and was therefore translated to refer to the availability, access, and utilisation of enough and quality food. Focus group discussions were recorded using electronic devices and transcribed word for word. This process was supported by the researcher to clarify the notes taken during the discussion. Therefore, the recording, note taking, translation, transcription, and back-translation processes significantly assisted the researcher in getting the intention of the research described in each objective. The qualitative and quantitative data were collected by the enumerators and closely monitored by the researcher. In addition, policy documents from various sectors such as agriculture, marketing, cooperatives, health, and education, as well as reports related to agriculture, irrigation development, and food security were also examined. Systematically, the research also reviewed the methodologies used by previous researchers on the related topics. Finally, it has discussed the major findings of previous research, compared to the major findings of this research, and indicated the contribution to the existing knowledge. This confirms the validity, reliability/trustworthiness, and rigour of the inquiry.

4.3.4.2 Review of Data Collection Instruments

Journal articles that used qualitative or quantitative data collection methods, or a combination of both, to address the study questions were analysed as part of the systematic review of the literature. Table 4.9 provides a summary of these data.

Table 0-9 Review of data collection instruments used in previous studies

No	Data collection instrument types	Counts in journal articles	%
1	Household survey	45	32.37
2	HH survey Plus (FGD, KII, participants and field observation, field survey, transect walk, database source, and documents review)	44	31.65
3	Field survey	12	8.63
4	Field Survey plus (FGD, KII, database sources)	5	3.60
5	KII	3	2.16
6	KII plus (FGD, expert interview, observation)	4	2.88
7	Document review	13	9.35
8	Document review plus (peer review, FGD, observation)	6	4.32
9	Longitudinal survey data	1	0.72
10	National census data	3	2.16
11	Policy document	1	0.72
12	Online survey	1	0.72
13	Observation	1	0.72
	Grand total	139	100

Source: SLR (2021)

The findings of the systematic literature review revealed that the researchers used only household surveys (32.37%), comprising a mix of qualitative and quantitative data collection instruments (31.65%) to examine the relationship between SSI and food security outcomes, as well as the impact on smallholders. Document review (9.35%) and field surveys (8.63%) were also used. Among qualitative data collection tools Focus Group Discussions (FGD), and Key Informant Interviews (KII) were frequently used in conjunction with quantitative data collection instruments.

4.3.4.3 Quantitative data collection instruments of the study

Household Survey: Structured Questionnaires

A survey design is a way to gather a numeric description of opinions, attitudes, or trends of a population by studying a sample and aims to conclude the population based on the sample (Creswell, 2009). Household surveys use questionnaires to gather information from a sample of households, providing flexibility to the interviewer and allowing consistent questions to be asked (Gomez, 2010). This process involves using questions and prompts to collect data from the surveyed individuals. The quantitative data of the study was collected using a structured designed and adopted questionnaire. The study collected quantitative data by administering a structured questionnaire designed for interval and categorical variables. The first of the five sections of the questionnaire covers the social, economic, and demographic elements of the household. The second section concentrates on irrigation and food production, whereas the third section discusses irrigation and food diversity. The fourth part includes three acute food security outcome indicator questionnaires: the Household Dietary Diversity Scale questionnaire, the Household Hunger Scale Index Questionnaire, and the Household Coping Strategy Index Questionnaire. The fifth and final part covers other food security outcome indicators relevant to capability approach analysis, such as agriculture and non-agricultural assets, education, nutrition, health, drinking water, sanitation, and so on.

The structured questionnaires used in the study were pretested and adjusted based on feedback from non-sampled households. The questionnaires aimed to investigate the impact of SSI intervention on food production, food diversification and food security among rural smallholders in selected districts of the Wolaita Zone. The questionnaires included specific questions about the types of crops and animal foods produced, income generation, nutritional status, physical well-being, cognitive abilities, and other factors that affect the outcomes of sustainable food security. Furthermore, the questionnaires asked about the household's food consumption patterns, food insecurity and hunger experiences and coping strategies employed in times of food scarcity.

The household survey questionnaire was designed for 400 small-holder rural households. Only households that relied on rainfed and irrigated agriculture and other livelihood activities generated by farm activities and government support were included in the study. Households with additional permanent income sources, such as government work or other sources not related to rain-fed and irrigation farm activities, were excluded from the study.

Before starting the investigation, the researcher obtained permission to conduct the study in the Wolaita Zone, from the Department of Agriculture and Natural Resources, by submitting a request letter. Subsequently, the department approved the research to be conducted in each chosen district. The district agriculture offices then sent letters to the selected peasant association administration and agricultural offices. Once confirmed, the Kebele Administration and Agriculture Office received a letter of confirmation. A list of both users and non-users of the kebele was obtained from the kebele, which was verified by the kebele administrator, kebele manager, and agricultural development agent. Finally, potential participants were selected using the simple random sampling method from this list.

To improve the questionnaire's clarity and organisation, redundant questions were removed, and related questions were grouped into relevant categories or sub-sections of the modules. For example, all education and health-related questions were classified under their respective subsections. The time required to complete one questionnaire was determined, and it ranged from 60 to 90 minutes. Therefore, the questionnaire was redesigned based on the feedback of the pilot test. Then, the enumerators were recruited based on their educational background, previous experience, neutrality, and proficiency in the local language (Wolaitigna). Enumerators underwent a three-day training session on how to fill out the questionnaire, maintain ethical standards while communicating with respondents, and other relevant issues. After training, the questionnaires were distributed to the assigned enumerators in each sample kebele according to their sample size. Each enumerator also received the tools they needed, including bags, notebooks, pens, pencils, and erasers.

Enumerators described the research for respondents before data collection and confirmed their consent. The research aims, information about the researchers, the confidentiality of their information, and the voluntary nature of their involvement were then briefly explained to the randomly selected rural smallholders, both users and non-users. They were also asked to sign a consent form after reading an information leaflet describing the study details. Data collection only began after potential participants had been thoroughly informed about the study and given their informed consent by signing the informed consent form. The data collection process using this structured questionnaire was conducted in one round within 45 days from November 14 / 2022 to December 31 / 2022 and the researchers conducted a rigorous follow-up to maintain a high-quality data collection. In the first week, the completed questionnaires were reviewed for errors and any missed questions were filled in. This process continued throughout the fieldwork until data collection was completed.

One major challenge encountered during the data collection process was that sometimes respondents were not available in their homes. In such cases, another appointment was made to review those households and complete the questionnaire.

4.3.4.4 Qualitative data collection

Focus Group Discussion:

Focus group discussion (FGD) was used as a tool to understand the complexities of early intervention and gather subjective meanings of experiences (Ndinda et al 2007; Ndinda et al., 2017). In contrast, focus group interviewing involves a series of meetings with participants who share similar research interests and generate qualitative data through discussions focused on a topic determined by the research purpose (Ndinda et al., 2007; Rajasekar et al., 2006). The constructivist ideology emphasises the importance of individuals experiencing and reflecting on things to develop their understanding and knowledge of the universe (Ndinda et al, 2007; Kamberelis & Dimitriadis, 2005). Focus groups offer a fruitful method for exploring the complexity of views and meanings, rather than categorising them into a few ideas (Ndinda & Adebayo, 2021). The use of focus groups in qualitative research is grounded in this philosophy and provides a unique way to examine early intervention (Ndinda & Ndhlovu, 2016).

The total sample size of FGDs varies according to the purpose of the investigation. Reviews and textbooks in the literature show that recommendations can range from 2 to 40 focus groups. Empirical research data suggests that data saturation is typically reached within a narrow range of 4-8 focus group discussions, particularly when the study population is relatively homogeneous and the research objectives are narrowly defined (Ndinda et al, 2007; Ndinda & Adebayo, 2021; Guest et al., 2017; Hennink & Kaiser, 2022). However, within each FGD, data saturation can be reached with 6 to 12 participants within each theme and subtheme from each member's experiences (Ndinda & Ndhlovu, 2016; Ndinda & Adebayo, 2021; Fusch & Ness, 2015; Lasch et al., 2010; Onwuegbuzie et al., 2010). Other scholars suggest that focus group size can range from seven to ten individuals and can be small or large, depending on the research topic and purpose (Ndinda et al, 2007; Ndinda & Ndhlovu 2016; Ndinda & Adebayo, 2021; D'Amato, 2008; Kamberelis & Dimitriadis, 2005). The size of focus groups and participants needed for a study depends on the level of data saturation required.

The study used a stratified snowball sampling method to select participants for FGDs. SSI users were divided into male and female groups, and study participants for each group of FGD were selected based on age categories ranging from 18 to 24, 25 to 34, 35 to 54, 55 to 64, and above 65 (Ndinda & Adebayo, 2021; Ndinda & Ndhlovu, 2016). Two participants were selected from each age category, resulting in ten to 12 participants per FGD during data collection (Ndinda & Adebayo, 2021; Ndinda & Ndhlovu, 2016). Two FGDs were carried out in each district, for a total of ten homogeneous FGDs throughout the study. The number of participants available during data collection is presented in Table 4.10. There were 116 participants in all the FGDs conducted.

Table 0-10 Focus group members at different age groups between sample districts.

Age Group	Damot Gale		Abela Abaya		Boloso Sore		Humbo		Damot Woyde		Total
	M	F	M	F	M	F	M	F	M	F	
18-24	2	2	2	1	2	2	1	2	2	2	
25-34	2	2	2	2	2	2	2	2	2	2	
35-44	2	2	2	2	2	2	2	2	2	2	
45-54	2	2	2	2	2	2	2	2	2	2	
55-64	2	2	2	2	2	2	2	2	2	2	
>65	2	1	2	2	2	2	2	2	2	1	
Total	12	11	12	11	12	12	11	12	12	11	116

Source: FGD, (2022)

The FGDs are based on topics supplied by the researcher and rely on the interaction within the group (Ndinda et al, 2007; Ndinda & Ndhlovu, 2016; Krejcie & Morgan, 1970) The topics included in the FGD checklist and attribute forms (Ndinda & Adebayo, 2021) cover areas such as the role of irrigation on crop production, distribution of crops, availability of food, animal production, dietary diversity, consumption pattern change, income generation, health status, children schooling and performance, diversity of employment opportunities, individual interaction and community participation, food price change, farm and non-farm asset, access to health, credit and finance services, hygiene, water, emergency of other development initiatives, sustainable availability of food, adoption of new agricultural technologies, coping strategies and factors affecting rural smallholder food security.

The Focus Group Discussions (FGDs) were facilitated by a coordinator and note taker who were selected based on their experience in conducting FGDs, their understanding of the research topic, and their fluency in the local language spoken in the study area, known as 'Wolaitigna'. The study clearly defined the roles and responsibilities of the coordinator, facilitator and note-taker for FGDs. Training was provided to the coordinators and note-takers on the checklist items, their roles, and responsibilities, how to facilitate FGD and ethical considerations of the research. The necessary materials, such as video recording equipment, notepads, pens, and pencils, were provided to them. The discussions were held outside the kebele office in a comfortable location. To obtain permission to conduct the research, the district administration office provided a confirmation letter to the kebele administration office, who then coordinated and facilitated the participation of the male and female groups using snowballing methods within their respective age categories during their weekly meetings. Respondents who had already been screened in the household survey were not included. The kebele administrator or manager arranged the date of the discussion, which lasted from one and a half to two hours. Audio and video recordings were made during the FGDs. Totally ten recordings i.e. five recordings from each male and female group were done. To maintain the confidentiality of the identities of the participants and the information shared during the discussions, each study participant was assigned a number from 1 to 12 to use during FGDs. The assigned numbers (pseudonyms) were used when reporting the research findings in the thesis to ensure participant anonymity and maintain confidentiality of the information shared during the FGDs.

Each data collection began with participants filling out a private and anonymous attribute form outlining their traits. On this form, information was requested about the respondent's home address, gender, age, current living situation, family size, number of children, education level, language spoken at home, religion, sources of income, and employment status. The research assistants helped facilitate this process and the participants were willing to have the assistants help them fill out their information.

Participants were invited to participate in focus groups after meetings with the kebele committees, during which the purpose and objectives of the study were explained. To be eligible, participants had to be 18 years or older. Furthermore, participants' permission to take part in the conversation was requested and confirmed before data collection. A facilitator used open-ended questions and a checklist to regulate data collection. A note taker was present to record the ideas presented by each participant using their pseudonym, and the discussion was recorded electronically. This approach allowed the researcher to capture any ideas that were missed during the notetaking and fill in any gaps. The notes also facilitated the identification of participants by their pseudonyms during transcription. The FGD recordings were transcribed verbatim in the local language.

To ensure the reliability and validity of the data, the transcribed Amharic texts were submitted to an independent organisation that specialises in certified translation and transcription. This organisation was responsible for verifying the accuracy of the transcription and translating the text into English. Additionally, the researcher used an online translation application from Amharic to English to compare the translations provided by the organisation. This approach helped identify and preserve the original words of the participants which contributed to ensuring the reliability of the translations. Afterwards, the data were subjected to a cleaning process that involved comparing the meaning of the Amharic text with the English translation, explaining any terms that required clarification, and providing contextualisation. Then the researcher reviewed the transcripts, and the textual data was thematically analysed. The researcher finally took the task of coding and categorising the themes and interpreting the findings.

Key informant interviews

The key informant interview was conducted using open-ended questions. The use of key informants in qualitative research is becoming increasingly common in social science investigations (Ndinda& Ndhlovu, 2016; Ndinda et al, 2018; Marshall, 1996). Key informant interviews involve speaking with a small group of individuals who are knowledgeable about a particular topic (Ndinda et al, 2018; Kumar, 1989). The researcher selected appropriate groups from which to draw the key informants and chose individuals who can provide valuable insights and information (Ndinda & Adebayo, 2021; Ndinda et al, 2018). Key informants are particularly useful for providing a deeper understanding of cultural practices and beliefs. As a result, they are considered important respondents in communities with diverse cultures and experiences.

Assessing data saturation is a crucial aspect in evaluating the quality of qualitative research, as it ensures that the data collected is sufficient to address the research questions (Ndinda & Adebayo, 2021; Kerr et al., 2010; Lowe et al., 2018). Saturation is the point during data collection and analysis when new data no longer provides additional information to answer the research questions (Guest et al., 2020). The recommended sample size for achieving saturation varies widely, ranging from five to 60 interviews, according to systematic literature reviews and textbooks on qualitative research methodology (Guest et al., 2006; Hagaman & Wutich, 2017). However, studies using empirical data have found that saturation can be achieved with a relatively small number of interviews (9-17), especially when the study population is homogeneous and the research objectives are narrowly defined (Ndinda et al, 2007; Ndinda & Ndhlovu, 2016). Key informant interviews typically involve 15 to 35 participants (Kumar, 1989). Therefore, researchers can consider a range of five to 60 respondents until data saturation is achieved, based on the existing literature.

The research participants were chosen through purpose- and snowball sampling methods at their weekly meetings (Ndinda et al., 2018; Ndinda & Ndhlovu, 2016). Community leaders were selected based on their knowledge and experience. Seven community leaders were selected from each of the five kebeles, resulting in a total of 35 team leaders. Additionally, agricultural office heads at the kebele level were interviewed, with five individuals selected from the sample kebeles. The heads of the agricultural office of the kebele level were purposefully selected to provide their expert opinions on the research topic. The study had a total of 35 key informants, and all interviews were conducted by the enumerators and the researcher. Enumerators were briefed about the open-ended questions in the checklist, ethical considerations, and their proficiency in the local language. Their experience in similar jobs was also assessed and confirmed.

Participants completed their attribute forms with the assistance of research assistants (Ndinda & Ndhlovu, 2016). The form included information about their place of residence, gender, age, current living situation, household composition, number of children, level of education, language spoken at home, religion, sources of income, and employment status (Ndinda & Adebayo, 2021). The agricultural officials of Kebele provided information on their place of residence, sex, age, job title, work experience, and education level through the attribute form. The community leaders were cooperative and willing to receive assistance.

The kebele administrator and the enumerators contacted the participants either in person or by telephone to inform them of their selection and request their consent to participate in the investigation. When the informants agreed to participate, interviews were scheduled with them, and a consent form was signed beforehand. The participants were also informed of the research objectives. The interviews were conducted in the office or in a location outside the office that was comfortable for the participants. Before conducting the interviews, confirmation was obtained from the kebele-level authorities to conduct research in the area. The head or delegate of the office then assigned an expert or relevant respondent for the interview.

Key informants requested their views and experiences on the role of irrigation on crop production, farmland fertility status improvement, crop productivity change, distribution of food crops, availability of food, animal production, dietary diversity, consumption pattern change, income generation, health status, children schooling and performance. They also alluded to the diversity of employment opportunities, individual interaction and community participation, food price change, farm and non-farm assets, access to health, credit and finance services, hygiene, water, emergency of other development initiatives, sustainable availability of food, adoption of new agricultural technologies, coping strategies and factors affecting rural smallholders' food security. Sectors relevant to the study were also identified using purposive sampling. To gain access to the offices directly involved and obtain confirmation for conducting the research, a written application letter was submitted. The selected sectors for primary data collection and secondary data provision are agriculture, health, education, and administration offices.

Document review

To capture the context and content of the policy and identify any gaps, the research used document review. Four policy documents were used, which focused on agriculture, irrigation, health, and education policies. These documents included both published and grey literature, such as annual and strategic departmental reports, guidelines, and programme materials. In addition, unpublished dissertations and conference papers were also included. The research did not perform an extensive document analysis but instead focused on reviewing current working policy documents related to the research topic. Secondary data from authorised organisations were used for analysis. Specifically, the documents of the rural development and water resource management policies were reviewed because they are currently active and relevant to the research topic. Additionally, two journal articles that reviewed rural development and agricultural policies from the emperor to the current government were evaluated. Given that small-scale farmers who practise mixed rain farming dominate the sector, reviewing these policy documents was deemed sufficient to understand policy issues, identify gaps and relate these issues to the research topic.

4.3.5 Data Analysis of the Study

According to the results of the systematic literature review, various software programmes were used for data analysis in both quantitative and qualitative studies. Examples included different versions of SPSS (Mokari-Yamchi et al., 2020; Nadeiwa & Koring, 2017), SPSS version 20 and MINITAB version 14 (Adams et al., 2020), Stata 13·0 and NVivo 10 (Ghattas et al., 2019), SPSS 16 and Amos 22 (Zamani-Alaei et al., 2018), and SPSS and Microsoft Excel 2010 version (Haule, 2015). Therefore, researchers commonly used SPSS for quantitative analysis and NVivo, Stata and Amos for qualitative data analysis.

In this study, initially, a systematic literature review was conducted, and the findings were analysed using descriptive analysis to understand previous research on the topic in various concepts. Next, both quantitative and qualitative data were collected simultaneously, and analysed separately, and then the results were integrated and interpreted. To facilitate analysis, the latest versions of SPSS and Atlas-ti software were used.

4.3.5.1 Quantitative Data Analysis

The Statistical Package for Social Sciences (SPSS) software was used to analyse quantitative data. The data were coded and entered into the software. For interpreting the results, descriptive and inferential statistical techniques were employed, such as frequency distribution, mean, percentage, variance, covariance, standard deviation, t-test, bivariate correlation, and correlation matrix. The mean difference for selected variables was compared using an independent sample t-test between users and non-users. Moreover, a multinomial logit model was used to identify the factors that influence the outcomes of sustainable food security in rural smallholder households. Additionally, multivariate regression was performed on independent variables and each of the three food security outcome indicators HDDS, HHS and HSCI as the dependent variable. The determinant variables were identified, and the results were interpreted for each of the three acute food security outcome indicators. Finally, the mean score of the three acute food security outcomes indicators was compared between SSI users and non-user's groups.

4.3.5.2 Review of analysis methods in previous studies

Data analysis methods used in previous studies

Various data analysis methods were used to identify the contribution of irrigation to food production and diversity. Ohikere and Ejeh (2012) assessed the impact of SSI technology on crop production, which is a single concept of food security, using the Farm Budgeting Model, Farm Production Model, Linear Programming Model, and descriptive statistics analysis. However, Usman (2015) used multiple regression statistical tools along with descriptive statistics to identify the effects of SSI technologies on crop output yield, factors influencing adoption, and limitations of SSI technologies, despite the linear relationship. Similarly, Gebrehiwot and Mesfin (2015) used multiple regressions and Pearson's correlation (r) to assess the role of SSI in promoting agricultural production and food security. These studies show the use of econometric statistical techniques to examine the effects of SSI methods on agricultural production and food security, including multiple regressions, linear programming, and descriptive statistics. The adoption of SSI was treated as an independent variable, while the total crop output from irrigated and rainfed agriculture was considered the continuous dependent variable.

Passarelli et al. (2018) used the HDDS and the results of a simultaneous equation (3SLS) model to investigate the potential of SSI to enhance dietary diversity and identify the pathways through which irrigation affects the diversity of diets. To investigate the impact of irrigation on food diversification among small farmers, this research used descriptive statistics and an independent sample t-test. It compared the mean difference in the dietary diversity score between SSI users and non-users. The researcher calculated the HDDS for both groups and conducted an independent sample t-test. The dependent variable, HDDS, is continuous, while the independent variable is categorical and indicates whether the farmer is using irrigation or not.

Review of analysis methods used to assess food security.

Previous studies have used various analytical methods to evaluate the food security status of the world, regions, countries, and individuals. Among these methods, the prevalence of undernourishment (PoU) is used to provide an overview of the food security status of regions, countries, and the world by identifying populations with insufficient dietary energy consumption. To measure the relationship between any rural development activity and its contribution to the food security status of individuals, Baiyegunhi et al. (2016) used the Household Food Insecurity Access Scale and the Tobit regression model to investigate the relationship between mopani worm consumption and household food security. Similarly, Yahaya et al. (2018) investigated the relationship between household food security in Northwestern Ghana and involvement in sustainable agricultural intensification techniques (SAIP) using the Household Food Insecurity Access Scale and an endogenous treatment effects model. This suggests that the Household Food Insecurity Access Scale was employed in these two studies to evaluate food access.

In addition, a combination of methods was also used to assess the impact of participation in programmes and projects on food security. For instance, Doocy et al. (2017) employed child anthropometry, the HDDS, and the Household Food Insecurity Access Scale in addition to a community-matched strategy. Furthermore, the study employed descriptive statistics, including paired t-tests and analysis of covariance, along with bootstrap regression models, to assess the impact of Farmer Field School participation on agricultural production techniques, household food security, and child nutritional status. Similarly, Rivera et al. (2018) used the US Household Food Security Survey Module and covariates in mixed multiple linear regression modelling to examine the relationship between policy, systems, and environmental factors and improved household food security among low-income Indiana households with children after a direct nutrition education intervention of the Supplemental Nutrition Assistance Programme. Charoenratana and Shinohara (2018) also utilised the Food Security Survey Module and covariates in mixed multiple linear regression modelling to explore how land and legal rights impact agricultural production and income. Furthermore, to provide a quick evaluation of food insecurity vulnerability at the national level across a variety of climate change and adaptation investment scenarios, Richardson et al. (2018) adopted the Hunger and Climate Vulnerability Index methodology. To evaluate the efficacy of governmental initiatives, these studies have brought attention to supplementary techniques for measuring food security, such as the Hunger and Climate Vulnerability Index, Child Anthropology, and the HDDS.

The link between women's empowerment in agriculture and food security has also been investigated using different methods. For example, Swindale & Bilinsky (2006) analysed various aspects of household food and nutrition security and women farmers' empowerment using the HHS, HDDS, and logistic regression model. Similarly, Leung et al. (2019) used the Cooking and Food Provisioning Action Scale, Body Mass Index, United States Adult Food Security Survey Module, and linear models to investigate differences in dietary intake, food and cooking agency, and body mass index by food security status in a sample of college students at a large public Midwestern university. Researchers like Sibhatu & Qaim (2017) investigated the seasonal effects of market purchases and subsistence production on food security and dietary quality in smallholder farm households using the Household Consumption and Expenditure Survey (HDDS). Furthermore, Ahmadzai and Aryobi (2021) calculated food consumption scores and examined the correlation to identify factors that affect food security in the rural area of Paktia province, Afghanistan. Therefore, these reviews have expanded the range of analytical methods and highlighted measurements such as the HHS, Body Mass Index, United States Adult Food Security Survey Module, Household Consumption and Expenditure Survey, Cooking and Food Provisioning Action Scale, and Food Consumption Scores.

Data analysis methods used to assess the nexus between rural smallholders and food security outcomes.

The impact of various government intervention effects on rural food security outcomes was evaluated using different research analysis methods. According to the review, Addinsall et al. (2017) conducted a literature review on the relationships between agriculture, conservation and tourism and analysed the case of smallholders in rural Ni-Vanuatu and determined whether participation in tourism activities had contributed to improving the outcomes of conservation and food security outcomes by applying the Agroecology and Sustainable Rural Livelihoods

Framework. Similarly, Sandhu (2014) tried to comprehend how the National Food Security Act affected India's food security results. Using a methodology for measuring food security, he examined the history of the debate surrounding the right to food as well as the reasons behind the ongoing failure of food security results. Hence, these two works of literature have highlighted two frameworks, the Agroecology and Sustainable Rural Livelihoods Framework and the Food Security Measurement Framework, to measure the effect of policy-related issues on food security outcomes.

In addition, other analysis methods were employed to examine multiple intensification activities. Aseres et al. (2019) used three food security indicators simultaneously, namely, food availability, access, and utilisation, to assess the adoption of multiple sustainable intensification practices and their impact on food security among rural farmers in Ethiopia. They used a scientific model combination, whereby principal part analysis was employed for variable reduction without losing data, and a multinomial endogenous switching regression model was used to avoid endogeneity and self-selection bias, leading to a strong and consistent estimation. Similarly, Goshu (2015) integrated multiple indicators, such as the direct consumption indicator, the food consumption score, the access scale to household food insecurity, and anthropometric indicators, to analyse the link between household food security and child nutrition in the rural Gubalafto District of the programme, which is subject to drought. Therefore, since food security outcomes encompass more than one concept of food security, research has tried to include the act on three dimensions of food security outcomes.

In addition, to understand the multidisciplinary nature of food security, research has also attempted to blend qualitative and quantitative approaches. Limon et al. (2017) employed a mixed method approach to describe smallholder profiles and assess the four pillars of food security and coping methods among smallholders, applying the Food Consumption Score, thematic analysis, and multivariate analysis. They used multivariate analysis to define the characteristics of smallholders and calculated the food consumption score for each household.

Using thematic analysis, the qualitative step entailed constructing themes to characterise these smallholders' experiences. Similarly, Khalid and Schilizzi (2013) offered a conceptual model of food security based on three well-known components: food availability, accessibility, and use. They used a meta-analysis technique to determine which food security indicators have been identified and how well causation has been proven in Africa and Asia. Finally, they discovered that food availability is the most researched component in both regions, followed by food accessibility while food use is the least explored component in the studies they analysed.

Similarly, Nicholson et al. (2021) highlight the lack of attention paid to the other three dimensions of food security, namely access, stability, and use, in food security assessments using agricultural systems models. To bridge this disparity, they exhibited how three indicators of access—food consumption expenditures, a measure of food insecurity, dietary diversity, and their stability—may be integrated into two dynamic models of production systems: a dynamic household-level model of a maize-based system in the highlands of Kenya, and a dynamic regional model of sheep production and marketing in Mexico. They used hardness, or the capacity to withstand shocks, and elasticity, or the capacity to return to pre-shock circumstances, to examine how resilient food security outcomes were to shocks. On the other hand, Dam Lam et al. (2017) suggested a quick evaluation technique that uses household caloric intake to comprehend food security outcomes and encompasses food security across its four pillars: availability, access, utilisation, and stability. They took into consideration the situation of industrial crop expansion in SSA's smallholder environments. Additionally, Galeana-Pizaña et al. (2021) put up a conceptual model to determine the relationship between food availability, accessibility, and utilisation and the structure of agricultural systems in Mexico. At the national and ecoregional levels, they evaluated the modelling of the structural equation of rural food security. Nonetheless, they discovered that food utilisation had less of an impact on the simulated food security concept on both scales than did food availability and accessibility.

On the other hand, Dompreh et al. (2021) evaluated the food security outcomes of certification adoption among Ghanaian cocoa and oil palm smallholders using Propensity Score Matching and several standardised food security metrics, including the Food Consumption Score, the Household Food Insecurity Access Scale, and the Coping Strategies Index. Similarly, Balde et al. (2019) conducted an exploratory study to analyse the food security outcomes of small-holder-based oil palm and rubber production at the household level using six standardised food security parameters. The application of a set of metrics to evaluate the resilience characteristics of household livelihoods depending on important driving factors was also shown by Kasie et al. (2018). They based their assessment on resilience theory as applied to social-ecological systems with an application of modern portfolio theory. Therefore, these and the previously mentioned journal articles recommend integrating both qualitative and quantitative methods and use of a set of metrics that can assess the comprehensive nature of food security outcomes is better than using a single method and approach.

Data analysis methods to evaluate the nexus of SSI, small farmers, and food security.

Rainfed agricultural systems have become difficult to meet the global food demand owing to climate change and other considerations. The methods of production of rural smallholders have been made more sustainable through the development of a variety of water delivery devices. To address this, irrigation technology has been developed to improve the production and productivity of rural smallholders. To understand the impact of irrigation technology on food security, scholars have employed various analytical methods. For instance, Furi (2015) used conventional analyses and a logit model to assess the socioeconomic impact of SSI on users and nonusers. Ayele et al. (2013) also used a logit regression model to evaluate the effect of irrigation on household income. In addition, Habineza et al. (2020) extended their study by assessing the profitability of SSI adoption in farmers in the Nasho sector, Kirehe District in Rwanda using profitability analysis and cost-benefit ratio. Adela et al. (2019) identified the effect of accessing irrigation on poverty levels among farmers using the Foster-Greer-Thorbecke method, and they also used the endogenous switching regression model to assess the relationship between scheme governance, perceived water scarcity and access to information. Therefore, these four journal articles have used different research methods to study the impact of SSI on the broader concept of socio-economy and specific components of food security, such as income and crop production.

The Heckman two-step model is a popular choice among researchers studying the impacts of SSI on household income and food security. Aseyehegu et al (2012); Astatike (2016); Feleke et al (2020); Gebrehiwot (2015); Leza et al (2020); Sisay and Fekadu (2013); Shono and Kibret (2020); and Mottaleb and Rahut (2018) have all used this model, along with descriptive statistics and other techniques, to analyse various aspects of SSI. These studies have looked at the challenges and problems related to SSI, as well as the impact of participation on household income and food security. Therefore, according to these studies, it may be possible to understand the factors that influence household income and, more broadly, food security, using a combination of the Heckman two-step model, descriptive statistics, and other econometric models.

In addition to the aforementioned methods, the impact of SSI has also been analysed using descriptive and propensity score matching methods. Propensity score matching was found to be the second most popular method after Hackman's two-step model. Muleta et al. (2021) evaluated the effect of SSI on household food security using descriptive and econometric data analysis techniques. They measured the impact of irrigation use on household food security using the logistic regression model and the propensity score matching approach. In a similar vein, Dessale (2020) and Hadgu (2020) estimated the factors influencing irrigation participation and its effect on food security using the binary logit model and the propensity score matching approach.

Similarly, Temesgen et al (2018) assessed the effect of SSI on household income solely using the propensity score matching method. Similar techniques were employed by Ochieng et al (2015) and Zeweld et al (2015) to examine the effects of SSI on household livelihood and the role of staple crop commercialisation in food security in rural households, respectively. Furthermore, Gebremariam and Ghosal (2016) used the matching of the propensity score with the probit model to identify the determinants that affect the income from SSI. Legesse et al (2018) investigated SSI membership and its effects on household farm income and asset holding using propensity score matching and descriptive statistics. Ahmed et al. (2014) used logistic regression and propensity score matching to evaluate how irrigation improvements affected smallholder farm households' ability to generate revenue and level of food security. Thus, the impact of SSI on household income, asset holding, and food security status has been examined by the application of the propensity scores matching approach in conjunction with several econometric models, including the binary logit model, probit model, and logistic regression model.

In addition to the aforementioned methods, other regression models have also been used to understand the relationship between SSI, rural smallholders and food security. Similarly, Mango et al. (2018) used binary logistics with normal least squares regression to determine the impact of adopting SSI on income among small-holder farmers. However, Bjornlund et al. (2019) integrated Ordinary Least Squares regression with the probit model to explore irrigators' profitability.

Although different data analysis techniques were used to describe the effects of SSI on income and crop production, most of the articles in the journal (Agidew, 2017; Asayehegn, 2012; Anteneh Astatike, 2016; Belete & Melak, 2018; Gebremariam & Ghosal, 2016; Legesse et al., 2018; Leza et al., 2020; Han et al., 2019; Mohammed, 2016, Siraw, 2016) are more about food availability and pay little attention to food access and are biassed towards quantitative data and analysis.

M'nabea (2013) has used a mixture of Pearson's correlation and content analysis to determine the effect of SSI on household food security. Pearson's correlation analysis was also applied with the Food Consumption Score, a segmentation approach using cluster analysis. Multinomial regression models explore smallholder households' differentials based on these three phenomena and other factors that affect smallholder typologies (Adeniyi & Dinbabo, 2020). These journal articles demonstrate the various regression models that can be applied to understand the intricate connection between rural smallholders, SSI, and food security.

Few studies have looked at food security in a variety of dimensions, according to the systematic literature review, although a variety of food security measuring methods have been used in conjunction with econometric methods to understand the relationship between SSI and single variables or concepts of food security. However, recent research has tried to close this gap. For example, Wondimagegnhu and Bogale (2020) used the Household Food Balance Model, binary logit regression, and descriptive statistics to analyse the effect of SSI on the food security of rural households. Similarly, Getinet and Lorato (2020) assessed households' food security and determined their livelihood options using the Household Food Insecurity Access Scale and descriptive data. Additionally, Shisanya and Mafongoya (2016) examined how small farmers adapted to climate change and how it affected household food security using the Household Food Insecurity Access Scale and descriptive data. Conversely, Passarelli et al. (2018) have expanded the scope of their study to examine how SSI affects nutrition as well as income and dietary variety. Similarly, Legesse et al (2018) have explored participation in SSI and its impact on household farm income and asset holdings. Despite these efforts, rural household food security remains a complex and important phenomenon (Bashir & Schilizzi, 2013).

Two key flows in modelling analyses linking agriculture to food security outcomes are revealed by Nicholson et al (2021) through their analysis of household and regional-level models: an overemphasis on availability indicators (which may implicitly assume improvements in the other indicators) and a lack of attention to the food security dimensions of access, utilisation, and stability. Consequently, the influence of SSI on enhancing all variables of food security outcomes is not thoroughly covered in the studies mentioned above.

It is not complete to understand the impact of SSI on food security outcomes by relying on a single concept, such as crop production and income. Furthermore, it would not provide a comprehensive understanding of irrigation using a single statistical method to describe all aspects of food security. As a result, these researchers have suggested that combining quantitative and qualitative data analysis methods can result in a deeper comprehension of the interdisciplinary nature of food security and irrigation. To gain a deeper understanding of the complex relationships between irrigation and food security, they advise conducting additional research on the non-linear interactions between independent and dependent factors. The research discovered that previous studies had neglected the interdisciplinary character of irrigation by focusing only on how it affected crop yield and profitability. It is not sufficient to understand the role of irrigation using only quantitative or qualitative data analysis methods. To create a more complete understanding, empirical data must be integrated with the irrigators' qualitative notions and experience. Moreover, food security is more than just agricultural productivity and revenue. Food availability, food access, food utilisation, and food stability are the four dimensions of food security, and they should all be measured in any government action aiming at improving food security outcomes. Proxy indicators for each of these dimensions must be implemented simultaneously to provide a complete understanding of food security outcomes.

Finally, this systematic review has found that multivariate regression analysis and metricizing multiple food security outcome indicators simultaneously could better describe the role of any agricultural interventions in food security outcomes. In a variety of ways, the use of several metrics can enhance the evaluation of food security outcomes results. Comprehensive evaluation: Because food security is a multifaceted concept, it is possible to evaluate its effects on all four pillars—availability, access, use, and stability—by utilising a variety of measures. Accuracy is increased by using various indicators that give a more robust and comprehensive view of the results of food security. Different metrics may capture different dimensions of food security, and the use of multiple metrics can help account for this variation. Identification of key factors: Using multiple metrics can help identify the key factors that contribute to food security outcomes. For example, if a household has adequate food availability but poor access to food, using multiple metrics can help identify this issue and provide insights into how to address it. Comparison across time and space: Using multiple metrics can facilitate comparisons of food security outcomes across time and space. The use of numerous metrics might provide a more nuanced view of the results of food security in various scenarios. Different metrics may be more appropriate for different contexts. By offering a more thorough, accurate and nuanced understanding of food security in various circumstances, the use of numerous metrics can, overall, improve the assessment of food security outcomes. Therefore, this study further recommends that researchers need to formulate a comprehensive methodological approach or model to understand the role of irrigation schemes in the improvement of rural people's food availability, food access, food utilisation, and food stability in a comprehensive way as outcomes of food security.

4.3.5.3 Application of data analysis techniques.

The role of irrigation in food security outcomes among smallholder farmers was examined using descriptive statistics, multivariate regression, and an independent sample t-test of three (3) indicators of food security outcomes, including the HHS, Household Coping Strategy Index (HCSI), and HDDS. Then it was inferred to users and non-users using an independent sample t-test. The three acute food security outcome indicators score was considered a dependent variable. The independent variables were categorical, and they are user and non-user groups of small-scale irrigation. Therefore, the selected predictor variables for the multivariate linear regression analysis were analysed to identify the actual determinant and their coefficient. Integrating these three food security outcome indicators simultaneously would give a better understanding than a single indicator. Therefore, this study would provide a new contribution to the existing knowledge.

I/ Household Dietary Diversity Score (HDDS)

To precisely document changes in HDDS over time, data collection should occur when food scarcity is at its peak (e.g., immediately before harvest). To avoid the effects of seasonal shifts, subsequent data collection (such as final evaluations) should take place at the same time of year. The study's findings were gathered between November and December of 2022. Which seasons did the research area experience food shortages? Recall Period: The previous 24-hour period should be used as a guide when collecting data on household food consumption. Since this indicator collects information about food consumed during the last 24 hours, the reference year for the data collected was 2022.

Longer reference periods yield less reliable information due to defective recall. A single 24-hour recall is typically adequate to quantify performance indicators of a program's overall influence over time when indicators are set as group averages, such as the average nutritional diversity of a target population's households (Swindale & Bilinsky, 2006). Before using the 24-hour recall approach, the interviewer should determine whether the preceding 24-hour period was "normal" or "usual" for the home. If the interview fell on a holiday, such as a feast or burial, or if most of the household was absent, an alternate day was selected. Therefore, the 24-hour recall method was used. During the fieldwork, the data collectors were trained not to take data on special occasions. Therefore, the data collected to compute HDDS was collected during the normal period and the 24-hour recall time.

HDDS was computed using quantitative data. By posing a sequence of "yes" or "no" questions to the respondent, the HDDS indicator data is collected. The person responsible for meal preparation was the target of the questions, or in case that person was not accessible, they were aimed at another adult who was present and had dinner with the family the previous day. The data for this study were collected from both persons. In this study, both women and men-headed households were interviewed (Table 4.11.). Therefore, according to the result, 18.2% of the respondents were female household heads who are responsible for food preparation. On the other hand, of the total of the respondents, 81.8% were male households, adults and ate the food in the household the previous day. The household, not any one individual, is the subject of the inquiries. The responder was asked to list the food types that comprised crops and animals that were either consumed at home by household members or were prepared at home and consumed outside the home (e.g., at lunchtime in the fields).

Table 0-11 Household survey respondents' gender category

	N	%	Valid Percent
Male	327	81.8	81.8
Female	73	18.2	18.2
Total	400	100	100

Source: Household Survey (2022)

Generally, HDDS is intended to reflect the average variety of dietary preferences in the household among all members. Individual members' purchases and consumption of food purchased and consumed outside the home may result in an overestimation of HDDS overall. However, survey implementers may choose to include non-home-cooked items if such consumption is frequent outside the home (Yohannes et al., 2002). Such judgments should be properly documented so that subsequent polls follow the same process and can be interpreted and compared correctly (ibid.). In this study, foods consumed outside the home are included and clearly documented during the survey and are interpreted during the analysis. Because food consumed outside of his finances indicates the income generated due to his farm activities and is related to the capacity of the household.

The amount of distinct food groups ingested throughout a specific reference period is indicated by the term "household dietary diversity" (Swindale & Bilinsky, 2006). It describes the diversity of crop and animal foods consumed in the home. The role of irrigation in increasing the capacity of small farmers to consume different crops and animal food was discussed. The capacity is related to the income generated due to SSI and autonomy of the household on the benefit of production and consumption of variable crop and animal food. These two concepts are incorporated into the HDDS. Rather than counting the number of distinct foods ingested, the number of different food categories consumed is estimated to better represent a healthy diet. For example, the knowledge that households eat an average of four different food groups suggests that there is some diversity in the macro and micronutrient composition of their diets. Compared to knowing that households eat four distinct foods, which could all be cereals, this is a more significant indicator (ibid).

The 12 food groups listed below were used to determine the HDDS indicator: A. Cereals, B. tubers and roots, C. Vegetables, D. Fruits, E. Poultry and meat, F. Eggs, G. Seafood and fish, H. Peas, beans, and nuts, I. Milk and dairy products, J. Fats/oils, K. Honey/sugar, L. Other things. A score of 1 (if consumed) or 0 (if not consumed) is given to each food group. The household score will range from 0 to 12 and is equal to the total number of food groups consumed by the household (INDDEX Project, 2018):

HDDS = sum (A+B+C+D+E+F+G+H+I+J+K+L)

The number of crop and animal food groups consumed from their farming activity and purchase was used as the independent variable while HDDS is considered as the dependent variable. Respondents are asked to answer a 'yes' or 'no' questionnaire. The variables were continuous.

Despite long-standing attempts to promote global food security, food insecurity and its physical implications remain a persistent problem in resource-poor places around the world. Therefore, creating accurate metrics for food insecurity is one of the first steps toward tackling it head-on. Without accurate measurement, it is hard to plan interventions, track and assess policies and programs, or draw lessons to make such initiatives more successful in the future (USAID FANTA Project, 2011). Several know-how measuring methods have been developed around the world to measure food security outcomes. However, although many measuring methods have been developed, very few are commonly used by scholars. Analysis of the systematic literature review has indicated that most scholars implemented a single measure to determine the role of irrigation. However, this research considered three main indicators of food security outcomes together to measure the role of the intervention among small farmers in rural areas. HDDS is among these indicators of food security outcomes.

The construction procedures for the HDDS were described above. The mean of the HDDS for the study population was calculated as follows (INDDEX Project, 2018):

$$\frac{sum(HDDS)}{total\ number\ of\ household\ surveyed}$$

HDDS are generally accepted as proxies for food quality; they are most effectively employed in determining the calibre and nutritional content of foods consumed by individuals (ibid.). Therefore, it is used to describe the food availability, food access and food utilisation dimensions.

II/ HHS Score (HHSS)

The HHS is a new and straightforward indicator for measuring household hunger in food-insecure areas (USAID FANTA Project, 2011). Unlike other household food security indicators, the HHS was developed and approved specifically for use across cultural boundaries. This indicates that to determine where resources and programmatic interventions are needed, as well as to design, implement, monitor, and evaluate policy and programmatic interventions, the HHS generates reliable and comparable results across cultures and settings (Ballard et al., 2011; USAID FANTA Project, 2011).

The HHS module has three "occurrence" questions and three "frequency-of-occurrence" questions, covering a 30-day memory period (USAID FANTA Project, 2011). The respondent was initially asked if they had experienced a specific ailment (yes or no) and if so, how frequently (rarely, occasionally, or frequently). All the questions were specifically designed to focus on the hunger-specific experience of uncertain food access, while also being as broadly applicable as possible. The answers received turned into a constant gauge of hunger. Each of the six elements was given a score between 0 and 2, where 0 meant "did not occur," 1 meant "rarely and sometimes," and 2 meant "often" when the HHS was calculated as a continuous indicator. The total HHS, which varies from 0 to 6, represents the degree of insecure food availability and is calculated by adding the scores for each of the three questions (ibid.). The mean or average of the HHS for the study population was calculated by dividing HHS by the total number of households surveyed. The HHS is typically recognised as a proxy for the food stability dimension.

III/ Coping Strategies Index Score (CSIS)

The CSI is simple to use, quick to grasp and correlates well with more sophisticated measures of food security (Maxwell & Caldwell, 2017). A straightforward numerical score is obtained by asking a series of questions concerning how households handle a lack of food for consumption. The behaviour that people exhibit when they are malnourished is measured by the CSI. Individuals respond to food insecurity in different ways and develop coping mechanisms to deal with food shortages in the home (ibid.). These coping mechanisms are simple to see in action. Information on coping mechanisms can be gathered more quickly, easily, and affordably than actual household food consumption levels (Maxwell et al., 2003). It serves as a gauge for longer-term shifts in the state of food security as well as for tracking the effects of emergency actions (ibid.). As a result, frequency and severity data were integrated into a single score known as the CSI, which represents the level of food security in the household (Maxwell et al., 2003; USAID, 2008).

To determine the household response strategy index score, four primary procedures were followed. First, a list of consumption coping strategy behaviours described in the guideline was employed, together with sets of 'yes' or 'no' questions to capture people's basic consumption-related coping reactions to not having enough money to buy food or not having appropriate access to food in the research location. Second, during the seven-day recall period, each group was asked to rate the frequency with which the identified local behaviours had been utilised in the recent past. At the household level, the number of days or frequency was answered using numbers ranging from 0 to 7. Third, the degree to which each of these distinct coping mechanisms was deemed "severe." The frequency of a specific behaviour was weighted by the perceived severity of that behaviour at the household level, that is, the frequency was multiplied by the severity of each behaviour and was summed up across all the behaviours in the list that were derived for that location. The severity was classified or weighted using numbers from 1 to 4. In other words, all identified consumption coping strategies were classified from 1 to 4. The number '4' refers to very severe or more frequent, '3' for severe, '2' moderately severe, and '1' refers to the least severe or less frequent. This index yields a score that reflects the current and perceived future status of food security (Maxwell & Caldwell, 2017). A quick indicator of whether food insecurity is getting better or getting worse is changes in the index. Higher food insecurity is correlated with higher coping levels, which are indicated by higher scores. By dividing the Household Coping Strategy Index Score (HCSIS) by the total number of households surveyed, the mean of the HCSIS for the study population was determined. As a result, HCSIS is commonly accepted as a stand-in for food quantity; it is most useful for quantifying the amount of food ingested but does not offer information on the food's nutritional value (Maxwell & Caldwell, 2017). Therefore, it indicates food availability more than food access, utilisation, and stability.

Household scores for the aforementioned three food security outcome indicators were used to analyse the role of small irrigation in rural smallholder food security outcomes. Then the amount of crop produced, the value of the total livestock unit (TLU) of the livestock owned by the household, the number of crop and animal food groups consumed from purchase, and the amount of income generated from the sale of crop products and the amount of income generated from animals, animal by-products and non-production assets were considered independent variables and the aforementioned three household scores of acute food security outcomes were used as a dependent variable. These independent and dependent variables were analysed using a multivariate regression analysis model to identify the factors that affect rural smallholders’ food security outcomes positively or negatively and the role of SSI in food security outcomes. That is, equated as:

$$yi = \beta o + \beta 1\, Xi1 + \beta 2Xi2 + \beta 3Xi3 + \cdots + \beta 6Xi6 + \epsilon$$

Where: -

Y_i= HDDS/ HHS Score (HHSS)

β_o= intercept

β1, β2…, β6= the average increase of Yi per unit increases of X_i1, Xi2…, Xi6

X_i1= amount of crop produced

X_i2= Total value of livestock unit (TLU) of available livestock (owned)

X_i3= number of crop and animal food groups consumed from the harvest.

X_i4= number of crop and animal food groups consumed from purchase,

X_i5= amount of income generated from crop sales,

X_i6= amount of income generated from the sale of animals, animal by-products, and other assets

= residual standard deviation (error)

In HDDS regression, the regression of HDDS number of crop and animal food groups consumed from the harvest and purchase of the own farm was not included as an independent variable.

Analysis of factors that affect the outcomes of food security for rural smallholders.

A multinomial logit model was used to identify the factors that influence food security outcomes in rural small-holder households. The explanatory variables used in the study are farm size, education level, age, household size, sex, farming experience, extension service, irrigation access, total income earned from crop product sales, and total income generated from animal, animal by-products and other assets. Therefore, each of these explanatory variables was analysed towards the probability of HDDS, HHS and HSCIs categories. Finally, factors among explanatory variables that affect the outcomes of rural smallholder food security were identified.

Description of Variables

Throughout this study, three variable types were used. These are independent, explanatory, intermediate, and dependent variables (Table 4.6). They are used separately or together to analyse each objective of the study. First, the six independent variables (see Table 4.5) were analysed separately using three household scores for acute food security outcomes using multivariate linear regression. Finally, the result was interpreted using descriptive and inferential statistics for SSI users and non-users.

Table 0-12 Description of major variables used to analyse the role of irrigation in the indicators of food security outcomes under the econometric model.

No	Variables	Variable category	Variable type	Description of the variables
1	Total amount of crop Produced	Independent	Continuous	Total production throughout the year (all seasons)
2	Number of crop and animal food groups consumed from own production	Independent	Continuous	
3	Number of crop and animal food groups consumed from purchase	Independent	Continuous	
4	Total number of animals owned in Total Livestock Unit (TLU)	Independent	Continuous	All animals available at the household are converted to TLU
5	Total income earned from crop sale	Independent/ Explanatory	Continuous	Only from the sale of crops,
6	Total income earned from animals, animals	Independent/ Explanatory	Continuous	

No	Variables	Variable category	Variable type	Description of the variables
	by product and non-productive assets sale			
7	Total farmland size	Explanatory	Continuous	Includes only owned by the HH in the data collection year
8	Household Education level	Explanatory	Categorical	
9	Household Age	Explanatory	Categorical	
10	Household Sex	Explanatory	Categorical	
11	Household Farming Experience	Explanatory	Categorical	Household farm experience after marriage
12	Participation years to get any extension service	Explanatory	Categorical	
13	Irrigation access	Explanatory	Categorical	
14	Family Size (No of household members)	Explanatory	Continuous	All active labour force
15	HDDS	Dependent	Continuous	
16	HHS Score	Dependent	Continuous	
17	Household Coping Strategy Index Score	Dependent	Continuous	

4.3.5.4 Qualitative Data Analysis

The qualitative data collected was analysed using Atlas/ti 8 version software. Furthermore, previous journal articles were reviewed based on their concepts (Ndinda et al., 2018). Thematic analysis was used to analyse data collected through FGDs and key informant interviews. Textual data from the open-ended questions, checklist for FGD and KII, questions were categorised under each research question, and codes were assigned to each transcribed text. Similar codes were merged to form themes and then different themes were arranged according to their similarities to establish a network. The network among themes was then interpreted. The findings obtained from the systematic review of the literature, the review of documents and the qualitative analysis were mixed to interpret the general result, confirming the transferability and dependability of the results.

Reliability is important in quantitative and qualitative research and refers to consistency and replicability over time (Bashir et al., 2008; Lincoln & Guba, 1985). Credibility, neutrality, consistency, dependability, and applicability are frequently used to denote similar notions in qualitative research (Lincoln & Guba, 1985). In qualitative research, the word "dependability" is used to describe something that is closely related to the word "reliability" in quantitative research (ibid). Data validity may be affected by the researcher's presence, which can also have an impact on researcher bias and competence (Brink, 1993). Therefore, to improve reliability, data collection devices, statisticians, certified translators and transcribers are recommended for use in any inquiry.

To test the credibility of the research, triangulation was used by combining the findings obtained from a household survey, FGDs and key informant interviews. Participants in qualitative data collection methods were varied and experienced fieldworkers and statisticians were used to ensure the quality of data collection and analysis. To ensure voluntary participation, all respondents or participants were previously briefed. The bibliographic information of external participants was evaluated and described in detail before they participated in the investigation. In addition, recent research journals within the last ten years (since 2010) were reviewed and related to the findings of the research until its completion.

To maintain conformability, the research triangulated and related its findings to previous works. The participation of external personnel in data collection and statistical analysis helped reduce biases owing to the researcher, further ensuring conformability. The researcher monitored the household data collection process, collected completed data from field workers and acted as a coordinator in FGDs and key informant interviews to oversee the process.

The study evaluated the validity of the measurement tools chosen in terms of both internal and external validity. External validity was assessed to determine the tool's potential to reveal the conceptual framework and causal relationships in areas with different geographical and socioeconomic characteristics. The research considered significant resources that could be available and adaptable to different environments, geographies, and socioeconomic situations around the world. The study analysed the available natural resources that may be degraded in the future owing to population growth and climate change. To confirm transferability, the research was carried out in an area where surface water was used for irrigation and the average rural land size was below the African average of two (2) hectares (the study area had an average rural land size of 0.25 hectares).

The concepts of crop production, animal production, food diversity, dietary diversity, food availability, food access, food utilisation, food stability, income generation, and food security outcomes for rural smallholders were analysed using the findings of a systematic literature review. Furthermore, the factors that impact the outcomes of food security for rural smallholders and the efficiency and effectiveness of SSI were also reviewed. To provide further insight, photographs collected during the data collection period were included to illustrate important issues. Therefore, finally, by mixing quantitative and qualitative findings, the long-term effect of adoption and non-adoption of the SSI intervention was analysed in all four dimensions of food security using the approach of human development and nutrition capacity and contributing to existing knowledge (Table 4.13).

Table 0-13 Food security pillars, information, variables, and scales of the study

No	Food security pillars to be measured	Information	Variables (Independent, Intermediate, Explanatory and Dependent)	Scales
1	**Food Entitlement**			
	Food accessibility and Food stability	Endowment	Labour force (productive)	Interval
			Productive assets (livestock, other animals, land size, warehouse, farm implements, transportation assets)	Interval
			Wealth (Income from farm and non-farm, other non-productive assets)	Interval
			Membership	Categorical
		Exchange condition	Prices of food items	Interval
			Wages (payment from any off-farm activities)	Ordinal/Interval
			Prices of non-food goods and services (Health, education, transportation, agricultural inputs, and tools)	Interval
		Production possibilities	Skills gained	Categorical
			Technologies used (inputs, fertilisers, pesticides, herbicides or any other)	Interval
			Coping strategies	Interval/categorical

No	Food security pillars to be measured	Information	Variables (Independent, Intermediate, Explanatory and Dependent)	Scales
		Food stability Strategies	Adaptation (any farm activities)	Categorical
		Employment status	Types of employment	Categorical
		Individuals Autonomy	Right/ legal claim to public provisions	Categorical
2	**Basic Capability**			
	(Food availability + Food access + Food stability)	Being free from hunger	Quantity of food produced	Interval
			Food groups produced/ consumed	Interval
			Calorie's intake	Interval
			Sex /Age	Nominal/Interval
			Law/rules/norms	Categorical
			Climate condition	Categorical
			Frequency of natural disasters	Categorical
		Being educated	School enrolments	Interval
			Educational achievements	Interval/categorical
			Participation in Adult literacy courses	Categorical
			Participation in non-formal education programmes	Categorical
		Being in good health	Access to health services	Categorical

No	Food security pillars to be measured	Information	Variables (Independent, Intermediate, Explanatory and Dependent)	Scales
			Resistance to the main disease	Interval/Categorical
			Self-reported health status	Interval/Categorical /
			Access to drinkable water and sanitation	Categorical
		Being able to take part in HH decision-making & community life	Participation in household decision-making	Interval/Categorical
			Participation in community life	Interval/Categorical
3	**Capability to be food secure**	Being free from hunger	Described Above	Described Above
	Food availability + Food access + Food stability + Food utilisation	Being Educated	Described Above	Described Above
		Being in good health	Described Above	Described Above
		Individual Autonomy	Described Above	Described Above
		Food Utilization	Diet Quality consumed	Interval
			Diet Diversification consumed	Interval
			Nutrition knowledge	Categorical
			Hygienic practises	Categorical
			Culture and religious beliefs about food products	Categorical

Source: Sen (1976, 1997) adopted by the author

4.4 ETHICAL MEASURES

The researcher explained to each participant the protection of personal information as outlined in Act No. 4 of 2013 (Protection of Personal Information that discloses the necessity of how access was gained). Participants were informed about their privacy and the voluntary participation, with no penalty or loss of benefit for nonparticipation. They were given the option to withdraw at any time without giving any reason if they needed to. The confidentiality of the information shared was emphasised and participants were informed not to expect any special benefit beyond contributing to the scientific knowledge on this topic. Data collection was consistent with the university's COVID-19 guidelines. Before beginning data collection, confirmation of the COVID-19 alert level was obtained in the Wolaita Zone and approval for research was obtained from the local health sector authorities. Data collection was only carried out if the researcher, co-workers, and participants felt well and did not exhibit any symptoms of COVID-19. Participants were selected prior to contact with the researcher.

This study approved by the Unisa Research Ethics Committee (REC) and approved, reference number 64142280_CREC_CHS_2022 (see Appendix 1). Participants were also informed of their right to express any concerns about the research processes, as well as to obtain information about the final research findings.

4.5 SUMMARY

This chapter addressed validity, reliability, conformability, transferability and rigour of the inquiry:

Validity: Systematic literature review to understand existing knowledge gaps. Triangulation of quantitative and qualitative data from different sources (survey, FGDs, KIIs) with different participants. External participants are involved in data collection and analysis to reduce bias. Tools adapted from existing literature and evaluated for internal and external validity. Conceptual framework and relationships assessed for transferability to other contexts. Tables/figures/Photographic evidence supported interpretations.

Reliability: Experienced fieldworkers, statisticians, and translators involved in data collection and analysis. Data collection tools were pre-tested and revised based on feedback. Training provided to fieldworkers on data collection procedures and ethical issues. Transcripts were verified by third-party translators and transcription services were also secured. Data collection was closely monitored, and incomplete data was retrieved. Audio/video recordings and notes taken during FGDs to ensure accuracy.

Conformability: Findings triangulated with previous literature. External personnel are involved in data collection and analysis to reduce bias. The research process and methodology are described in detail.

Transferability: Study conducted in a context like other areas (rural smallholder farmland size, water source availability, population density, food insecurity). Concepts analysed through established frameworks for wider application. Significant resources and themes were assessed for different environments.

Rigour: Participants provided informed consent and anonymity was maintained. Quantitative and Qualitative data were analysed using software. Codes/themes were developed for qualitative analysis. Quantitative and qualitative findings mixed to interpret results. The research methodology, tools and analysis process are described in detail. Findings triangulated with previous literature. Tables/figures/Photographic evidence provided to support interpretations. Results are interpreted through established conceptual frameworks. Process contributed new knowledge to existing literature. Ethical clearance certificate was confirmed by the Unisa Research Ethics Committee. The study applied multiple strategies to enhance the trustworthiness of findings through establishing validity, reliability, minimising bias, enabling transfer to other contexts and rigorously following ethical standards and analytical procedures.

CHAPTER 5: FINDINGS

THE ROLE OF SMALL-SCALE IRRIGATION ON FOOD PRODUCTION IN WOLAITA

5.1 INTRODUCTION

This chapter presents the findings of SSI in food production. It describes the socio-economic status and the role of SSI in food production among smallholder farmers. The chapter presents and interprets findings on the role of SSI in improving crop production at the household level in the Wolaita Zone, southern Ethiopia.

5.2 DEMOGRAPHIC AND SOCIO-ECONOMIC PROFILE

5.2.1 Geography of districts & kebeles

Boloso Sore woreda is a densely populated area with a high potential for irrigation, containing 28 kebeles. The density of population in the district was 829 per km^2 in 2019 (ZoFED, 2019). Three SSI schemes, Soke, Woybo and Ettana, were constructed in the woreda in 1993 / 1994 (ibid). Small-scale soke irrigation serves two kebeles, Achura and Tiyo Himbecho. Ettana SSI irrigates one kebele, Guromo Koisha. The Woybo SSI scheme is in and irrigates two districts, Boloso Sore and Boloso Bombe, and two kebeles, Matala Hembecho and Ajora.

The Ettana SSI (SSI) scheme serves households in Gurumo Koisha, with a population of 8,590 and 1,828 households, based on the national 2007 population census of the Wolaita Zone Finance and Economic Development. The economy of these kebeles is based on both crop production and animal husbandry. The Ettana SSI was constructed and started operating in 2012/13, initially intended to serve 105 households, but provides water to 95 households. Irrigated agriculture includes annual and perennial crops such as cereals, vegetables, and fruits.

Damot Gale woreda is a densely populated potential irrigation area in the Wolaita Zone, containing 26 kebeles. The density of population in the district was 706 per km^2 in 2019 (ZoFED, 2019). Two SSI schemes, Yechia and Damte, were constructed in 2006/07 (ibid). The Yechia scheme is newly constructed and serves rural smallholders in Damot Boloso Kebele. The selected Damte micro dam irrigation is irrigating beneficiaries in households in the Buge Kebele and Buge Municipality. The projected population and households of these two kebeles and municipality are 12,768 (Buge 10,910 + Buge Municipality 1,858) and 2,249 (Buge 1,771+ Buge Municipality 478) respectively, based on the national 2007 population census projection by the Wolaita ZoFED. These households practise agriculture, including crop cultivation and animal husbandry, and participate in small-scale trade. The Damte Micro Dam irrigation was constructed and operated for 14 years, initially intended to benefit 260 households, but serves about 42 households. They grow cereals, industrial crops (tobacco, sugar cane), vegetables, and fruits.

Humbo woreda is a potential irrigation area in the Wolaita Zone, containing 22 kebeles, with a population density of 250 per km^2 in 2019 (ZoFED, 2019). Three SSI schemes, Bosa Wanche, Lintala, and Ella, were constructed in 1993/94 (ibid.). SSI schemes of Bosa Wanche and Lintala irrigate kebeles 'Bossa Wanche' and 'Sere Tawrata', respectively. The selected Ella SSI serves beneficiaries in Ampo Koisha kebele. The projected population and households of the kebele are 7,488 and 1,576, respectively, based on the 2007 national population census projection by the Department of Finance and Economic Development Department. Ella SSI was constructed in 1993/94. Initially intended to benefit 164 households, it serves 224 households which grow crops and practice animal production.

Damot Woyde woreda is a potential irrigation area in the Wolaita Zone, containing 20 kebeles, with a population density of 203.7 per km^2 in 2019 (ZoFED, 2019). Only one SSI scheme was constructed in 1999/2000 (ibid). The selected Bedessa SSI serves beneficiaries in Adecha Kebele. The projected population and households of the kebele are 7,167 and 1,425, respectively, based on the national 2007 population census projection by the Department of Finance and Economic Development Department. Bedessa SSI was constructed and functioning in 1999/2000, initially intended to benefit 102 households, but currently benefits 63 households. They cultivate crops and practice animal production.

Abela Abaya woreda is a potential irrigation area in the Wolaita Zone, containing 14 kebeles, with a population density of 465.4 per km^2 in 2019 (ZoFED, 2019).

Only one SSI Lasho was constructed in 1993/94 (ibid). SSI schemes irrigate Abela Mareka kebeles. The selected small-scale Lasho irrigation serves beneficiaries in Abela Mareka kebele. The projected population and households of the kebele are 3,937 and 819, respectively, based on the 2007 national population census projection by the Department of Finance and Economic Development Department. Ella SSI was constructed and operated in 1993/94, initially intended to benefit 164 households, but currently benefits 194 households. They cultivate crops and practice animal production.

5.2.2 Demographic profile

Most of the respondents fell under the age category of 35 to 44, followed by those 45 to 54 years of age. This suggests that the sample was skewed towards the middle-aged population. Most (96.25%) respondents were under productive age, that is, the respondents were in the age range where they were actively engaged in the workforce and contributing to the economy. This information is useful information for policymakers and companies looking to target this demographic. However, age alone does not determine productivity, because factors such as education, experience and health also play a role.

Table 0-1 The age category of the respondents

	HH survey		Community KII		KII officials	
	Frequency	%	Frequency	%	Frequency	%
18-24	11	2.8	0	0	0	0
25-34	46	11.5	5	14.3	2	40
35-44	183	45.8	15	42.9	3	60
45-54	91	22.8	10	28.6	0	0
55-64	54	13.5	4	11.4	0	0
65+	15	3.8	1	2.9	0	0
Total	400	100	35	100	5	100

Source: Household Survey (2022)

Most of the Wolaita districts are densely populated. According to this research, the mean number of people in the household including the children of the sample households (HH survey, KII and FGD) is 6.97, which is equal to 7. The minimum and maximum of people in the household are 2 and 12 respectively. On the other hand, the mean of the children in the household is 4.76 or 5. The minimum and maximum of children are 0.5 (0) and 9.56 or 10 respectively. The languages spoken by sample households are Wolaitigna, Amharic and Hadiyigna. The ethnicity of this sample household is Wolaita and Hadiya. Among the sample households, 90.2% live with their children and wife while the remaining 9.8% live with one of two, either husband or wife.

Most rural smallholders can write and read. Among the household survey and the FGD participants, that is, 516, 64.5% of them are above grade 4 (it includes grade 4), but the rest 35.5 are below grade 4 (including no schooling). All key officials have a bachelor's degree. Their work experience in the area ranges from 3.1 to 11 years. All key officials are men and the head of the agricultural office of Kebele. Among 35 key community informants, three were female.

Most of the rural Wolaita smallholders are protestant. Among those religions, people attend the “Kale Hiwot”, Full Gospel, and Ethiopian Apostolic church. Among key community leader informants (35) and focus group participants (116), Kale Hiwot (56.29%), Full Gospel (13.25%), Ethiopian Catholic (7.28%), Lutheran (5.3%), Orthodox (5.3%), Catholic (5.3%), Assemble of God (4.6%) and Hiwot Kal (2.6%) were the top listed.

The main economic source of the sample household is farming. They spent most of their time doing farm activities. However, some households are engaged in small business, and private work and get income from different activities and remittances. Among household survey samples, there are 29 (7.3%) disabled households. The disabilities are physical, sight, hearing, and mental illness.

5.3 SMALL-SCALE IRRIGATION ROLE IN FOOD PRODUCTION

In Africa, agriculture plays a crucial role in supporting people's livelihoods. As one of the African nations, Ethiopia is predominantly an agricultural country with a sizable population engaged in agriculture either directly or indirectly (Dessale, 2020). The nation's economy is mostly driven by agriculture (Assefa, 2020). Ethiopia has the capacity for intensive agriculture, particularly irrigation farming, and is endowed with resources such as land, water, and labour (Asayehegn, 2012). But the nation's agriculture is small-scale, rain-fed, survival-oriented, and limited in its access to institutional support services and technology (Dessale, 2020).

To ensure food security in Ethiopia, irrigation is considered important in increasing farm production (Debele & Mohammad, 2016). To boost food and nutritional security, empower women, reduce time, and enhance yields and incomes, the Ethiopian government supported several agricultural innovations (Theis et al., 2018). There are many ways to define food production: producing food crops, processing, and preparing food, raising crops and livestock, and so forth. The government has also implemented small, medium, and large-scale irrigation projects, distributed several types of irrigation technologies, and constructed irrigation dams. Therefore, this section of the chapter presents empirical evidence of different variables that contribute to crop production and the role of irrigation in food production in the Wolaita Zone.

5.3.1 Crop types in irrigating and non-irrigating areas

The researcher used both quantitative and qualitative methods to identify the types of crops grown before and after irrigation. In the quantitative section, the study describes the crops currently cultivated by both irrigation users and non-users. In contrast, in the qualitative section, users were asked to provide information on indigenous crop types grown before the introduction of irrigation and changes in crop types in the area after irrigation. Finally, the study summarises the impact of irrigation

n on the varieties and types of crops grown in the study area.

Quantitative analysis

The Wolaita Zone has a diverse ecology and soil types that are conducive to the growth of various lowland and highland crops. The agro climatic situation of the zone is favourable for growing various varieties of crops. The zone ranges from 501 to 3000 metres above sea level However, rural smallholders who do not use irrigation technologies grow two times a year. Rural smallholders of irrigation users cultivate more than three times a year. Crop types that grow in different agroclimatic zones within the Wolaita Zone were identified. In addition to indicating the types of crops grown in the lowland, midland and highland areas, the study also identified annual and perennial crops cultivated in the region. Before identifying each crop type, all sample irrigation users were asked if they irrigated their entire garden and field farmland (see Table 5.2).

Table 0-2 Household response to irrigation accessibility to all their farmland

	N	%	Valid Percent	Cumulative Percent
Yes	116	58	58	58
No	84	42	42	100
Total	200	100	100	

Source: Household Survey (2022)

Based on the results of the survey, it was found that 58% of rural households who use irrigation methods fully irrigate all their owned farmlands, while the remaining 42% only partially irrigate their total farmlands. The reasons behind why they fully irrigate their farmland or not were also explained (see Table 5.3). Although not all households cultivate their entire farmland using irrigation, the crop types indicated in this section include all crop types grown in both garden and field farms.

Table 0-3 Respondents' reasons for the full and partial irrigation of their accessible land

	N	%	Valid Percent	Cumulative Percent
the benefit of irrigation is encouraging	116	58	58	58
the land is not accessible for irrigation	1	0.5	0.5	58.5
the water is not sufficient	78	39	39	97.5
do not have enough labour	4	2	2	99.5
do not have enough finance and farm implements	1	0.5	0.5	100
Total	200	100	100	

Source: Household Survey (2022)

One of the reasons for not cultivating the entire farmland is owing to insufficient water discharge from the river or diversion, which accounts for 39%. This suggests that climate change in the area has affected the amount of accessible water available after the design of SSI schemes. As a result, this climatic effect on river discharge has had an impact on food production in Wolaita Zone, southern Ethiopia. Despite the challenges posed by climate change, SSI beneficiaries utilise diverted irrigation both as a supplementary and complementary source of water. Additionally, considering this climatic effect, non-users cultivate crops that are resistant and supplemented by seasonal rainfall (see Tables 5.4 and 5.5).

Table 0-4 Annual crops cultivated in sample farmland from households.

Annual crops cultivated by the HH [a]	SSI User			SSI NON-Users		
	Responses		Percent of Cases	Responses		Percent of Cases
	N	%		N	%	
Maize	190	17.3	95	188	21.3	94
Wheat	150	13.7	75	19	2.2	9.5
Sorghum	1	0.1	0.5	11	1.2	5.5
Teff	97	8.9	48.5	121	13.7	60.5
Haricot Bean	124	11.3	62	161	18.3	80.5
Pea	20	1.8	10	37	4.2	18.5
Bean	21	1.9	10.5	37	4.2	18.5
Chickpea	69	6.3	34.5	62	7	31
Tomato	70	6.4	35	0	0	0
Pepper	100	9.1	50	60	6.8	30
Local cabbage	66	6	33	46	5.2	23
Cabbage	63	5.7	31.5	0	0	0
Onion	39	3.6	19.5	0	0	0
Beetroot	8	0.7	4	0	0	0
Potato	15	1.4	7.5	54	6.1	27
Sweet potato	62	5.7	31	84	9.5	42
Taro	1	0.1	0.5	2	0.3	1
	1096	100	548	882	100	441

a. Dichotomy group tabulated at value 1.

Source: Household Survey (2022)

Based on the results of the quantitative data, the main cereal crops grown by the users were maize, wheat, haricot beans, and teff, with respective percentages of cases 95%, 75%, 62% and 48.5%. Furthermore, the main vegetable crops grown by users were pepper, local cabbage, cabbage, onion, tomato, and beetroot, with percentages of 50%, 33%, 31.5% and 16.5%, respectively. Non-users, on the other hand, mainly cultivated maize (94%), teff (60%), and haricot bean (80.5%) from cereal crops, while only cultivating pepper (30%) and local cabbage (23%) from vegetable crops (refer to Table 5.4).

Table 0-5 Perennial crops available in sample household

Perennial crops available in the HH farm [a]	SSI Users			SSI non-users		
	Responses		Percent of Cases	Responses		Percent of Cases
	N	%		N	%	
False Banana	127	14.4	63.5	188	22.2	94
Cassava	50	5.7	25	67	7.9	33.5
Mango	159	18	79.5	120	14.2	60
Avocado	148	16.8	74	170	20.1	85
Papaya	86	9.8	43	34	4	17
Guava	53	6	26.5	26	3.1	13
Coffee	147	16.7	73.5	195	23	97.5
Banana	79	9	39.5	27	3.2	13.5
Sugar Cane	9	1	4.5	1	0.1	0.5
Moringa	15	1.7	7.5	19	2.2	9.5
Lemon	6	0.7	3	0	0	0
Other (orange)	2	0.2	1	0	0	0
Total	881	100	440.5	847	100	423.5

a. Dichotomy group tabulated at value 1.

Source: Household Survey (2022)

Moreover, the study reveals that the main perennial crops grown in the area include "Enset" or false banana, mango, avocado, and coffee. In addition, other perennial crops that are essential for human health, such as papaya, banana, lemon, and orange, were found to grow better among SSI users compared to non-users. Among the total users surveyed (200), these crops accounted for 43%, 39.5%, 3%, and 1%, respectively. However, despite their health benefits, more expansion of these crops is necessary to ensure their full potential is realised.

In many rural areas, small farmers not only grow crops on their field farms but also use their backyard space to grow crops. Backyard farming involves the cultivation of crops in the space surrounding a farmer's home, typically on a smaller scale compared to field farming. Perennial crops, which are plants that have a longer life and produce fruits or seeds repeatedly, are often planted by small farmers around their homes. These crops include fruit trees such as mango, avocado, and citrus, as well as other perennial plants such as "Enset" or false banana. By growing these plants close to their homes, small farmers take care of them and harvest the fruits or seeds they produce.

Backyard farming not only offers a means of food and financial gain but also provides other advantages. It raises the diversity of plants and animals by offering a safe space for them to thrive, while also fostering soil healthfulness and controlling soil erosion. Additionally, it gives smallholders a feeling of safety and autonomy, as they create some of their food within their government.

Table 0-6 Annual crops cultivated in the backyards of the sample household.

Annual crops cultivated in HG Using Irrigation [a]	SSI Users			SSI non-Users		
	Responses		Percent of Cases	Responses		Percent of Cases
	N	%		N	N	
Paper	18	8.3	10.8	50	22.6	43.1
Local Cabbage	163	74.8	98.2	55	24.9	47.4
Onion	1	0.5	0.6	0	0	0
Beetroot	10	4.6	6	0	0	0
Potato	8	3.7	4.8	46	20.8	39.7
Sweet Potato	11	5	6.6	67	30.3	57.8
Garlic	6	2.8	3.6	1	0.5	0.9
Taro	1	0.5	0.6	2	0.9	1.7
Total	218	100	131.3	221	100	190.5

a. Dichotomy group tabulated at value 1.

Source: Household Survey (2022)

According to the quantitative studies, the crops grown in the backyard of the respondents are pepper, local cabbage, onion, beetroot, potato, sweet potato, garlic, and taro. Among these crop types, local cabbage and pepper are planted widely by SSI users. The percentage of cases for these crop types was 10.8% and 98.2% respectively. However, non-users of SSI cultivate paper (chillies), local cabbage, potato, and sweet potatoes, their respective percentage of cases for these crop types is 43.1%, 47.4%, 39.7% and 57.8% (Table 5.6). These crops are used for home consumption and cash crops. But onions and beetroots are not cultivated by non-users. In Wolaita, smallholders not only cultivate perennial crops such as "Enset," mango, avocado, and coffee, but also grow annual crops on their backyard farms. These crops are not only consumed for personal consumption but also provide an additional source of income for the farmers.

The backyard farmlands were managed by various family members (Table 5.7) and were small plots of land. According to the household survey, every household uses irrigation to increase its yield for both domestic use and market. As a result, the maintenance of the home garden is the responsibility of each member of the household. Husband, wife, and children take part in the agricultural tasks of backyards. However, women and children are more responsible and save money generated from harvest to handle their home expenses. But in the irrigation area, the husbands also take part in the decision of the benefits from the backyards since the harvest and the benefit from the backyard are also equal to the harvest of the field crops. Therefore, husband (23.5%), wife (16%), both wife and husband (17.5%), both wife and children (9.5%) and husband and children (29%) account for more. However, for non-users' husbands (2%), wife (5%), both wife and husband (39%), wife and children (21.5%) and husband and children (28%), this indicates the responsibility and use of the benefit variable according to profit, size, and access to irrigation.

Table 0-7 Responsible family member to cultivate backyards.

	SSI Users		SSI non-Users	
	N	%	N	%
Husband	47	23.5	4	2
Wife	32	16	10	5
Children	3	1.5	2	1
Both (Husband and wife)	35	17.5	78	39
Wife and children	19	9.5	43	21.5
Husband and children	58	29	56	28
All the family	6	3	7	3.5
Total	200	100%	200	100%

Source: - Household Survey, (2021)

Qualitative analysis

The variety of crops that grow varies in relation to the agro climatic category of the area. Therefore, to understand and show this variability, the crops grown in each sample district were explained separately.

The results of the qualitative analysis results for Damot Gale District - Buge kebele, a mid-land district, indicate that community leader key informant interviews identified the crops growing before irrigation and their respective frequencies towards community leaders in the district. These crops included maize, sugarcane, sorghum, potato, local cabbage, teff, "Enset" or false banana, sweet potato, barley, peas, chickpeas, taro, banana, avocado, local potato, haricot beans, tobacco, beans, lemon, pepper, chilies, and coffee. The head of the kebele agricultural office also mentioned taro, sweet potato, potato, sorghum, barley, teff, and local cabbage as crops grown before irrigation. In the male and female FGDs, maize, sorghum, and haricot beans were listed among crops grown before irrigation. Farmers were aided by rains in spring and autumn to grow the mentioned crops.

Based on the data sources mentioned above, maize, sugarcane, sorghum, potato, local cabbage, teff, 'Enset', sweet potato, barley, peas, chickpeas, and haricot beans are considered the main crops in Damot Gale District - Buge kebele before irrigation. These findings indicate that the local community had a wide range of crops before the intervention, including cereal crops, root crops, legumes, and others. The inclusion of crops such as "Enset" or false bananas and tobacco reflects the diversity of agricultural practices in Buge kebele. Therefore, the result of this qualitative analysis highlights the importance of traditional knowledge and the role of natural resources, such as rainfall, in the local agricultural system.

The qualitative analysis results indicate that the types of crops grown in the Damot Gale-Buge kebele after irrigation intervention were also discussed by focus group members and key informants. According to interviews with seven community leaders, the crops grown after irrigation and their respective frequencies were as follows: local cabbage (n=7), cabbage (n=6), carrot (n=6), wheat (n=6), tomato (n=5), potato (n=5), beetroot (n=4), red onion (n=4), pepper (n=4), lettuce (n=2), sorghum (n=1), haricot bean (n=1), “Enset” (n=1), bananas (n=1), teff (1) and maize (n=4). The following crops were also mentioned: sugarcane (n=5), chilli (n=2), tobacco (n=1), barley (n = 1) and sweet potato (n=1).

Furthermore, according to the leader of the kebele agricultural office, the main crops grown in Buge kebele during the previous two years were wheat, tomatoes, cabbage, peppers, red onions, and cabbage. Furthermore, during the female and male FGDs, various garden vegetables, potatoes and wheat were mentioned as crops grown after irrigation.

Therefore, the results of the qualitative analysis suggest that after irrigation intervention, a diverse range of crops were grown in the Damot Gale District - Buge kebele, including various vegetables, cereal crops, and root crops. Local cabbage, cabbage, carrot, wheat, tomato, and potato were the crops mentioned the most frequently by community leaders, while tomatoes, cabbage, peppers, red onions, and wheat were reported as the main crops by the kebele agricultural office head.

The qualitative analysis results for Abela Abaya District - Abela Mareka kebele, a low-land area, indicate that the indigenous crops grown before the intervention were discussed with seven key informant community leaders. All key community leaders' respondents listed chickpeas, maize, cotton, and sorghum. However, six of them add haricot beans and cassava. Two among seven community key informants added taro, banana, cowpea, and teff to their list. In addition, the same question was addressed to the Kebele agricultural office to check the comments made by community leaders. According to the kebele agricultural office, before the intervention, the Abela Mareka kebele grew maize, sorghum, haricot beans, chickpeas, cotton, sweet potatoes, and chilies.

In addition, male focus group participants brought up native crops that were produced in the area before the intervention, such as haricot beans, teff, chickpeas, maize, sorghum, and cotton. On the contrary, the female participants claimed that they raised crops such as sorghum, cotton, maize, chiles and chickpeas. Therefore, the results of this qualitative analysis suggest that these crops were commonly grown in the area before the intervention and reflect the agricultural practices and preferences of the local community.

In addition, the results of the qualitative analysis suggest that after the implementation of irrigation, the types of crops grown in Abela Abaya District - Abela Mareka kebele have become diverse in type and variety. The crops most frequently mentioned by the community leaders were onion, mango, pepper, tomato, avocado, sugar cane, wheat, sweet potatoes, potatoes, pigeon pea, cabbage, banana, carrot, local cabbage, chickpeas, “Enset”, maize, haricot beans, taro, beetroot, guava, lettuce, and sesame.

The head of the Abela Mareka kebele agriculture office confirmed that crops such as bananas, cabbage, onions, tomatoes, avocados, mangoes, papayas, guava, watermelons, sugarcane, and wheat were commonly grown after irrigation. Furthermore, participants in the women's focus group said that the introduction of irrigation led to changes in the crops grown in Abela Mareka Kebele. They stated that among the crops that started to sprout in the irrigation area were carrots, onions, cabbage, beetroot, and others.

Therefore, as a summary, the qualitative analysis results highlight the diversity of crop types grown after the implementation of irrigation in the Abela Abaya District - Abela Mareka kebele. The inclusion of new crops such as beetroot, carrots, cabbage, and red onion in the area reflects the potential for agricultural development and adaptation to changing environmental conditions.

The qualitative analysis results for Boloso Sore District - Gurumo Koisha kebele, a highland area, indicate that the interviews of key informant community leaders identified the indigenous crops grown before the intervention and their respective frequencies. These crops included maize, sweet potatoes, wheat, teff, false banana, potatoes, barley, beans, peas, haricot bean, taro, lentils, and flax. Similarly, the head of the kebele agricultural office was interviewed and reported that maize, haricot bean, potato, pea, bean, banana, “Enset”, teff, and sweet potato were the crops grown before irrigation. These crops were also mentioned during the male and female FGDs. Therefore, this qualitative analysis results suggest that the local community had a diverse range of crops that they grew before the intervention, including cereals, root crops, and legumes.

The qualitative analysis results for Boloso Sore District - Gurumo Koisha kebele indicate that after irrigation, the crops grew, and their respective frequencies resulted were pepper, cabbage, beetroot, carrot, wheat, tomato, local cabbage, red onion, and potato. Furthermore, during the key official interview with kebele, a wide range of garden vegetables such as tomato, cabbage, carrot, beetroot, onion, and spices such as "Hariti", "Dimbilal", "White and Black Azmuds", etc. were reported to be growing in Gurumo Koisha kebele. These crops were also mentioned during the FGD.

As a summary, the qualitative analysis suggests that the implementation of irrigation has resulted in a shift toward the cultivation of garden vegetables, spices, and other crops in the Boloso Sore District - Gurumo Koisha kebele. The inclusion of crops such as beetroot and spices such as "Hariti" and "Dimbilal" highlights the diversity of agricultural practices in the Gurumo Koisha kebele. The findings emphasise the importance of irrigation in expanding the range of crops grown in Gurumo Koisha kebele and the potential for further agricultural development.

The qualitative analysis results for Humbo District - Ampo Koisha kebele, a lowland area, key community leaders indicate that before the irrigation intervention in Ampo Koisha kebele, indigenous crops grown included local maize, teff, haricot bean, sweet potato, chickpea, sorghum, false banana, local banana, avocado, mango, coffee, cassava, taro, local paper, sugarcane, local lemon, local cabbage, pumpkin, potato, and yam.

The Ampo Koisha kebele agricultural office confirmed that maize, teff, beans, chickpeas, sweet potatoes, cassava, pepper, and local cabbage were also grown in the kebele before irrigation. These crops were also mentioned during the male and female FGDs, which further confirmed their prevalence in Ampo Koisha kebele. Therefore, the qualitative analysis suggests that the local community in Humbo District - Ampo Koisha kebele had a diverse range of indigenous crops before the implementation of irrigation. The inclusion of crops such as false bananas, local pepper, and yams highlights the diversity of agricultural practices in the area.

The qualitative analysis results for Ampo Koisha kebele in Humbo District suggest that the introduction of irrigation has led to the replacement of local crop varieties with improved ones. Local communities have begun to produce improved varieties of crops that are suitable for the environment. For instance, improved varieties of pepper have replaced local types of pepper and local varieties of maize and banana have been replaced by improved varieties of maize and banana, respectively.

The crops grown in Humbo District - Ampo Koisha kebele after the construction of irrigation include vegetables like onions, tomatoes, cabbage, and oranges. Root crops and fruits such as improved varieties of sweet potatoes, ginger, bananas, mangoes, and avocados were cultivated. Additionally, the participants mentioned that they have also begun to cultivate carrots, cabbage, and beetroots.

Figure 0-1 Crop and animal production in the study area

Source: Photos taken by researcher, 2021

Source: Photos taken by researcher, 2021

In addition, the participants mentioned that, since the area is a lowland, they did not sow wheat and grapes, which are crops commonly grown in the highlands. However, after receiving training from the government and being informed that it is possible to grow wheat using irrigation in the summer season, they have started cultivating it. Therefore, the results of the qualitative analysis highlight the impact of irrigation on the local agricultural system in the Humbo District - Ampo-Koisha kebele. There is a shift towards improved crop varieties and the cultivation of crops previously not grown in Ampo-Koisha kebele. The findings underscore the importance of government support and training in promoting sustainable agricultural practices in the area.

The qualitative analysis results for Damot Woyde District - Adecha kebele indicate that during the FGD, participants explained the crops they were cultivating by referencing their settlement year in the area. According to the male FGD, people started living in the area in 1980, and irrigation was built in the kebele and started working in 1994. In Adecha kebele, irrigation users from Damot Woyde woreda plant crops such as cotton, maize, and sorghum after their settlement (male focus group participants). This information was also confirmed by community leaders and key officials' interviews, which reported the same crop types. Therefore, qualitative analysis suggests that the local community had limited crop options before the implementation of irrigation in Adecha kebele, Damot Woyde District.

Furthermore, the qualitative analysis results for Adecha kebele in Damot Woyde woreda suggest that there are three farming seasons in a year. The first starts in spring and promotes the growth of crops such as taro, cassava, haricot beans, maize, and wheat. The second season starts in autumn, and the crops that grow in this season are haricot beans, wheat, teff, and sorghum. The third season runs from summer to winter. In the southern region of Ethiopia and the Wolaita Zone, this season is considered an irrigation season. This season is further categorised into two periods, the first irrigation season in summer and the second irrigation season in spring. In Adecha kebele in Damot Woyde Woreda, the types of crops produced during irrigation are tomato, pepper, red onion, cabbage, and local cabbage. Therefore, 'irrigation water acts as a supporting and main source of water in the kebele as well as district' (Participants 10, Male FGD_ Damot Woyde - Adecha).

Key community leaders and key officials' interviews explained the types of crops produced and their frequency of selection after irrigation in Adecha kebele, Damot Woyde Woreda. These crops included maize, pepper, red onion, wheat, sweet potato, teff, tomato, cabbage, local cabbage, mango, avocado, banana, lettuce, haricot beans, cassava, and taro. Therefore, qualitative analysis suggests that the introduction of irrigation has led to the expansion of crop options in Adecha kebele, Damot Woyde Woreda. The inclusion of crops such as mango, avocado and banana reflects the potential for agricultural diversification in the area.

Among the five SSI schemes sampled, Ell and Lasho were built in a lowland area to settle rural smallholders who were suffering from food shortages and had little to no land from the nearby kebeles of Damot Woyde and Humbo woreda. The settlers initially grew crops that could withstand the area's climate and were used for their consumption until they became familiar with the local climate and learned how to use irrigation. Qualitative analysis has shown that the main crops grown in Abela Abaya and Damot Woyde woreda can resist lowland climate and are suitable for daily consumption. Although the settlers did not immediately start growing irrigated crops, they benefited from the irrigation intervention by cultivating drought-resistant crops.

In summary, the crops mentioned in the preceding paragraphs include hybrid and indigenous varieties. In Wolaita, modern agricultural intervention began in 1972 during the "Derg" regime through the establishment of government-initiated units such as the Wolaita Agricultural Development Unit (WADU), etc. The primary goal of these units was to introduce modern agricultural technologies and train rural small farmers on their use, disseminating these practices to improve the traditional farming system throughout the country. WADU aimed to increase crop and livestock production, and farm family incomes and provide a package programme to settle farmers, along with technical assistance, infrastructure, and marketing facilities for small farmers in the lowland area of the 'Wolaita Awraja' (Griffin, 2006). During this time, the programme introduced various improved varieties of different crops, and rural farmers adopted and used these varieties. Before the establishment of the unit, farmers in the area cultivated their local seeds, which are no longer available. Currently, smallholder farmers use hybrid or third-generation or more varieties. For example, maize was traditionally grown in southern Ethiopia, Wolaita Zone, using indigenous seeds with unique genetic makeup and characteristics. However, this variety is no longer present in the area, and the maize variety used now is mixed. This may be one of the negative effects of the introduction of new technology, which can have a detrimental impact on indigenous biomass. Therefore, when referring to indigenous crops in the preceding paragraphs, we are referring to their local varieties.

The Ethiopian agricultural system is classified into four main types: seed farming, Enset planting complex, pastoral complex, and shifting cultivation, as described by Beshah (2003). The Wolaita Zone falls under both the “Enset” planting complex and shifting cultivation. The foods grown in different regions of the country are influenced by the environment and regional eating habits (Beshah, 2003). However, several factors, including government regulations, the use of modern technologies such as irrigation, and the degree of food poverty in the area, are currently affecting agricultural productivity.

Previous Ethiopian regimes have implemented various interventions aimed at obtaining raw materials for industries, transforming traditional agricultural systems, and improving the food security situation of rural smallholders. One intervention was the establishment of irrigated agricultural systems designed to improve the food security of small farmers living in the mid and lowlands of the country. In southern Ethiopia, and particularly in the Wolaita Zone, there has been a gradual change in the crops grown from indigenous varieties to other types.

Before irrigation was introduced, annual and perennial indigenous crops were produced in Wolaita, southern Ethiopia. Among the crops grown in the region are maize, potato, local cabbage, sorghum, teff, “Enset”, sweet potato, barley, wheat, chickpeas, haricot beans, sugarcane, cotton, cassava, chillies, taro, beans, pea, and pepper are some of the crops grown by most rural smallholders. However, after irrigation, new annual and perennial crop types and varieties were included in the agricultural system, including tomatoes, cabbage, peppers, onions, improved potatoes, avocados, wheat, mangoes, papayas, guavas, bananas, watermelons, sugarcane, beetroot, carrot, oranges, improved sweet potatoes, ginger, and improved maize. Consequently, irrigation has contributed to the diversification and introduction of new crop types. Most perennial crops are cultivated by both users and non-users of irrigation. However, mango, papaya, guava, banana, and oranges are widely planted by irrigation users.

5.3.2 Irrigation and crop production

In Ethiopia, land tenure has long been a divisive topic in various political frameworks. The spiritual, economic, political, and institutional growth of civilization has been greatly influenced by land, which has been a focal point for power dynamics between the populace and its representatives, including governors and monarchs. Each nationality in Ethiopia had its system of land tenure and land served as the cornerstone and basis of the economy for a long time.

Under the "Derg" regime, the use of land as a political tool gave way to its use as a tool for socialist-based economic development. Consequently, the landlord-tenant relationship was replaced by a state-peasant interaction, exposing the latter to socialist economic ideas and their ancillary issues. While most of the restrictive laws from the "Derg" era were repealed after 1991, state-peasant relations persisted. Therefore, to ensure food security, rural smallholders have the right to use, manage and develop their land.

The Ethiopian government has implemented land appraisal, monitoring, and certification procedures to effectively manage and administer rural land. A crucial aspect of this programme is to certify each rural smallholder and determine the size of their land area. Although this project is not yet complete, it has established a stronger framework for collecting information on the overall land area owned by each sampled farmer. According to the household survey, 316 individuals, or 79% of the sample, have been certified and have received their certification, while the remaining households await certification. Using this data source, the farmland owned by each sampled rural smallholder was identified (Table 5.8.). Therefore, it is crucial to describe the current landholdings of rural households to understand the relationship between irrigation and food production. To distinguish the landholding sizes of the two groups, they will be treated individually.

The average cropland owned by SSI users is 0.724 hectares, while non-users hold 0.7818 hectares. According to the irrigation policy, the maximum land size allowed to be distributed in irrigation areas is 0.5 hectares if rural smallholders are settled after the irrigation scheme is constructed. In our study area, two of the five irrigation schemes included in the study were constructed to settle smallholder farmers in rural areas that were affected by natural and artificial disasters. Therefore, the land distribution in these two SSI schemes is uniform for every landholder, each receiving 0.5 hectares of farmland, excluding backyards and settlement areas. In the remaining three schemes, which were constructed in already existing communities, the landholding size of each rural household was not redistributed, and they retained what they had before construction. Therefore, the size of the landholding varies individually within SSI users, and to understand this variability, other statistics are needed. The minimum and maximum land sizes for SSI users are 0.14 and 2.5 hectares, respectively, while for non-users, it is 0.25 and 5 hectares, respectively. The median land size for users and nonusers is 0.75 and 0.50 hectares, respectively. This indicates two issues: firstly, those with very small land holdings are highly affected by population density, and secondly, although land is not a property that can be sold or transferred to other individuals, the rules and regulations outlined in land policy are violated, and people transfer their land given for use only owing to various reasons. Those who have the capacity to purchase or obtain it through a long-term contract can have a larger land size.

Table 0-8 Total respondent's farmland size owned by all respondents in farmland.

		SSI Users		Non-SSI Users	
		Statistic	Std. Error	Statistic	Std. Error
Mean		0.724	0.02648	0.7818	0.04424
95% Confidence Interval for Mean	Lower Bound	0.6717		0.6945	
	Upper Bound	0.7762		0.869	
5% Trimmed Mean		0.7023		0.7089	
Median		0.75		0.5	
Variance		0.14		0.391	
Std. Deviation		0.37444		0.6256	
Minimum		0.14		0.25	
Maximum		2.5		5	
Range		2.36		4.75	
Interquartile Range		0.5		0.88	
Skewness		0.995	0.172	3.245	0.172
Kurtosis		2.198	0.342	16.129	0.342

Source: Household Survey (2022)

There is variability between the minimum and maximum land size owned between SSI users and non-users. The SSI user group had lower values for the variable total farmland size owned by sample rural households (M=0.7240, SD=0.37444) than the SSI non-user group (M=0.7818, SD=0.62560). The result of Levene's test is that the p-value is 0.000 which is below the defined level of 5%. Therefore, Levene's test is significant, and the null hypothesis is rejected. Therefore, there is no equality between the variances of the sample. In other words, Levene’s test of variance equality has shown that variance equality cannot be assumed. A t-test for an independent sample (equal variance not assumed) showed that this difference was not statistically significant, t (df=325.363) = -1.121, P=0.263, 95%. Confidence interval [-0.15921,0.04363] (Table 5.9.).

Table 0-9 Independent t-test of land size owned by sample rural households.

	Levene's Test for Equality of variance		t-test for Equality of Means							
					Significance				95% Confidence Interval	
	F	Sig.	t	df	One-sided p	Two-sided P	Mean Difference	Std. Error Difference	Lower	Upper
Equal variance assumed	17.38	0.000	-1.121	398	0.13	0.26	-0.05779	0.05155	-0.15914	0.0436
Equal variance not assumed			-1.121	325.36	0.13	0.26	-0.05779	0.05155	-0.15921	0.0436

Source: Household survey (2022)

Rural farmers in the Wolaita Zone typically own small farmland and often seek to acquire additional land to maintain food security and availability at home. The survey findings indicate that SSI users use various sources to cultivate additional land, including renting, buying, and collaborating with other households that own more land. As a result, they cultivate more farmland than their own each year. On the other hand, non-users prefer to work with households that have ample farmland and receive extra harvest each year (Table 5.10). This suggests that SSI users are willing to rent and purchase additional land since they can generate adequate profits from their irrigation land. Rural farmers typically contract their land for short- and long-term, and while the government of Ethiopia has set a maximum contract period of five years for rural land, rural farmers often contract their land for longer periods and transfer it to third parties illegally. This is often done as a coping strategy by smallholder farmers who do not harvest enough to feed their families during times of food crisis or famine (discussed in detail in Chapter 7). This situation is most often observed in rainfed areas, but irrigation users are not exposed to this risk, since they use irrigation water as a supplementary and complementary source of irrigation. Consequently, they are not as vulnerable to extreme food shortages and crises. The relationship between irrigation and food security outcomes will be discussed in subsequent chapters, and its role in sustainable food availability will be outlined in detail in Chapter 7. In general, irrigation has contributed to the availability of additional land for cultivation, rather than the transfer of land already available to third parties.

Table 0-10 Sources of additional farmland in the study area

	SSI Users		Non-SSI Users	
	N	%	N	%
Rental	14	7.00	0	0.0
Purchase	2	1.00	0	0.0
Gifted from family	2	1.00	0	0.0
legal share distributed after family death	1	0.50	0	0.0
Working for share	41	20.50	32	16.0
NA	140	70.00	168	84.0
Total	200	100.00	200	100.0

Source: Household survey (2022)

SSI users have cultivated more additional farmland from other sources compared to non-users, with the maximum land size cultivated as additional farmland being 2 and 1 hectare for users and nonusers, respectively (Table 5.11). Therefore, this maximum land size number highlights the availability of various sources for irrigation users to acquire additional land. However, while irrigation users have a higher mean and maximum land added from other sources, this alone does not indicate the significance of variability or its contribution to the final harvest. Therefore, it is necessary to test whether this mean difference is significant and whether it contributes significantly to the final harvest. Furthermore, the variability within the variances of this should also be tested and explained.

The SSI user group had higher values for the variable “total additional farmland size from other sources” by sample rural households (M=0.1438, SD=0.29701) than the SSI non-user group (M=0.0838, SD=0.22314) (Table 5.10). The result of

Levene’s tests is that the p-value is 0.002 which is below the defined level of 5%. Levene's test is, therefore, significant and the null hypothesis is rejected (Table 5.12).

Table 0-11 Descriptive statistics of total farmland added from other sources.

		SSI Users		SSI non-Users	
		Statistic	Std. Error	Statistic	Std. Error
Mean		0.1438	0.021	0.0838	0.01578
95% Confidence Interval for Mean	Lower Bound	0.1023		0.0526	
	Upper Bound	0.1852		0.1149	
5% Trimmed Mean		0.0972		0.0431	
Median		0		0	
Variance		0.088		0.05	
Std. Deviation		0.29701		0.22315	
Minimum		0		0	
Maximum		2		1	
Range		2		1	
Interquartile Range		0.25		0	
Skewness		3.416	0.172	3.098	0.172
Kurtosis		15.621	0.342	9.338	0.342

Source: Household Survey (2022)

Therefore, there is no equality between the variances of the sample. In other words, Levene’s test of variance equality has shown that variance equality cannot be assumed. A t-test for the independent sample (equal variance not assumed) showed that this difference was not statistically significant, with t-value of 2.284 (df = 369.38), P=0.23, 95%. The confidence interval was [0.00834, 0.11166] (see Table 5.12). Based on the two separate results discussed earlier, there was no significant difference in the variability of land to be cultivated from their own and other sources between the two groups. However, it is important to confirm whether this holds true when analysed together. Combining both results and analysing them would not provide a meaningful understanding of the role of irrigation in crop production. Instead, it is necessary to analyse the land cultivated annually or crop intensity since available land could be left fallow for various reasons and cultivated one to three times a year. Therefore, the total land cultivated was used for analysis.

Table 0-12 Independent sample t-test of additional farmland from other sources

	Levene's Test for Equality of variance		t-test for Equality of Means							
					Significance				95% Confidence Interval	
	F	Sig.	t	df	One - sided p	Two-sided P	Mean Difference	Std. Error Difference	Lower	Upper
Equal variance assumed	9.419	0.002	2.28	398	0.011	0.023	0.06	0.02627	0.0084	0.1116
Equal variance not assumed			2.28	369.38	0.011	0.023	0.06	0.02627	0.0083	0.1117

Source: Household Survey (2022)

To account for all land cultivated by households, including land owned by the household and those obtained from other aforementioned sources, the total land cultivated was measured, including land cultivated during all three seasons. Accordingly, a single plot of land might be used for cultivation two to three times a year. Compared to the SSI non-user group, the SSI user group exhibited higher values for the variable "total land cultivated by sample rural households" (M=2.3350, SD=1.57516) (Table 5.13).

Table 0-13 Total land cultivated in hectares of sample households (2021)

	N	Mean	Std. Deviation	Std. Error Mean
SSI User	200	2.335	1.57516	0.11138
SSI non-user	200	0.8126	0.74903	0.05296

Source: Household Survey (2022)

The result of Levene's test indicates that the p-value is 0.000, which is below the defined level of 5%. Therefore, Levene’s test is significant, and the null hypothesis of equality between variances of the sample is rejected. In other words, Levene's test of variance equality has shown that variance equality cannot be assumed. A t-test for independent samples (with equal variance not assumed) revealed that this difference was statistically significant, with a t-value of 12.344 (284.6 degrees of freedom), P=0.00, and a 95% confidence interval of [1.27962, 1.76514] (see Table 5.14).

Table 0-14 Independent sample Test of total land cultivated (2021) in hectares.

	Levene's Test for Equality of variance		t-test for Equality of Means							
					Significance				95% Confidence Interval	
	F	Sig.	t	df	One - sided p	Two- sided P	Mean Difference	Std. Error Difference	Lower	Upper
Equal variance assumed	69.982	0.00	12.34	398	0.000	0.000	1.52238	0.12333	1.2799	1.7648
Equal variance not assumed			12.34	284.62	0.000	0.000	1.52238	0.12333	1.2796	1.7651

Source: Household survey (2022)

In addition to examining the size of the land owned, the land added from other sources and the total land cultivated, this study also investigated the variability of other major factors that could contribute to an increase in crop production in the area. One such factor is fallowing activity, which refers to the practice of leaving a plot of land uncultivated for a certain period to restore soil fertility. The study examined the frequency and duration of fallowing among households, as well as the reasons for fallowing and the crops planted after fallowing.

Another important factor examined is the fertility status of the available land. The study examined both the soil fertility of the land owned by households and the application of fertilisers and other soil amendments to improve soil fertility. The study also looked at composting and crop rotation as organic farming practices to maintain soil fertility.

The study also investigated the frequency of use of agricultural inputs such as seeds, pesticides, and herbicides. In general, the study looked at these additional aspects to provide a full understanding of the components that affect crop productivity in Wolaita Zone. Using these data, customised interventions can be created to increase regional food security and agricultural production.

Fallowing refers to the practice of leaving farmland uncultivated for more than one season to increase productivity, control pests and diseases, and restore soil fertility. While fallowing is not a common practice in communities with very small farmland, respondents in this study were asked if they fallowed their land. Of the total respondents in each group, 91.5% of users and 98% of non-users reported that they did not fallow their land (Table 5.15). The remaining percentage of both user and non-user respondents was also asked to provide reasons for fallowing their land. The user respondents reported that they fallow their land to improve the fertility status of their land (5.5%), reduce the incidence of crop diseases and pests (1.5%), or increase production (1.5%). In contrast, non-user respondents reported that they have fallow their land to improve the fertility status of their land (2%).

Table 0-15 Respondents' farmland fallowing habit.

	SSI Users		SSI non-user	
	N	%	N	%
Yes	17	8.5	4	2
No	183	91.5	196	98
Total	200	100	200	100

Source: Household survey (2022)

Although the fertility status of farmland is typically determined through soil laboratory tests, this study also sought to understand the perceptions of agricultural experts and household survey respondents on the differences in fertility between irrigation users and non-users. Therefore, the fertility status of the farmland in Wolaita Zone was examined using qualitative methods, including the views of experts and the self-understanding of the survey respondents. In particular, the study conducted interviews with key officials, such as heads of the kebele agriculture office to gain insight into their perceptions of the fertility status of farmland in Wolaita Zone.

During interviews with key agricultural officials, two different concepts were discussed. The first concept was related to the frequent use of irrigation, which can lead to an increase in soil salinity in irrigation areas. This salinity problem can cause the irrigated land in some areas to produce less than required. Furthermore, acidity problems are common in both irrigated and non-irrigated farms. Although corrective measures and the use of agricultural inputs can address these problems, they persist and can cause differences in fertility between irrigated and non-irrigated land.

The second concept discussed during the interviews was that irrigated land receives more input and compost compared to non-irrigated land. Additionally, irrigated crops are rotated, which allows the use of different root depths and the use of minerals at shallow depths since their root systems are also shallow. After harvest, shallow-rooted crops, such as tomatoes and cabbage biomass, are often left in the field, where they decompose quickly and are used as a natural fertiliser to improve the soil fertility of the farmland. As a result, irrigated land tends to have higher fertility rates. This makes irrigation a favourable practice for using additional technologies such as natural and artificial fertilisers.

Household survey respondents were also asked the same question, and the quantitative response showed that 92.5% (185) of user respondents agreed with the findings of the qualitative study and acknowledged the existence of fertility differences between irrigated and non-irrigated farmland. Non-user respondents, on the other hand, were able to observe the variability in the production they harvested from the same plot, which allowed them to compare their final harvest with that of irrigated land. The research team asked the same question to non-user respondents to understand their observations and knowledge about agricultural inputs. There were 106 (53%) respondents who reported observing differences between irrigated and non-irrigated land fertility out of 200 respondents. The remaining 47% (94) of the sample respondents did not know about the variation or did not observe any differences (Table 5.16).

Table 0-16 Self-evaluation of fertility status of irrigated and non-irrigated farmland

	SSI Users		SSI non-User	
	N	%	N	%
Similar	7	3.5	0	0

Different	185	92.5	106	53
I do not know	8	4	94	47
Total	200	100	200	100

Source: Household survey (2022)

5.3.2.1 Utilisation of agricultural input in the study area

Quantitative analysis

The SSI user group had higher values for the variables "total DAP, UREA, pesticides/herbicides/insecticides and different improved seeds used" in the 2021 production year by sample rural households [(M=173, SD=137.19095), (M=165.3750, SD=131.47017), (M=1.2856, SD=1.37520), (M=30.2583, SD=49.19158), than the SSI non-user group [M=80.80, SD=83.85265), (M=58.7250, SD=67.86774), (M=0.0675, SD=0.25400) (M=5.7900, SD=8.39296)], respectively (Table 5.17).

Table 0-17 Respondents' Agricultural inputs from respondents in the 2021 production year.

		N	Mean	Std. Deviation	Std. Error Mean
DAP in Kg	SSI User	200	173	137.19095	9.70087
	SSI non-user	200	80.8	83.85265	5.92928
UREA in Kg	SSI User	200	165.375	131.47017	9.29635
	SSI non-user	200	58.725	67.86774	4.79897
Pesticide/herbicide in Litre	SSI User	200	1.2856	1.3252	0.09371
	SSI non-user	200	0.0675	0.254	0.01796
Different improved seeds in Kg	SSI User	200	30.2583	49.19158	3.47837
	SSI non-user	200	5.79	8.39296	0.59347

Source: Household Survey (2022)

For the total DAP, UREA, pesticides/herbicides/insecticides, and improved seeds used in the 2021 production year by sample rural households, Levene's test yielded a p-value of 0.000, which is below the defined level of 5%. This indicates that Levene's test is significant, and the null hypothesis of equality between variances of the sample is rejected. In other words, Levene's test of variance equality has demonstrated that variance equality cannot be assumed.

A t-test was performed for independent samples for variables total DAP, UREA, pesticides/herbicides/insecticides, and different improved seeds used in the 2021 production year by rural sample households (with no assumed equal variance). With df and t values of [(329.475) = 8.11, (298.028) = 10.2, (213.602) = 12.8, and (210.576) = 6.98] and a P value of 0.00 in a 95% confidence interval, the results demonstrated that there was a statistically significant difference in the means of these variables. According to Table 5.18, the respective confidence intervals of the variables were [(69.83424, 114.56576), (86.06137, 127.23863), (1.03003, 1.49617) and (17.51227, 31.42423)].

Table 0-18 Independent sample Test of respondents' agricultural input utilisation of respondents.

		Levene's Test for Equality of variance		t-test for Equality of Means							
						Significance				95% Confidence Interval	
		F	Sig.	t	df	One - sided p	Two-sided P	Mean Difference	Std. Error Difference	Lower	Upper
DAP/NPS in kg	Equal variance assumed	18.02	0.000	8.11	398	0.000	0.000	92.2	11.36939	69.84843	114.5516
	Equal variance not assumed			8.11	329.5	0.000	0.000	92.2	11.36939	69.83424	114.5658
UREA in kg	Equal variance assumed	32.36	0.000	10.2	398	0.000	0.000	106.65	10.46194	86.08243	127.2176
	Equal variance not assumed			10.2	298.1	0.000	0.000	106.65	10.46194	86.06137	127.2386
Pesticide/ Herbicide in litre	Equal variance assumed	295.1	0.000	12.8	398	0.000	0.000	1.2181	0.09541	1.03053	1.40567
	Equal variance not assumed			12.8	213.6	0.000	0.000	1.2181	0.09541	1.03003	1.40617
Different improved seeds in kg	Equal variance assumed	47.93	0.000	6.93	398	0.000	0.000	24.46825	3.52864	17.53116	31.40534
	Equal variance not assumed			6.93	210.6	0.000	0.000	24.46825	3.52864	17.51227	31.42423

Source: Household survey (2022)

Qualitative analysis

Community leaders in Damot Gale District- Buge Kebele, noted the implementation of new agricultural technologies had a positive impact on production and productivity. Raw planting and new summer wheat in irrigation led to increased crop yields. By moving away from the reliance on unpredictable rainfall and instead using irrigation, farmers have been able to obtain better crop yield three times a year. The implementation of new agricultural technologies has also helped farmers better utilise fertilisers, such as DAP and urea, using irrigation pumps and diversion schemes. As a result, the availability of irrigation schemes has created opportunities for improving crop and vegetable seeds not only for individual families, but also for the kebele and the district. Furthermore, community leaders in Damot Gale District - Buge Kebele suggest that the use of new agricultural technologies has played a significant role in increasing production and improving crop yields. Moreover, one of the community leaders in Damot Gale District, Buge Kebele, has explained the contribution of using agricultural technology to fulfil his family's food needs with available water resources: ‘I have increased my ability to use agricultural technologies to meet local and family food needs by using improved crop seeds and garden vegetables. I expect better results by planting improved avocado seeds now in irrigated areas’ (Participant 15, KII_Damot Gale District - Buge).

During FGD, participants agreed that their adoption of improved seeds was facilitated by receiving skill training from experts. This training allowed them to develop the practice of sowing these improved seeds in a resource centre where there is access to adequate water, land and human resources. The head of the Buge Kebele agricultural office further explained that the implementation of intercropping technology has helped overcome past challenges related to conventional and rain-fed production. Specifically, the use of intercropping has replaced the previously unproductive root crop production system with more productive vegetable crops. These changes have led to improved agricultural productivity and overall crop yields in Buge Kebele.

Community leaders in the Abela Abaya district - Abela Mareka kebele reported that the adoption of improved crop and animal species, particularly those cultivated by irrigation, has had a positive impact on agricultural productivity in Abela Mareka kebele. They specifically noted the use of improved crop types such as wheat, teff, maize, onion, tomato, and others. Additionally, the head of the agricultural office in Abela Mareka Kebele explained that the introduction of irrigation had facilitated the adoption of new agricultural techniques, including the cultivation of new crops and animal species such as banana, papaya, avocado, mango, guava, and others. Overall, these modifications have increased agricultural productivity in Abela Mareka Kebele.

During interviews with community leaders in Gurumo Koisha kebele, Boloso Sore District, the adoption of new agricultural technologies was reported to have produced benefits in agricultural production. Specifically, they noted the use of new crops such as wheat, tomato, cabbage, carrot, beetroot, and various spices. The head of the Gurumo Koisha Kebele agricultural office explained that the implementation of new technologies, such as productive garden vegetables, has contributed to increased agricultural productivity. The use of fertilisers has also helped to improve production, with the example given that a single farmer in the area using 2 quintals of NPS per hectare has been able to obtain three times more production per hectare than usual. Therefore, the adoption of new agricultural technologies has had a positive impact on agricultural productivity in Gurumo Koisha kebele.

Key informants and focus group respondents from Ampo Koisha kebele, Humbo District, were sampled and explained that irrigation has played a significant role in the adoption of new agricultural technologies, such as new crop and animal varieties. These include new wheat varieties in summer, improved animal breeding, different breeds of chicken, teff seed production, and various crop and livestock production lessons, such as row sowing, intercropping methods, and the use of high-quality seeds, soil fertilisers, and chemicals. Transfer of knowledge has also been facilitated, allowing community members to learn and use these different technologies. The head of the Ampo Koisha kebele agricultural office further explained that the implementation of irrigation has led to changes in Ampo Koisha kebele specifically and all irrigate areas in Humbo District, such as providing a source of additional income through the cultivation of various garden crops and the ability to produce irrigated crops twice or three times a year. In general, the adoption of new agricultural technologies has been facilitated by irrigation and has had a positive impact on agricultural productivity in the area.

One of the male focus group participants said that:

> "We have started using new improved agricultural technology that is cultivated by irrigation. For example, it made us able to use improved wheat, teff, maize, tomato, onion, cabbage, etc. We have left the teff seed that we used to sow by spreading and now since irrigation has come, we have learned, and we are sowing the teff using line technology. Wheat sowing in the maize field and the lowland area was not common in the past. But now, since this technology has come, we have planted wheat in our area and are getting a bright harvest. Accordingly, we can grow any highland and lowland crop in any season using irrigation. Since there is irrigation hearing, other agricultural technologies such as DAP, Urea and NPS as well as various pesticides, herbicides and insecticides are provided by the government. Therefore, we use these opportunities to improve our production" (Participant 12, Male FGD_Damot Woyde -Adecha).

The group members agreed with the issue raised by the mentioned participant.

5.3.2.2 Rotation and shift cultivation in the study area.

Different agricultural practices are essential to improve farmland fertility, reduce the prevalence of diseases and pests, and ultimately increase production. Rotational and shifting farming techniques are efficient in reaching these objectives among agricultural activities. Shifting agriculture includes relocating crop production to different fields or locations each year as opposed to rotational agriculture, which involves producing several crops in succession on the same plot of land.

Training programmes were set up to give rural farmers the knowledge and abilities. A basic survey was carried out to find out how much they knew and used shifting, and rotational farming technologies among rural smallholders. According to the survey findings, 69% of non-users and 85% of users were aware of the advantages of shifting and rotating farming. This shows that most of the respondents knew something about these farming practices, although not completely.

Additionally, it was discovered that irrigation users had the propensity to employ shifting and rotating cropping techniques more frequently than non-users. This may be explained by the fact that irrigation systems give farmers more freedom in terms of crop choices and production schedules, making it simpler to put these techniques into effect. The use of irrigation can also decrease the damaging effects of pests and diseases and maintain soil fertility.

The survey findings indicate that rural farmers are generally aware of the advantages of shifting and rotating cropping approaches. To increase the acceptance of these practices, there is still potential for improvement, especially among non-users. It may be possible to further encourage the use of these agricultural technologies and ultimately increase agricultural productivity and sustainability by giving farmers access to training and resources.

5.3.2.3 Training in agricultural production in the study area

Enhancing farmers' knowledge and abilities and increasing the ability of rural smallholders both depend heavily on training. Rural farmers can change crop production practices and increase agricultural food production by increasing their knowledge and abilities. A research study was conducted among a sample of rural smallholders to assess the availability of guidance on crop production and examine its influence on crop yield.

As of the survey, 86.7% and 65.5% of non-users and users received one or more training on crop production, respectively. Among these respondents, 10.37% of respondents obtained training from other non-organisational sectors and 89.63% from the government sector. These respondents claimed that the training had a favourable impact on their crop production in their self-reported responses, with

79.5% of non-users and 61% of users reporting this. The study shows that rural farmers in Wolaita Zone still need training despite the availability of training opportunities. Therefore, it is necessary to offer varied and regular training on crop production as well as other topics related to food security. This would strengthen rural farmers' ability to adopt advanced agricultural technologies and improve their knowledge and abilities. Overall, the study findings highlight the value of training in improving rural smallholder capacity and increasing agricultural food production. Therefore, offering rural farmers training opportunities can help them accept new agricultural techniques and technologies, ultimately promoting sustainable agricultural growth and food security.

5.3.3 Food Availability

Scholars have researched to investigate the impact of different agricultural interventions on human livelihoods. Irrigation is one of these interventions that is believed to be an intense agricultural activity that can improve human livelihood. When SSI is compared to medium- and large-scale irrigation, it is frequently considered a more environmentally responsible and sustainable choice. Irrigation can have a beneficial or adverse impact on rural homes, depending on the situation. To learn more about the effects of SSI on rural households and national economies, several research has been conducted. The objective of this subsection is to discuss the empirical data supporting irrigation's contribution to food production, particularly crop output.

Quantitative analysis

The study aimed to compare the total crop amount harvested by sample rural households in the SSI user group and the SSI non-users' group. The findings in Table 5.19 showed that the mean value for this measure was significantly higher in the SSI user group (M=96.9967, SD=69.14522) than in the SSI non-user group (M=26.9680, SD=38.21348).

Levene's test was used to determine whether the variances between the two groups were identical to further examine the significance of this difference. The test's p-value was 0.000, which is less than the specified level of 5%. This indicates that Levene's test is significant, and the null hypothesis is rejected, implying that variance equality cannot be assumed between the two groups.

Table 0-19 Total crop production of respondents in quintal (2021)

	N	Mean	Std. Deviation	Std. Error Mean
SSI User	200	96.9967	69.14522	4.88931
SSI non-user	200	26.968	38.21348	2.7021

Source: Household Survey (2022)

A statistical test (equal degrees of freedom) discovered a substantial divergence in mean values within each group: with the t-value of 12.536 (df= 310.188), the calculated level of significance is 0.00 at 95% predictability. The confidence interval for differentiation between both groups, which falls between 59.037 and 81.021, is given through these statistics to evaluate data integrity (Table 5.20).

Table 0-20 Independent sample Test of respondent's total crop harvested in quintal (2021)

	Levene's Test for Equality of variance		t-test for Equality of Means							
					Significance				95% Confidence Interval	
	F	Sig.	T	df	One-sided p	Two-sided P	Mean Difference	Std. Error Difference	Lower	Upper
Equal variance assumed	60.18	0.00	12.54	398	0.00	0.000	70.0287	5.58629	59.0464	81.0110
Equal variance not assumed			12.54	310.19	0.00	0.000	70.0287	5.58629	59.0369	81.0201

Source: Household Survey (2022)

These findings suggest that the use of SSI technology is associated with a significantly higher total crop amount harvested by rural sample households. Therefore, SSI technology allows for more efficient use of water resources, which can contribute to higher crop yields, as well as greater agricultural productivity and sustainability. Therefore, it could be possible to increase crop yield and improve food security in rural communities by providing farmers with access to SSI technology and related resources.

Qualitative analysis

During the qualitative thematic analysis, irrigation and food availability was considered as a subtheme and using irrigation, food, crop, production, productivity, and availability as a code. The heads of the agricultural offices of the sample kebele (Humbo-Ampo Koisha, Abela Abaya-Abela Mareka, Damote Gale-Buge, Damot Woyde-Adecha, Boloso Sore-Gurumo Koisha) reported significant changes in crop production and productivity owing to irrigation. Crops normally yielded 1 to 2 quintals per hectare before irrigation, but after irrigation, production increased to 3 to 4 quintals per hectare on the same area of land. Respondents pointed out that there is still a distinction between irrigated and rainfed crops. During the irrigation period, pest and weed attacks are more common, and loss of natural properties of the soil can result in insufficient nutrients for the crop.

However, crops cultivated through irrigation receive enough water at the desired time and enough sunlight in a wide area, which is particularly important during the dry season, when photosynthesis occurs favourably during exposure to sunlight and adequate water. This, in turn, leads to greater plant food synthesis, resulting in improved yields and productivity compared to rainfed crops. During the wet season, the respondents also saw a difference in yield between irrigated and rain-fed crops. Various associated events, such as ice damage, flooding and the occurrence of various root diseases owing to the amount of water can affect the yield of rainfed crops. In contrast, irrigated crops receive the appropriate amount of water according to their needs, providing a wider opportunity for crops to receive the appropriate amount of sunlight and water without any damage. This leads to increased productivity and higher crop yields. Therefore, the results indicate that irrigation can greatly increase agricultural output and productivity, especially during the dry season when water is scarce. However, insect, disease, pest, and weed control throughout the irrigation period is critical to making sure of significant crop yields. It may be possible to increase crop yield and improve food security in rural communities by providing farmers with access to irrigation technologies and related resources.

According to the Damot Gale district-Buge FGD, some of the respondents described the role of irrigation in food availability as follows:

> ‘As a result of irrigation, various products were produced in Kebele, so the food availability was found to be better. It has created an opportunity for them to use different types of food to eat. After irrigation, good food, good clothes, good beds, and good children have reached the stage.’ (Participant 6, Mele FGD_ Damot Gale-Buge).

> ‘The change caused by using irrigation in this kebele/district has contributed to the production of the types of crops that are in demand in the market. For example, it has contributed to the wide production of various garden vegetables and fruit crops. Under this method, farmers replaced long-term crops such as taro, cassava, etc. with three- or four-month crops, i.e., vegetable crops.’ (Participant 2, Male FGD_Damot Gale District-Buge)

Similarly, key informants from Abela Abaya District - Abel Mareka Kebele explained their view on the role of irrigation in food availability and crop production.

> ‘Compared to rainfed production, irrigated production is much better. Since irrigation began, the food supply has improved greatly because we have access to irrigation water. As a result, food is never missing in our house because we produce crops in autumn and spring and eat to our fill.’(Participant 6, KII_Abela Abaya-Abel Mareka)

Boloso Sore District - Gurumo Koisha kebele respondent on the economic impact of irrigation on crop production and food availability –

> ‘After irrigation, there is a change in food supply: the availability of food has improved for both buyers and sellers in the vicinity and Gurumo Koisha. It was profitable for both the buyer and the seller. We sell products from the family and even to our Kebele, district and even to the zone. The overall supply in this area has vastly improved in quantity and variety.’ (Participant 3, KII- Boloso Sore-Gurumo Koisha)

The role of irrigation in food availability in general and crop production specifically was explained in detail in the FGD and the KII. According to the Humbo District - Ampo Koisha respondent,

> 'Before irrigation came, we used to produce only once a year due to lack of rain in the area. However, after irrigation came, we started doing it twice a year. As a result, food does not go missing in our home throughout the year. Our previously hand-to-mouth existence has transformed, and we are now able to create surplus products and sell them to the market. Because we now have access to irrigation water, food availability has improved substantially. As a result, we produce crops in autumn, spring and irrigation; so, food is never lacking in our house. Thus, we produce three times a year.' (Participant 7, Male FGD_ Humbo -Ampo Koisha)

Moreover, key informants of the Damot Woyde district - Adecha kebele said:

> 'After the introduction of irrigation, the food availability of the Kebele people has changed significantly. When we see the use of garden vegetables, it is seen that residents who did not use vegetables before are using them for food, and it has greatly improved food availability.' (Participant 1, KII_ Damot Woyde - Adecha)

The testimonials from Damot Gale-Buge, Abela Abaya-Abela Mareka, Boloso Sore-Gurumo Koisha, Humbo-Ampo Koisha, and Damot Woyde-Adecha kebeles all show the significant positive impact of irrigation on food production, availability, and security. Before irrigation, these areas faced challenges such as limited food supply, famine, and the need to buy food from other places. However, after the introduction of irrigation, the availability and variety of food greatly improved, allowing families to eat food they preferred and even sell surplus products to nearby markets. Irrigation also allowed them to produce crops throughout the year, reducing the need for government assistance and increasing their income. With better yield per hectare and reduced production loss, irrigation has transformed the way of life of these communities, therefore, improving their food security and economic opportunities.

5.3.4. Sustainable Food Availability

Irrigation and Sustainable Food Availability

According to the heads of the sample kebeles agricultural office, irrigation's contribution to the sustainable production of food in Wolaita Zone irrigation area is that it is possible to produce crops in all three seasons of the year despite the lack of rain because the role of irrigation is high. Since irrigated crops do not last more than three months, the ability to produce throughout the year has made it sustainable. The other thing is that cabbage does not disappear in the field. Garden vegetables cannot be stored. So, they eat what they can and sell the rest. They store grain crops such as beans, maize and the like in the warehouse and keep them at home until the next harvest. They cultivate all year round, and they sell the garden vegetables they have grown and purchase crops that are not in their fields at any time; they can easily buy and use them (Damot Gale-Buge, Abela Abaya-Abela Mareka, Boloso Sore-Gurumo Koisha, Humbo-Ampo Koisha, Damot Woyde-Adecha).

Irrigation leads rural farmers to produce three times a year. All key informants from the Kebeles community sample elaborated on the role of irrigation in the sustainable availability of food at home.

> Participants: 'We were also able to buy food sustainably from the market**.** We grow food sustainably three times a year through irrigation, so food does not go to waste at our home. In this way, it helped us to eat our fill at home and maintain food for the coming year so that there is no food shortage and to solve the problem that may sustainably arise in the next year. People in non-irrigated areas are at risk of starvation because they produce only once a year. But we never go hungry because we get food from the garden, Habesha cabbage is often used for food, and if maize flour is available without additional cost, it can be used for sustainable food at home; so, the food is available sustainably. It has also changed the way we think about making our own food sustainable at home. In previous times, we were very hungry. But now, since irrigation has come, we are not hungry because we grow crops that are grown three times a year, and another food (crop) arrives in the middle of the day. As a result, keeping produce (food) in our barn helped

keep food in our house until next year.' (Damot Gale-Buge, Abela Abaya- Abela Mareka, Humbo- Ampo Koisha, Damot Woyde-Adecha, Boloso Sore-Gurumo Koisha)

5.3.4 Food Distribution

According to the interview with key informants from the Damot Gale-Buge kebele community leaders, the distribution of the crop was not before irrigation. Two years ago, through cooperative union, surplus produce was collected and supplied to different areas. However, after irrigation, *'we provide surplus crops from the family to the local and district market and the neighbouring districts, as well as to the zone market*' (Participant 7, KII_ Damot Gale-Buge). Traders buy onions and tomatoes from this area and take them to Addis Ababa and elsewhere. For example, those that are sold from the kebele to the city of the district are onion, cabbage, mango, corn, tomato, and summer wheat. Focus group members in both male and female groups, Damot Gale-Buge kebele, also raised the same issue regarding the distribution of surplus food to the nearby district and zonal market. In addition, different crops, for example, beetroot, carrot, cabbage, and red onion, go to the Sodo city market and other areas of the kebele.

Similarly, the head of the agricultural office Abela Abaya - Abela Mareka Kebele described the food products sold in the district market of Wolaita Zone such as cabbage, tomatoes, taro, beetroots, Haricot Bean, onions, sorghum, wheat, mango, maize, and potatoes. Furthermore, the leaders of the Abela Abaya District - Abela Mareka kebele KII community describe that irrigation brought good beginnings to surplus production and food distribution: '*We used tomatoes, cabbage and Habesha cabbage, for consumption and sold the rest which is surplus to the market to create capacity because they are perishables*' (Participant 4, KII_Abela Abaya- Abela Mareka). There is better distribution of crops to the district market. In the production year 2021/22, better summer wheat production was achieved, and better distribution processes were established in the district.

'Through the increase in production and productivity, we better produced tomatoes, cabbage and carrots and benefited the neighbouring districts. We use the cereal crop and store it in the warehouse for the next sowing time. Additionally, storing the surplus helped us to distribute various non-perishable crops to neighbouring districts.' (Participant 2, KII_Abela Abaya- Abela Mareka)

Furthermore, the Boloso Sore district- Gurumo Koisha kebele focus group respondents describe and agreed that:

> 'There is a change in the distribution of crops in our kebele and district since the introduction of irrigation shows a great change in quantity, type, and price. In terms of quantity, we produce near our backyard, so there is an abundance of produce available. We were able to get different types of crops whenever we wanted. We obtain as much as we want at a reasonable cost. Therefore, it means that it has brought a large change in the price. It is loved because it comes from another country before. We sell products from the family and outside the kebele to the district zone. However, despite the adjustment, there remain certain issues with crop distribution. Road problems are one of the issues that affect the distribution of crops. Market linkage problems are also challenges that hinder distribution. Our kebele has the highest production of garden vegetables; so, when the crop arrives, there is always a situation where the market conditions are reduced in terms of prices in all the nearby markets.' (Participant 9, Male FGD_ Boloso Sore - Gurumo Koisha)

Similarly, the discussion of the Humbo-Ampo Koisha kebele male and female focus groups indicated that irrigation also affected the distribution of crops within and beyond the kebele. They explain and agree that:

> 'Since irrigation started, we have started raising surplus crops in the area. As a result, we sell our products by going to the nearby markets along the road built through the irrigation area. For example, we take our products to the market in Tebla City in Humbo District and the market in Sodo City. We are producing various annual and cash crops and supplying them to nearby markets. As a result, city dwellers get enough production without causing the price increase. In addition, neighbouring kebeles also get different food crops at affordable prices. '(Participant 6, Male FGD_ Humbo-Ampo Koisha)

The leaders of the Adecha Kebele community in Damot Woyde District have reported that after the implementation of irrigation, excess crops produced by families are distributed to both the local district market and neighbouring districts, as well as markets throughout the zone. The construction of roads has facilitated the transportation of crops, such as onions, cabbages, mangoes, maize, tomatoes, and summer wheat, from Kebele to the district city. Traders buy onions and tomatoes from the kebele and transport them to Addis Ababa for sale.

Moreover, the head of the Damote Woyde-Adecha kebele agricultural office has explained the contribution of irrigation to the increased food production in the kebele, as well as the distribution of the surplus to neighbouring districts. According to his explanation:

> 'For example, before irrigation bananas, avocados, mangoes, sugarcane, tomatoes, peppers, cabbage, wheat, beans, fruits, grains, and vegetables were supplied from neighbouring districts and through traders, and now, after the establishment of irrigation, the mentioned vegetables, fruits and grain crops are also being used by neighbouring kebeles for this kebele.' (KII_ Damote Woyde-Adecha)

In summary, crop distribution has been positively impacted by the introduction of irrigation in various Wolaita areas. Community leaders in Damot Gale-Buge kebele noted that after the introduction of irrigation, surplus crops were able to be distributed to local and district markets, as well as to neighbouring districts. Similarly, community leaders in the Abela Abaya-Abela Mareka kebele highlighted the better distribution of crops, with different types of crops distributed from kebele to district. In the Boloso Sore District - Gurumo Koisha kebele, the introduction of irrigation has led to an abundance of produce available, allowing cheaper prices and greater availability. However, challenges such as road problems and market linkage issues can hinder distribution. In the Humbo District - Ampo Koisha kebele, irrigation has allowed surplus crops to be sold in nearby markets, ensuring adequate production without causing price increases. Similarly, in the Damot Woyde District - Adecha Kebele, the establishment of irrigation has led to the distribution of crops to neighbouring districts and even to Addis Ababa. Overall, the introduction of irrigation has had a positive impact on crop distribution, allowing greater availability and lower prices for various crops.

Finally, inquiring whether SSI users were interested in irrigation intervention in the area revealed that most respondents, specifically 183 (91.5%), were interested, while 10 (5%) expressed ambivalence and 7 (3.5%) were not interested. Furthermore, respondents were asked to assess the adequacy of crops produced from their farms using irrigation, given the available farm size. The survey findings showed that 71% and 40% of users and non-users, respectively, expressed satisfaction with the production and harvest obtained from available water and land resources (as presented in Table 5.21).

Table 0-21 Respondent evaluation of the sufficiency of the food produced.

	SSI Users		SSI non-users	
	N	%	N	%
Yes	142	71.00	80	40.00
No	58	29.00	120	60.00
Total	200	100.00	200	100.00

Source: - Household Survey (2022)

The high level of interest of the respondents in SSI technologies is a positive indicator of the potential influence that such interventions can have on improving agricultural output and improving food security in Wolaita Zone, southern Ethiopia. That most users and nonusers were satisfied with the output and harvest from existing water and land resources underscores the potential benefits of irrigation. This implies that SSI interventions, with good planning, management, and support, can be beneficial in increasing crop production and improving the livelihoods of smallholder farmers. To maximise the benefits of such interventions, it is critical to ensure that essential resources, such as water and input, are available and that farmers are trained in the proper use and administration of irrigation systems. Therefore, the high level of interest of the respondents in SSI and the positive comments from users and non-users emphasise the area's irrigation's potential to contribute to crop production, food production, agricultural development, food security, and poverty alleviation in Wolaita Zone, southern Ethiopia.

5.4 SUMMARY

The study in this chapter was conducted among a sample of rural smallholders to assess the role of irrigation on crop production and examine its influence on crop yield. The study aimed to compare the total crop amount harvested by sample rural households in the SSI user group (SSI user group) and the SSI non-users group. The findings indicate that the mean value for this measure was significantly higher in the SSI user group than in the SSI non-user group. These findings suggest that the use of SSI technology is associated with a significantly higher total crop amount harvested by rural sample households. The results of the qualitative and quantitative analysis indicate that after irrigation intervention, a diverse range of crops were grown in the sample Wolaita zone kebeles, including various vegetables, spices, cereal crops, and root crops. Furthermore, the findings highlight the importance of training in improving smallholder capacity and increasing agricultural food production. Therefore, SSI technology allows for more efficient use of water resources, which can contribute to higher crop yields, as well as greater agricultural productivity and sustainability. Moreover, it has contributed significantly to food production, availability, and distribution in Wolaita zone, southern Ethiopia.

CHAPTER 6

THE ROLE OF SMALL-SCALE IRRIGATION ON FOOD DIVERSIFICATION

6.1 INTRODUCTION

There are two dimensions to explaining food diversification. The first involves the availability of various types of food items at the household level, while the second refers to the diversity of food consumed. Although you have access to multiple food items, not all may be consumed. Food can be consumed from own production, purchase, borrow, and aid from different sources. This depends on the production, wealth, and nutritional understanding of rural households. The study evaluates the diversity of quality food at home, in addition to its availability and consumption. In other words, it assesses the household's access to food purely based on its own crop and animal production as well as its use of cash from farming operations to purchase crop and animal goods.

In this section of the study, the food groups ingested by irrigation users and non-users are compared, together with the types of crops and animals' food groups that were eaten before and after the adoption of irrigation. Qualitative analysis was conducted to identify food types and groups consumed before the SSI intervention. Subsequently, quantitative analysis was performed, using an independent sample t-test to compare the mean HDDS between irrigation users and nonusers and to test for statistical significance. HDDS was calculated. Descriptive statistics were also used to analyse the role of irrigation in the diversification of food for smallholder farmers in rural areas of Wolaita Zone. The HDDS results are discussed in detail concerning the SSI technology intervention and its impact on the nutrition of rural smallholder households. The number of crop and animal food groups consumed from the harvest and purchase of the own farm was considered as dependent variables and individually analysed relative to the independent variable (user and non-user groups) using an independent sample t-test. The results were then interpreted for both user and non-user groups to determine the impact of the intervention on the diversity of crop and animal food groups consumed. Finally, the qualitative and empirical results of the study on the role of

SSI in improving the diversity of crop and animal foods among smallholder farmers at the household level in the Wolaita zone of southern Ethiopia are presented.

6.2 IRRIGATION AND FOOD ACCESSIBILITY

Assessing household food access is important for various reasons, such as identifying food insecurity, characterising the nature of insecurity (e.g., seasonal versus chronic), monitoring changes in circumstances, and evaluating the impact of interventions (Yohannes et al., 2002).

Quantitative analysis

Providing people with access to a wide variety of foods is the primary objective of food access. Food types are frequently categorised to do this based on their nutritional value. According to the study, SSI users had a greater variety of food than non-users, they ate items from all the food groups. Non-users were found to consume less food from the meat and fish group.

The study also revealed that SSI users were changing their diets away from cereals, roots and tubers in favour of other food categories that could contribute more to dietary diversification. The survey of 200 SSI-user households found that more of them consumed cereals (97.5%), vegetables and tubers rich in vitamin A (80%), dark green leafy vegetables (65.5%), fruits rich in vitamin A (29%), eggs (45%), foods made from beans, peas, lentils or nuts (51%), cheese, yoghurt, milk, or other milk products (68.5%) and foods made with oil, fat or butter (72.5%) than non-users (Table 6.1).

Rural smallholders often buy food from the market in addition to growing their food to suit their dietary needs. Depending on their knowledge of nutrition and their financial ability to buy food, smallholders buy a variety of foods. Small farmers often buy food that is not available on their farms or in their storage facilities.

Table 0-1 Household Dietary Diversity of the Sample Household

	HDDS frequency [a]					
	SSI Users			SSI non-users		
	Responses		Percent of Cases	Responses		Percent of Cases
	N	%		N	%	
Cereals	195	11.30	97.50	185	18.40	92.50
Roots and tuber	93	5.40	46.50	146	14.50	73.00
Vitamin A-rich vegetables and tubers	160	9.30	80.00	102	10.10	51.00
Dark green leafy vegetables	131	7.60	65.50	49	4.90	24.50
Other vegetables	180	10.50	90.00	74	7.40	37.00
Vitamin A-rich fruits	58	3.40	29.00	7	0.70	3.50
Other fruit	40	2.30	20.00	26	2.60	13.00
Organ meat	48	2.80	24.00	0	0.00	0.00
Any flesh meats	50	2.90	25.00	0	0.00	0.00
Any egg	90	5.20	45.00	2	0.20	1.00
Any fresh or dried fish or shellfish or seafood	7	0.40	3.50	0	0.00	0.00
Any foods made from beans, peas, lentils, or nuts	102	5.90	51.00	62	6.20	31.00
Any cheese, yoghurt, milk, or other milk products	137	8.00	68.50	46	4.60	23.00
Any food/s made with oil, fat, or butter	145	8.40	72.50	70	7.00	35.00
Any sugar or honey	84	4.90	42.00	39	3.90	19.50
Any other food/s, such as condiments, coffee, tea, spices, beverages	199	11.60	99.50	197	19.60	98.50
Total	1719	100.00	859.50	1005	100.00	502.50

a. Dichotomy group tabulated at value 1.

Source: - Household Survey (2022)

According to the study, smallholder food purchases were also influenced by their income levels. Small farmers with better incomes were able to purchase foods that met the preferences of their families. Despite this variation, the results of the survey revealed that consumers who use SSI nevertheless buy a wider variety of food categories than those who do not. This shows that SSI can increase both the variety of food that households produce and the variety of food that households buy (Table 6.2).

The study emphasises how critical it is to consider both food production and food consumption when evaluating rural smallholder access to food and nutritional outcomes. The results imply that SSI improves both aspects of food access, ultimately resulting in enhanced household nutrition.

Table 0-2 Food groups purchased by sample households.

Purchased food groups [a]	SSI Users			SSI non-users		
	Responses		Percent of Cases	Responses		Percent of Cases
	N	%		N	%	
Cereals	110	13.90	55.30	34	5.40	17.00
Vegetables	67	8.40	33.70	92	14.70	46.00
Fruits	40	5.00	20.10	40	6.40	20.00
Meats	84	10.60	42.20	125	20.00	62.50
Eggs	67	8.40	33.70	41	6.50	20.50
Root crop	43	5.40	21.60	53	8.50	26.50
Fish	40	5.00	20.10	15	2.40	7.50
Milk and milk products	52	6.60	26.10	34	5.40	17.00
Oil and fat	145	18.30	72.90	85	13.60	42.50
Sugar and honey	112	14.10	56.30	81	12.90	40.50
Oil crops	33	4.30	16.60	26	4.20	13.00
Total	793	100.00	398.60	626	100.00	313.00

a. Dichotomy group tabulated at value 1.

Source: Household Survey (2022)

To further understand the differences in food diversity between SSI users and non-users, the researcher conducted an independent t-test for food groups purchased. The results showed that the SSI user group had higher values for the variable total food group purchased by rural households sampled, with a mean of 3.9500 and a standard deviation of 1.99937. The SSI non-user group, in comparison, had a mean of 3.1250 and a standard deviation of 1.27179 which were both lower (Table 6.3).

This shows that smallholders who use SSI compared to those who do not tend to buy a more varied range of food groups. The greater diversity in the food groups these households buy is also indicated by the higher standard deviation of the SSI user group. The independent t-test provides further evidence that SSI has a positive impact on food diversity and access for rural smallholders. By facilitating increased food production and income, SSIs enable households to purchase a wider variety of foods and improve their nutritional outcomes.

Table 0-3 Total food group purchased by respondents.

	N	Mean	Std. Deviation	Std. Error Mean
SSI user	200	3.95	1.99937	0.14138
SSI non-user	200	3.125	1.27179	0.08993

Source: Household Survey (2022)

The researcher used Levene’s test and an independent t-test to assess whether there was a statistically significant difference in the dietary diversity between SSI users and non-users. Levene's test findings showed a p-value of 0.000, which is less than the threshold of 5%. This means that Levene’s test is significant, and the null hypothesis, which assumes equality between variances of the sample, is rejected. In other words, the variance equality cannot be assumed between the two groups.

After that, the researcher performed a t-test for independent samples under the presumption of unequal variances. With a t-value of 4.924 (df= 337.383) and a p-value of 0.00 in a 95% confidence interval, the findings demonstrated that the difference in food diversity between SSI users and non-users was statistically significant. The confidence interval range was between 0.49542 and 1.15458 (Table 6.4). The statistical analyses offer compelling evidence that the food diversity of smallholders who use SSI differs significantly from that of non-users, with SSI users generally making more varied food purchases. This demonstrates the potential benefit of SSI in improving rural smallholder access to food and nutrition.

The variety of dietary options for a household is commonly evaluated using the HDDS, which considers all household members. The food groups given in Table 6.1 were divided into 12 groups to analyse to determine the HDDS indication, which contains the following: A. Cereals B. Tubers and roots, C. Fruits, D.

Vegetables, E. Poultry, F. Eggs, G. Fish, H. Pulses, legumes, and nuts, I, Milk and milk-related items, J. Fats/oils, K. Sugar or honey, L. Other.

Table 0-4 Independent sample t-test of the total purchased food group.

	Levene's Test for Equality of variance		t-test for Equality of Means							
					Significance				95% Confidence Interval	
	F	Sig.	t	df	One - sided p	Two- sided P	Mean Difference	Std. Error Difference	Lower	Upper
Equal variance assumed	17.798	0.00	4.92	398	0.000	0.000	0.825	0.16756	0.4956	1.1544
Equal variance not assumed			4.92	337.39	0.000	0.000	0.825	0.16756	0.4954	1.1546

Source: - Household Survey (2022)

When the food is consumed, it is consumed by the household with a score of 1. Otherwise, it gets a score of 0. The HDDS household score is based on the total number of food groups consumed by the household ranging from 0 to 12 (INDDEX Project, 2018).

HDDS = sum (A+B+C+D+F+G+H+I+J+K+L)

The researcher used the number of crop and animal food groups that were consumed from both the household's farming activity and purchased sources as independent variables. The dependent variable used was the HDDS. The mean HDDS for the study population was then calculated according to the following methodology (INDDEX Project, 2018).

$$\frac{sum(HDDS)}{total\ number\ of\ household\ surveyed}$$

HDDS are commonly used as indicators of food quality and nutritional value. They provide a useful framework to understand the dimensions of food availability, access and use. Based on the survey results, SSI user households had significantly higher values for household dietary diversity than SSI non-user households. The mean HDDS for SSI users was 8.63, with a standard deviation of

2.204. On the contrary, the mean HDDS for SSI non-users was 4.94, with a standard deviation of 1.382 (Table 6.5).

This shows that compared to non-users, households that use SSI enjoy a more variety and healthy diet. The fact that SSI users have a higher mean HDDS shows that they eat a wider range of foods from different food groups, which is likely to contribute to better health outcomes. The survey findings emphasise the potential benefits of SSI in increasing food access and dietary diversification for rural smallholders, which ultimately leads to improved nutrition and health outcomes.

Table 0-5 Total Household Dietary Diversity Score of Sample Household

	N	Mean	Std. Deviation	Std. Error Mean
SSI Users	200	8.63	2.204	0.156
SSI non-users	200	4.94	1.382	0.098

Source: Household Survey (2022)

The researcher used Levene’s test and an independent t-test to see if there was a statistically significant difference in household food diversity between SSI users and non-users. Levene's test revealed a p-value of 0.000, which is less than the 5% level. This means that Levene’s test is significant, and the null hypothesis, which assumes equality between variances of the sample, is rejected. In other words, the variance equality cannot be assumed between the two groups.

After that, the researcher used a t-test for independent samples with unequal variances. The findings revealed a statistically significant difference in the diversity of the diet of the household between SSI users and non-users, with a t-value of 20.087 (df=334.559) and a p-value of 0.00 in a 95% confidence interval. Table 6.6 shows the confidence interval range of 3.333 to 4.057. These statistical tests provide strong evidence that there is a significant difference in the household dietary diversity between SSI users and non-users, with SSI users having a significantly higher mean HDDS.

Table 0-6 Independent t-test of respondents Household dietary diversity

	Levene's Test for Equality of variance		t-test for Equality of Means							
					Significance				95% Confidence Interval	
	F	Sig.	t	df	One - sided p	Two- sided P	Mean Difference	Std. Error Difference	Lower	Upper
Equal variance assumed	86.483	0.00	20.09	398	0.000	0.000	3.695	0.184	3.333	4.057
Equal variance not assumed			20.09	334.559	0.000	0.000	3.695	0.184	3.333	4.057

Source: Household survey (2022)

Furthermore, the researcher evaluated the diversity of micronutrient and vitamin-rich meals taken in by the study participants in addition to the diversity of macronutrient consumption. The study found that the respondents consumed a variety of foods rich in micronutrients during the data collection year, including pigeon peas, pineapples, bananas, onion, garlic, and beans. Similarly, both SSI users and non-users eat vitamin-rich meals such as carrots, sunflower seeds, vegetables, haricot beans, pumpkin, cereals, beans, peas, avocado, potato, sweet potato, peppers, lemon, and oranges. In addition, both SSI users and non-users consume a varied range of micronutrient meals, which may improve their nutritional outcomes. The study's examination of macronutrient and micronutrient/vitamin consumption gives a comprehensive picture of the dietary heterogeneity of rural smallholders. This information can be used to create initiatives to increase food access and nutrition in these communities. Therefore, the study emphasises the value of food accessibility in promoting a varied and nutritious diet and contends that SSI can be a key factor in improving family food diversity and nutritional results.

6.2.1 Irrigation, animal Food production and diversification

Rural smallholder farmers typically sell their animals and non-productive assets when they require money for special events or when they face a shortage of food or funds to acquire necessary resources for their household's needs. Unless they accumulate animals and non-productive assets, such sales are uncommon. In Wolaita culture, some wealthy households raise livestock in large numbers, ranging from 100 to 1000, which are locally called "Dalla" and "Gimma”. However, such cases are becoming increasingly rare owing to various reasons. In contrast, in the South Omo Zone, nomadic rural households still own livestock numbering 10 to 1000 per household.

This section focuses on the role of irrigation in improving the availability of animals for rural smallholders in Wolaita Zone, southern Ethiopia. The farming system in Wolaita is mixed, and animal production is practised along with crop production. The smallholders in the area rear various types of animals, including cows, oxen, sheep, goats, chickens, and beehives, with only a few households owning donkeys for transportation purposes. To assess the variability in the number of animals owned by SSI users and non-users, an independent sample test was conducted on the two groups, with all animal types converted to tropical livestock units (TLUs). The conversion equivalents of each animal category in TLU are calf (0.25), heifer (0.75), sheep and goat (0.13), cow and ox (1), chicken (0.013), bulls (1.2) and adult donkey (0.70) (Ahmed & Mesfin, 2017). The results indicate that the group of SSI users had higher values for the variable "Total livestock unit by sample rural households" (with a mean of 3.3059 and a standard deviation of 2.11317) compared to the group of non-users of SSI (with a mean of 2.3841 and a standard deviation of 1.53238) (as shown in Table 6.7). This analysis excluded donkeys and beehives, with all animal categories except donkeys converted to TLU. Donkeys were not included in the analysis owing to cultural and religious considerations, as they are not consumed in Wolaita Zone, southern Ethiopia.

Table 0-7 Total livestock unit of respondents

	N	Mean	Std. Deviation	Std. Error Mean
SSI user	200	3.3059	2.11317	0.14942
SSI non-user	200	2.3841	1.53238	0.10836

Source: - Household survey (2022)

The higher values for the variable "Total livestock unit by sample rural households" for SSI users have several implications. First, it suggests that SSI leads to increased access to water for livestock, which in turn enable smallholders to expand their animal production and increase their income. Second, it may indicate that SSI users have better access to markets, which allows them to sell their animals at higher prices and generate more income. Third, it may suggest that SSI users have better access to credit and other resources that allow them to invest in animal production. In general, these implications suggest that SSI plays an important role in improving the livelihoods of rural smallholders by facilitating access to water and other resources necessary for animal production and allowing them to generate more income from animal sales.

The results of Levene's test show that the p-value is 0.000, which is lower than the significance level of 5%. Therefore, the test is considered statistically significant, and the null hypothesis is rejected, indicating that the variances of the two samples are not equal. This means that the assumption of equal variances cannot be made based on Levene's test. An independent samples t-test (with unequal variances) was performed, showing a statistically significant difference between the two groups, with a t-value of 4.994 (df= 362.953), a p-value of 0.00, and a 95% confidence interval of [0.55877, 1.28472] (as presented in Table 6.8).

The focus group participants agreed with the role of irrigation on food diversification. Among 116 FGD participants, 22 (19.0%), 74 (63.8%) and 20 (17.2%) rated its role as greatly increasing, and fluctuating, respectively. About 60% of participants noted that the animal productivity was reduced by lack of food/feed due to climate change and decreased river discharge.

Table 0-8 Independent sample t-test of the animal categories of respondents converted to TLU.

	Levene's Test for Equality of variance		t-test for Equality of Means							
					Significance				95% Confidence Interval	
	F	Sig.	t	df	One - sided p	Two- sided P	Mean Difference	Std. Error Difference	Lower	Upper
Equal variance assumed	13.2	0.000	4.99	398	0.000	0.000	0.92175	0.18458	0.55888	1.2846
Equal variance not assumed			4.99	362.95	0.000	0.000	0.92175	0.18458	0.55877	1.2847

Source: Household Survey (2022)

Beekeeping is a widespread practice in the Wolaita Zone, where rural farmers traditionally engage in the production of beehives and honey. In recent times, modern beekeeping technologies have been introduced to rural smallholders as part of rural development policies. Bees require water and flowers to produce honey, and in irrigation areas, these resources are readily available as water is diverted from the main sources of the river and various annual and perennial crops are present. Honey has both medicinal and nutritional value for humans. Analysing the number of beehives available can provide insight into rural smallholder awareness of the benefits of honey and their utilisation of available resources for beekeeping activities. The survey results indicate that the group of SSI users had higher values for the variable "number of beehives by sample rural households" (with a mean of 0.46 and a standard deviation of 1.821) compared to the group of non-users of SSI (with a mean of 0.04 and a standard deviation of 0.495) (as presented in Table 6.9). This survey result implies that SSI has a positive impact on beekeeping activities and honey production. The higher mean value for the variable "number of beehives by sample rural households" among SSI users suggests that they have better access to water and diverse flowers, which may enable them to expand their beekeeping activities and increase the production of honey. Additionally, SSI users have better knowledge and awareness of the benefits of beekeeping and the use of available resources for beekeeping activities.

Table 0-9 Respondents' group statistics of beehives

	N	Mean	Std. Deviation	Std. Error Mean
SSI user	200	0.46	1.821	0.129
SSI non-user	200	0.04	0.495	0.035

Source: Household Survey (2022)

Levene’s test yielded a p-value of 0.000, which is lower than the established significance level of 5%, indicating statistical significance. Therefore, the null hypothesis is rejected and there is no equality between the variances of the two samples. In other words, Levene's test for variance equality shows that the assumption of equal variances cannot be made. An independent samples t-test (with unequal variances) showed that the difference between the two groups was statistically significant, with a t-value of 3.186 (df = 224.85), a p-value of 0.00, and a 95% confidence interval of [0.162, 0.688] (as presented in Table 6.10).

Table 0-10 Respondents' independent t-test of beehives.

	Levene's Test for Equality of variance		t-test for Equality of Means							
					Significance				95% Confidence Interval	
	F	Sig.	t	df	One - sided p	Two- sided P	Mean Difference	Std. Error Difference	Lower	Upper
Equal variance assumed	43.187	0.000	3.17	398	0.001	0.002	0.425	0.133	0.163	0.687
Equal variance not assumed			3.17	228.255	0.001	0.002	0.425	0.133	0.162	0.688

Source: Household Survey (2022)

Therefore, as a summary, this result highlights the potential benefits of SSI in improving rural smallholder livelihoods by enhancing their income-generating capacity through beekeeping activities and honey production.

Animal production is highly valued in Wolaita, as every rural household considers animals an essential part of their livelihood. Animals are often treated as family members and share the same living space as household members. Rural smallholders in Wolaita typically produce one or more animal categories and have their grazing land, although the size of this land varies. Animals are fed at home or outside the home, and rural smallholders in Wolaita cut and carry grasses from the grazing lands to feed their animals. Smallholders in Wolaita rely on rainfed, irrigation after harvest, grazing lands, and markets as sources of feed and feed for their animals. SSI users have access to resources and more likely to benefit from the availability of the intervention than non-users (as shown in Table 6.11). Animals can access water from the diverted river.

Table 0-11 Sources of animal feed and animal feed

Sources of animal feed/fodders [a]	SSI Users			SSI non-users		
	Responses		Percent of Cases	Responses		Percent of Cases
	N	%		N	%	
Rainfed post-harvest	132	29.60	69.80	138	42.10	73.40
Irrigation post-harvest	183	41.00	96.80	0	0.00	0.00
Market	48	10.80	25.40	16	4.90	8.50
Grazing land	83	18.60	43.90	173	52.90	92.00
Total	446	100.00	236.00	328	100.00	174.50

a. Dichotomy group tabulated at value 1.

Source: Household Survey (2022)

Small-scale irrigation users benefit from the availability of different sources of feed/fodder in several ways. First, the availability of feeds from different sources helps to ensure a consistent and adequate supply of food for their animals throughout the year. Second, the use of diverse feed and feed sources helps to improve the nutritional quality of the animal diet, leading to better animal health and productivity. Third, having access to various sources of feed helps SSI users reduce their dependence on a single source of feed, which can be risky if that source becomes scarce or unavailable. Fourth, the availability of different sources of feed provides SSI users with more flexibility in their animal production practices, enabling them to adjust their feeding strategies according to changing conditions and market demands. The availability of different sources of feed enhances the resilience and profitability of SSI users' animal production activities, which contribute to their overall livelihood improvement.

6.2.2 Irrigation and food consumption

Qualitative analysis

Rural smallholder farmers often purchase and consume food based on their individual and collective capacities. Food consumed in households can come from a variety of sources, including their harvests and the market. The study examined the food consumption patterns of small farmers in sample districts. The researcher examined the food consumed by households both individually and collectively, considering their family potential.

According to the study findings, the patterns of food consumption differed according to the district and the capacity of the household. Households in the sample kebele relied mainly on their harvests for food and purchased some food from the market. Some households also consumed more food collectively, sharing meals with extended family members or neighbours.

Cereals, roots and tubers, fruits and vegetables, chicken and poultry products, milk and milk products, and meat and meat products were among the crop and animal types identified by the survey as consumed by rural smallholder families. Some of these crop and animal foods were consumed regularly (such as cereals and root and tubers), as well as during specified times of the year, month, and week. The consumption of these crop types was analysed qualitatively to provide evidence of the foods that families could access and consume based on their capacity. The amount and frequency of food consumed varied depending on the capacity of the home and other circumstances.

In a qualitative analysis conducted through interviews with seven community leaders in Buge Kebele, Damot Gale District, the frequency of crop types consumed by the community before irrigation was identified. All interviewees (n=7) consumed maize and local cabbage, followed by teff (n=6), sorghum (n = 6), beans (n = 5), haricot beans (n=5), sugarcane (n=5), potatoes (n=4), chickpeas (n=3), “Enset” (n=3), sweet potatoes (n=2), wheat (n=3), barley (n=3). Moreover, during FGDs, both male and female groups agreed that they consumed “godere” (Taro), “Enset” (False Banana), “Boye” (Yam), Red Tef and “Bolokee” (Haricot Bean). Additionally, according to the agricultural official Damot Gale-Buge Kebele, before the implementation of irrigation, the people of the Kebele typically consumed grains and root crops.

In a qualitative analysis of the food consumption patterns of the Buge Kebele community in the Damot Gale District, community leaders identified a variety of crops that were consumed after irrigation was implemented. Cabbage (n = 7), tomato (n = 7), carrot (n = 7), beetroot (n = 7), improved avocado (n = 7), peppers (n = 6), oranges (n = 6), improved banana (n = 6), lemons, maize, summer irrigated wheat, pea, chickpea, sugarcane, and lettuce were the food categories most consumed. Furthermore, according to a Damot Gale-Buge Kebele KII official, irrigation has increased the consumption of additional food types such as cabbage, tomatoes, carrots, onions, and lettuce. In the FGDs, the participants also identified and listed various crop types that were consumed in their gardens, including carrots, cabbage, and onions.

A qualitative investigation of the influence of irrigation on food availability and nutrition in the Damot Gale District - Buge Kebele discovered that irrigation has considerably improved food availability for men and women, giving them access to numerous jobs that meet their family's food needs. Children under the age of five have benefited from improved nutrition because their mothers' consumption of protein and carbohydrates, as well as vegetables and fruits like tomatoes and carrots, mango, avocado, and banana, lowers the risk of disease. Pregnant women have also benefited from irrigation by having access to a balanced food supply and nutrients that promote healthy children. Therefore, women have used food from their harvest and purchases to prevent food shortages before and after delivery, leading to better maternal health and reduced maternal mortality rates.

During a female group discussion conducted in the Abela Abeya - Abela Mareka kebele, a participant from the group explained that:

> ‘As soon as we settle here after the irrigation construction, there are various grants from the government, as well as food and financial aid. We are getting wheat with financial aid. However, gradually we started growing maize, sorghum, cassava, and cotton and started to consume them in addition. We sell cotton and buy other grains and animal food from the market, such as milk, cheese, butter, meat, and bread.’ (Participants 8, Female FGD _ Abela Abeya- Abela Mareka).

In addition, Abela Abeya - Abela Mareka kebele agricultural office identified taro, sweet potato, sorghum, barley, red teff and local cabbage as some of the main food types consumed by the community. Wheat, sweet potato, cabbage, chickpea, avocado, mango, banana, papaya, and potato were among the crops and food types mentioned by the community leaders interviewed.

Through a qualitative analysis of the impact of irrigation on food availability and nutrition in Abela Mareka kebele, Abela Abaya District, it was found that the food types in the community's diet have changed after the implementation of SSI.

As a result, irrigation has boosted the diverse food availability of men and women, with children under five getting fruits such as mangoes, avocados, and bananas, as well as grains that are important for human health. Food scarcity used to cause children to suffer from hunger and disease, but that has changed. Irrigation has also benefited pregnant women because they now have access to healthier food than they had previously. Rural small-holder irrigation users in Abela Mareka kebele have also benefited from increased food availability and improved nutrition. In general, SSI has resulted in significant changes in the diet of the community, increasing food diversification and nutrition for all members, including children, pregnant women, and men.

Before the onset of irrigation, rural smallholders in Boloso Sore - Gurumo Koisha kebele consumed sweet potato (n=8), fake banana (n=8), maize (n=8), taro (8), teff (n=8), wheat (n=3), lentils (n=1), flax (n=1), potatoes (n = 3) and milk, butter, cheese, meat, and eggs (KII_Boloso Sore- Gurumo Koisha kebele). Similarly, the head of the agricultural office of Gurumo Koisha kebele has explained the crop and the foods, among the crop types of maize, haricot bean, sweet potatoes, beans, peas, chickpeas, milk, butter, eggs, etc. were crop types consumed by rural kebele smallholders. However, ‘since irrigation came potatoes, cabbage, tomato, red root, carrot, and pepper have been added to our diet and we eat regularly’ (Participants 8, Male FGD_Boloso Sore - Gurumo Koisha). After the introduction of irrigation in Kebele, they have also fed different types of garden vegetables, such as cabbage, tomato, carrot, and beetroot (Agricultural head of Boloso Sore - Gurumo Koisha). As Gurumo Koisha kebele, female group discussion, irrigation has brought about a great positive change in food access and diet for all members of society in Gurumo Koisha kebele. One of the participants in the male focus group explained:

> "We can grow any crop in any season, we can grow, eat, feed, and eat any alternative meals we desire. As a result, the accessibility of nutritional foods has improved significantly. It means that we can eat as much as we want while still getting all the nutrients our bodies require. For example, we consume vegetables such as cabbage, potatoes, maize, and teff” (Participants 7, Male FGD, Boloso Sore- Gurumo Koisha).

Qualitative analysis conducted in the Humbo District - Ampo Koisha kebele revealed that before the implementation of irrigation, the community predominantly consumed crops such as sweet potato, “godare”, “Enset”, 'Kocho', sorghum, maize, local cabbage, teff, coffee, pumpkin, sugarcane, cassava, Wolaita potato, haricot bean, chickpea, sorghum, and local greens such as “chumadhia”, local lemon, and local banana. Animal products such as beef, goat meat, mutton, chicken, milk, cheese, and butter were also consumed. However, after the introduction of irrigation, the diet of the community has changed significantly, with the addition of improved crops such as peppers, cabbage, carrots, beetroot, potato, wheat, barley, apples, and fruits such as mango, avocado, and guava (KII_Humbo - Ampo Koisha).

Similarly, the head of the agriculture office in Humbo District - Ampo Koisha Kebele reported that after the implementation of irrigation, the community started to consume additional foods such as oranges, potatoes, tomatoes, cabbage, guava, and wheat. Furthermore, according to all men and women in the focus group, all family members who live in the house eat products made from the farmland, and with the income from irrigation, they can buy food for the family. The community is now producing and eating food that is useful for children and pregnant women, which is owing to the education and training provided by the government's health extension services and the support and supervision of agricultural experts.

Besides, qualitative analysis conducted in the Bedessa Irrigation Scheme, Adecha kebele, Damot Woyde District revealed that irrigation users were originally settled in nearby kebeles and districts and were receiving food and financial aid from the government. In addition to this assistance, they were cultivating and eating foods such as maize, sorghum, and “Boloke” (Wolaita haricot bean). For special occasions and holidays, animal items such as milk, cheese and meat were purchased from the market. Before the implementation of irrigation, the community mainly consumed crops such as maize, sorghum and haricot beans, according to the head of the agricultural office in Adecha Kebele, Damot Woyde District. However, after the introduction of irrigation, additional crops such as tomatoes, onions, wheat, sweet potatoes, cabbage, chickpeas, avocados, bananas, apples, mangoes, lemons, and sweet peppers were introduced into the community's diet. Furthermore, the community began to consume animal products such as eggs, chicken, goat, cattle, and mutton (KII_Damot Woyde-Adecha).

The qualitative study conducted through male and female focus groups in the Adecha kebele District, Damot Woyde, found that men, women, and children now get quality food available at home and on the farm such as mangoes, papayas and eggs. Pregnant women are increasingly getting nutritious foods such as cabbage, papaya, avocado, mango, peas, beans, and chickpeas. The SSI users are now eating a greater variety of healthful foods, including beetroot, which they did not eat before the irrigation system was constructed (Male and Female FGD_Damot Woyde-Adecha).

Thus, irrigation impacted the diet of the community, addition of new crops and fruits, increased food security, and access to a variety of nutritious foods for children, nursing mothers, and pregnant women in all kebele samples. The analysis highlights the impact of irrigation on food availability, diversification, and nutrition in all districts and kebeles in the Wolaita Zone, going beyond food security to nutrition security, and improving the health and well-being of the community.

Using a household survey, the researcher addressed the thoughts of SSI users to understand their perception of the contribution of SSI to the consumption of different foods in their families and communities. The results of the interviews revealed that most of the respondents thought that SSI had a good impact on food diversification. Specifically, 105 of 200 respondents (52.5%) said SSI significantly improved the diversity of meals consumed in their homes. In comparison, another 73 respondents (36.5%) reported that SSI increased the diversity of foods consumed to some extent (Table 6.12).

Table 0-12 Respondents' evaluation towards the contribution of SSI to the diversity of food consumed.

	N	%	Valid Percent	Cumulative Percent
Greatly Increasing	105	52.5	52.5	52.5
Increasing	73	36.5	36.5	89
Fluctuating	22	11	11	100
Total	200	100	100	

Sources: Household Survey (2022)

Therefore, these findings suggest that SSI is perceived as an effective strategy to improve food access and dietary diversity among rural smallholder communities. Positive attitudes shown by SSI users may inspire other smallholders to adopt SSI techniques, perhaps leading to further gains in food security and nutrition in Wolaita Zone. Therefore, the study adds the function of SSI in enhancing food access and dietary diversity in rural smallholder communities, showing the potential benefits of this method in terms of health and well-being.

The food consumption patterns of small farmers in rural areas are complicated and varied, affected by factors such as income, market access and cultural customs. The study highlighted the specific crop types that these households consume, with varying amounts and frequencies depending on individual household capacity and other factors. The data can be used to guide actions to improve food access and nutrition in these populations. Irrigation has considerably improved food availability in the Wolaita districts, allowing access to a wider variety of healthy foods and resulting in improved health outcomes, especially for pregnant women and children under the age of five years of age. Better job options and income conditions have also helped the community, therefore, leading to better health and productivity. Knowing the food consumption habits of small farmers is critical to devise effective treatments that target their requirements and contribute to improved health outcomes. The qualitative analysis reveals the impact of irrigation on the community's diet, leading to the addition of new crops and fruits, improved food security, and access to a wider variety of nutritious food, including animal products. SSI increased food security and nutrition for all members (children, pregnant women, and men). The quantitative findings illustrated the changes in food consumption patterns that occurred after the implementation of irrigation, contributing to improved nutrition and dietary diversity for the population. Therefore, irrigation contributed to the diversification of food and the consumption patterns in the Wolaita.

6.3 SUMMARY

This chapter examined the impact of SSI on food availability, diversification, and nutrition of rural smallholder households in the Wolaita zone of southern Ethiopia. The qualitative analysis was conducted in different kebeles and districts of the Wolaita zone in southern Ethiopia, highlighting the impact of irrigation on the community's diet, leading to the addition of new crops and fruits, improved food security, and access to a wider variety of nutritious food, including animal items for all members, including children, nursing mothers, and pregnant women in all kebele samples. The findings illustrate changes in food consumption patterns that occurred after the implementation of irrigation, contributing to improved nutrition and dietary diversity for the population. Therefore, the findings indicate the role of irrigation in rural smallholder's food diversification in Wolaita, southern Ethiopia.

CHAPTER 7

THE ROLE OF SMALL-SCALE IRRIGATION ON FOOD SECURITY OUTCOMES

7.1 INTRODUCTION

In this chapter, the results of qualitative and quantitative studies on the impact of SSI on the rural smallholder food security outcomes are presented. The analysis begins by examining the role of irrigation in the outcomes of food security among small-scale rural farmers. Linear multivariate regression is used to analyse the three acute food security indicators. The predictor variables selected for the regression analysis are total crop produced, total livestock unit (TLU) value of livestock owned by the household, sum of purchased food group, income from crop sales and income from animals, animal by-products and other asset sales. Furthermore, the sum of HDDS is used as an independent variable to analyse HHS as a dependent variable, and predictor variables are identified for each of the two acute food security outcome indicators through multivariate regression. Furthermore, the results of three acute food security outcome indicators HDDS, HHS, and WHCSI are analysed using independent sample t-tests and descriptive statistics for two groups: users and non-users. Other outcomes of food security are also examined in this chapter. It also indicates the findings from qualitative analysis. Finally, it explains the qualitative and empirical findings on the role of SSI in achieving three acute indicators of food security outcomes HDDS, HHS and WHCSI.

7.2 IRRIGATION AND FOOD SECURITY OUTCOMES

This subsection focuses on measuring the role of SSI on food security outcomes using three acute food security indicators and other variables. Food security outcomes refer to long-term changes that occur within a household. In the previous chapter (Chapter 6), the HDDS was analysed, and the results and conclusions presented there apply similarly to this chapter. However, in this chapter, the HHS, and Household Coping Strategy Index (WHCSI) are presented in detail. Previous research has shown that analysing food security outcomes using only one indicator does not fully represent the multidisciplinary nature of food security. Therefore, this research integrates more than two indicators to cover all concepts in the definition of food security. Although the HDDS is frequently used to analyse food security, it is not integrated with other indicators to fully understand the multidisciplinary nature of food security. Therefore, irrigated agriculture is an essential ingredient for sustainable livelihoods in the developing world (Gurmu et al., 2019). Moreover, the role irrigation agriculture plays in food security outcomes must be adequately documented, evaluated, and analysed. Therefore, in this research, the HHS and the WHCSI were added and integrated with HDDS to analyse the gap observed in previous studies.

Food security outcomes are referred to as having sufficient, safe, and nutritious food available to suit one's dietary needs and preferences for an active and healthy life. It is a complicated situation that is affected by several variables, including food availability, accessibility, use, and stability. In addition, food security outcomes can be measured on numerous scales, including the household, the local community, and the international levels. Food availability, accessibility and consumption inside the home are often considered when evaluating food security results at the home level. This includes elements such as the variety of the diet, the quantity and quality of food ingested and the consistency of food access throughout time.

On the contrary, climate change, lack of access to health services, education, and lack or shortage of resources are the main causes of food insecurity. This could involve actions to boost infrastructure, social protection systems, agriculture productivity, and the development of sustainable food systems.

In Ethiopia, irrigation is considered essential to ensure food security and is crucial to improving livelihoods and lifting people out of poverty (Debele & Mohammad, 2016). The HHS is a new and straightforward indicator used to measure household hunger in food-insecure areas (USAID FANTA Project, 2011). Unlike other indicators of household food insecurity, the HHS has been specifically developed and validated for cross-cultural use. This means that the HHS delivers results that are valid and comparable between cultures and circumstances, allowing meaningful and comparable assessments of the status of various demographic groups. These data can be used to determine where resources and programmatic interventions are required, as well as to create, implement, monitor, and evaluate policy and programmatic interventions. The HHS module covers a recall period of 30 days (USAID FANTA Project, 2011), and the construction of the HHS calculation was discussed in detail in Chapter 4. The mean value of HHS was compared among SSI users and non-users to better understand the effect of SSI on food security outcomes.

Compared to the group of SSI non-users, the group of SSI users had lower values for the variable sum of occurrence questions by sample rural households (mean = 0.22, standard deviation = 0.584), according to the data shown in Table 7.1. This indicates that SSI users experienced fewer occurrences of hunger and food insecurity during the recall period of 30 days than SSI non-users. SSI helps rural smallholders achieve better food security outcomes by reducing food insecurity, according to the difference in means between the two groups.

Table 0-1 Response of sampled households to the 'occurrence question' of Household Hunger scale.

	N	Mean	Std. Deviation	Std. Error Mean
SSI Users	200	0.22	0.584	0.041
SSI non-users	200	1.22	1.057	0.075

Source: Household Survey (2022)

The results of Levene's test indicate that the p-value is 0.000, which is below the defined level of 5%. Therefore, the test is statistically significant and the null hypothesis of equality between variances of the sample is rejected. This means that variance equality cannot be assumed. The independent samples t-test shows a significant difference between the two groups (with no assumption of equal variance). At 95% confidence level, the lower and higher values are -1.173 and -0.837, respectively, and the p-value was 0.00 (Table 7.2). The t-value was -11.772 (df=309.987). These findings imply that the variable under consideration differs significantly between the two groups. The data suggest that SSI users and non-users have significantly different food security outcomes.

Table 0-2 Independent sample t-test of the 'occurrence question' of the sample household

	Levene's Test for Equality of variance		t-test for Equality of Means							
					Significance				95% Confidence Interval	
	F	Sig.	t	df	One - sided p	Two-sided P	Mean Difference	Std. Error Difference	Lower	Upper
Equal variance assumed	167.22	0.00	-11.77	398	0.000	0.000	-1.005	0.085	-1.17	-0.84
Equal variance not assumed			-11.77	309.99	0.000	0.000	-1.005	0.085	-1.17	-0.84

Source: Household Survey (2022)

The Household Hunger Scale (HHS) is a technique for determining how much food is available in a family constantly. The test consists of six questions, three regarding "occurrence" and three about "frequency of occurrence." In this instance, the answers to the occurrence questions revealed that households that do not use SSI experienced these circumstances more frequently than those that do. For example, according to the household survey, out of 200 respondents, only 19 SSI user households responded "yes" to the occurrence question "ever no food to eat of any kind" within 30 days before data collection date. However, 91 non-user households did experience this situation. Similarly, 113 non-user respondents responded "yes" to the occurrence question "go to sleep at night hungry", while only 23 households of users reported experiencing this situation (Table 7.3).

Finally, 40 non-user responders who were asked if they had ever gone a full day and night without eating anything gave the affirmative, indicating that they had gone the entire time. These findings imply that households that use SSI are less likely to face food insecurity than non-SSI households.

Table 0-3 Responses to three occurrence questions of respondents

HHS occurrence frequency	SSI Users			SSI non-users		
	Responses		Percent of Cases	Responses		Percent of Cases
	N	%		N	%	
ever no food to eat of any kind	19	42.20	63.30	91	37.30	71.10
go to sleep at night hungry	23	51.10	76.70	113	46.30	88.30
go an entire day and night without eating anything	3	6.70	10.00	40	16.40	31.30
Total	45	100.00	150.00	244	100.00	190.60

Source: Household Survey (2022)

The HHS also includes three frequency-of-occurrence questions. The questions investigated how frequently a circumstance occurred in the last 30 days. In contrast to the SSI non user group, the SSI user group exhibited lower values for the variable "frequency-of-occurrence," according to the study of the HHS data.

The mean value of the SSI user group for the frequency of occurrence variable was 0.29, with a standard deviation of 0.818. The situations described in the frequency-of-occurrence questions occurred relatively infrequently in households that use SSI. In contrast, the SSI non-user group's mean value for the frequency-of-occurrence measure was 2.07 with a standard deviation of 1.784. (Table 7.4.). Households without access to SSI experienced the events described in the frequency-of-occurrence questions frequently. The findings offer evidence that SSI reduced food insecurity and improved sustainable access to food by households.

Table 0-4 Responses to "frequency-of-occurrence" questions

	N	Mean	Std. Deviation	Std. Error Mean
SSI Users	200	0.29	0.818	0.058
SSI non-users	200	2.07	1.784	0.126

Source: Household survey (2022)

The p-value for Levene's test was 0.000, which is < 0.05. Therefore, the null hypothesis is rejected and the variance of the two groups i.e., users and non-users are not equal. Therefore, a t-test for independent samples with not assumed equal variances was used because it was discovered that the variances were unequal. At the 95% confidence interval, the T and P values are -12.829 (df=279.185) and 0.00, respectively. The mean difference between the two groups is statistically significant. The mean confidence interval ranges from -2.053 to 2.507 (Table 7.5). As a result, SSI users and non-users had significantly different levels of sustainable food availability.

Table 0-5 Independent sample t-test for the responses to the "frequency of occurrence" questions.

	Levene's Test for Equality of variance		t-test for Equality of Means							
					Significance				95% Confidence Interval	
	F	Sig.	t	df	One - sided p	Two-sided P	Mean Difference	Std. Error Difference	Lower	Upper
Equal variance assumed	251.67	0.00	-12.83	398	0.000	0.000	-1.78	0.139	-2.05	-1.51
Equal variance not assumed			-12.83	279.19	0.000	0.000	-1.78	0.139	-2.05	-1.51

Source: Household Survey (2022)

In addition to conducting an independent t-test to investigate the relationship between selected variables, HDDS and HHS, a multivariate regression analysis was also performed. The variables selected for the regression analysis were the total crop produced, the value of the total livestock unit (TLU) of livestock owned by the household, the sum of purchased food groups, income from crop sales and income from the sale of animals, animal by-products, and other assets. Furthermore, the HDDS sum was used as an independent variable to analyse its impact on the HHS, which was used as the dependent variable in the regression analysis. Before performing the multivariate linear regression analysis, several assumptions were tested. There were eight assumptions in total, which are as follows:

- A continuous scale should be used to assess the dependent variable.

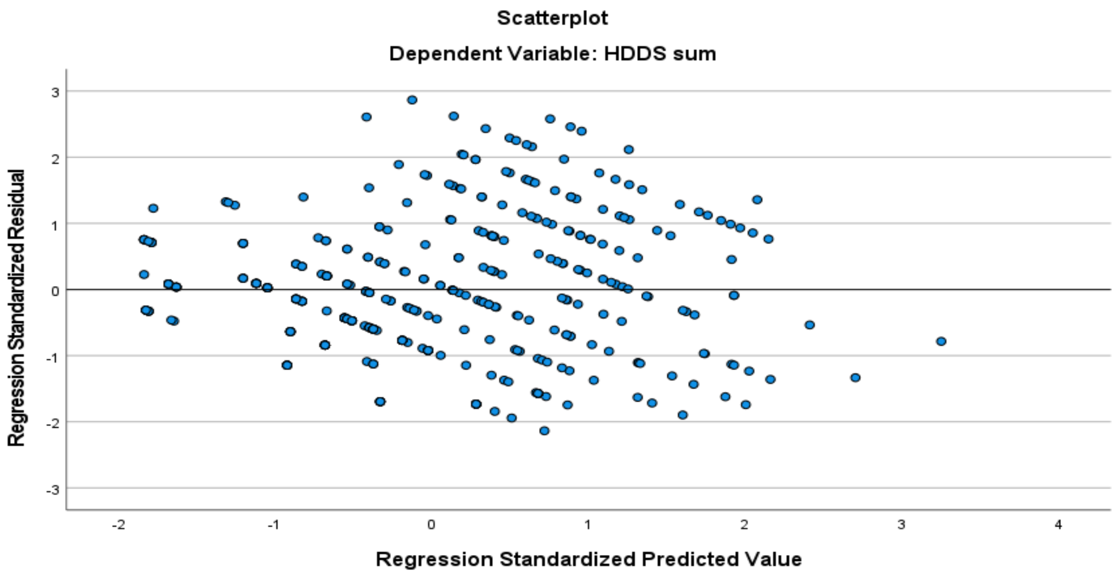
- Two or more independent variables should be continuous or categorical means.
- The scatterplot can be used to determine whether three or more variables of interest have a linear connection.
- The data should show homoscedasticity, and the variance of the residual should be constant.
- There should be multicollinearity between two or more independent variables or be not highly correlated. The tolerance value should be >0.1 and the VIF <10.
- There should be no spurious outliers or influential cases that bias the model. Cook distance statistics values greater than 1 are likely to be significant outliers, which may place undue influence on the model.
- The residuals, or errors, should roughly follow a normal distribution. This can be verified by charting the standardised residuals using a normal Q-Q plot or a p-p plot, or by using a histogram with a normal curve overlay. The residuals are closer to normal the closer the dots lie to the diagonal line.
- The value of the residuals should be independent, which can be checked using the Durbin-Watson test. The Durbin-Watson test range is between 0 and 4, with a value of 2 indicating no autocorrelation. This study used the Durbin-Watson test value range of the Durbin-Watson test from <1 and >3.

After testing these assumptions, the independent variables were first regressed with HDDS and then with HHS. Both HDDS and HHS are continuous variables, and all independent variables are continuous and categorical. Additionally, all dependent variables and independent variables were found to be linearly related, which was checked using scatter plots.

To verify homoscedasticity in the data, standardised residual plots were produced against the unstandardised predicted values. Because of homoscedasticity, the residual variance is constant, and the line of best fit does not change as the data points move down the line in either a positive or negative direction. To test for homoscedasticity, scatter plots were also utilised.

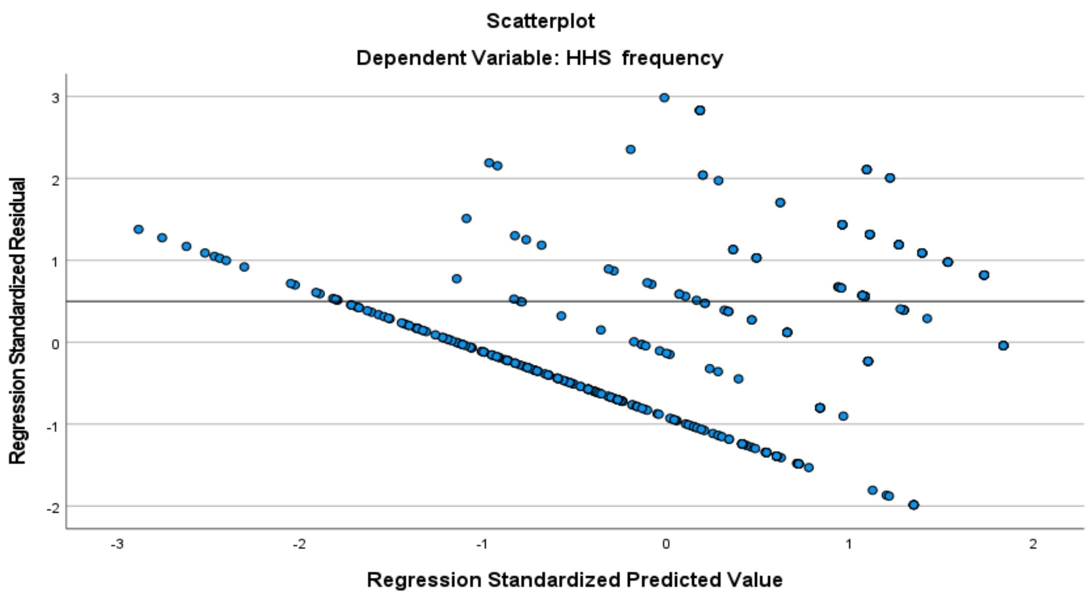
Figure 7.1 displays the scatter plot for the HDDS, and Figure 7.2 displays the scatter plot for the HHS. According to the survey findings, there is no evidence of heteroskedasticity in the data, which means that the variance of the residual is constant, and the variance of the dependent variable does not significantly differ over the range of the independent variable.

Figure 0-1 scatter plot of Households' Dietary Diversity score



Source: - Household Survey (2022)

Figure 0-2 Scatter plot of Household Hunger scale



Source Household Survey (2022)

The Household Hunger Scale was also subjected to a multicollinearity test using Tolerance and VIF scores. Tolerance and VIF values were greater than 1 and less than 10, respectively. In other words, the independent variables are not significantly correlated with each other and affect the regression result. Therefore, there is no multicollinearity.

Table 0-6 Collinearity statistics and standardised coefficients of independent variables

Coefficients [a]												
	Unstandardised Coefficients		Standardised Coefficients			95.0% Confidence Interval for B		Correlations			Collinearity Statistics	
Model 1	B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
(Constant)	3.073	0.269		11.45	0.000	2.545	3.601					
Total Crop produced	0.012	0.002	0.299	6.772	0.000	0.008	0.015	0.536	0.323	0.250	0.699	1.431
Sum of purchased food groups	0.283	0.058	0.189	4.855	0.000	0.168	0.397	0.372	0.238	0.179	0.896	1.116
TLU	0.022	0.057	0.016	0.384	0.701	-0.089	0.133	0.267	0.019	0.014	0.783	1.276
Income from crop sell	0.155	0.022	0.381	7.066	0.000	0.112	0.198	0.597	0.335	0.261	0.469	2.130

Income from animals, animal products and other assets sold	0.001	0.018	0.001	0.030	0.976	-0.035	0.036	0.355	0.002	0.001	0.562	1.779

a. Dependent Variable: HDDS sum

Source: - Household Survey (2022)

The Household Hunger Scale was also subjected to a multicollinearity test utilising Tolerance and VIF scores. Based on the survey results, the tolerance and VIF values were revealed to be greater than 1 and less than 10, respectively (as given in Table 7.7). In other words, the independent variables are not strongly connected and have no negative impact on the results of the regression analysis. This demonstrates that the variables do not have significant multicollinearity.

The impact of erroneous outliers was examined for both the HHS and the HDDS to compensate for situations that can potentially skew the model (HHS). Cook distance statistics was used to identify cases that may have a significant impact on the model. A Cook distance value of 1 or greater is a significant outlier, as it may have an undue influence on the model. Based on the survey results, the Cook distance values for all the data were found to be below 1. Thus, there were no significant outliers that could bias the model for either the HDDS or the HHS. The results of the regression analysis were not influenced by any influential cases or spurious outliers.

The independence of the residuals was analysed using the Durbin-Watson test, which has a range of values from 0 to 4. Although the literature suggests various acceptable value ranges, for this study, the range of values from less than 1 to greater than 3 was deemed suitable for analysis. According to survey data, the HHS had a Durbin-Watson value of 1.401 and the HDDS had a Durbin-Watson value of 1.257. The residuals for the HDDS and HHS indicated a modest positive autocorrelation. Although not strong enough to have a substantial impact on the outcomes, it is appropriate to accept the validity of the regression analysis results for both variables to the mentioned values.

Table 0-7 Collinearity statistics and standardised coefficients of independent variables

Coefficients [a]

Model 5	Unstandardised Coefficients		Standardised Coefficients		Sig.	95.0% Confidence Interval for B		Correlations			Collinearity Statistics	
	B	Std. Error	Beta	T		Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
(Constant)	3.523	0.198		17.75	0.00	3.133	3.913					
Income from crop sell	-0.08	0.016	-0.30	-4.936	0.00	-0.11	-0.05	-0.51	-0.24	-0.19	0.421	2.37
Total crop produced	-0.00	0.001	-0.18	-3.604	0.00	-0.01	-0.01	-0.48	-0.18	-0.14	0.628	1.59
Total livestock unit	-0.18	0.038	-0.21	-4.687	0.00	-0.25	-0.11	-0.35	-0.23	-0.19	0.786	1.27
HDDS sum	-0.13	0.033	-0.21	-3.955	0.00	-0.20	-0.07	-0.50	-0.20	-0.16	0.571	1.75
Income from animals, animal products and other assets sold	0.025	0.012	0.106	2.030	0.04	0.001	0.049	-0.28	0.102	0.080	0.562	1.78

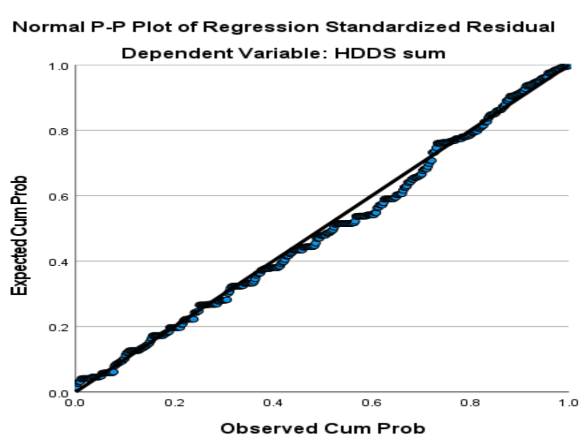
a. Dependent Variable: HHS frequency

Source: - Household Survey (2022)

To verify the normality distribution of the residuals, a histogram was plotted, and a p-p plot was used to plot the standardised residuals. The closer the dots on the p-p plot lie to the diagonal line, the closer the residuals are to be normally distributed.

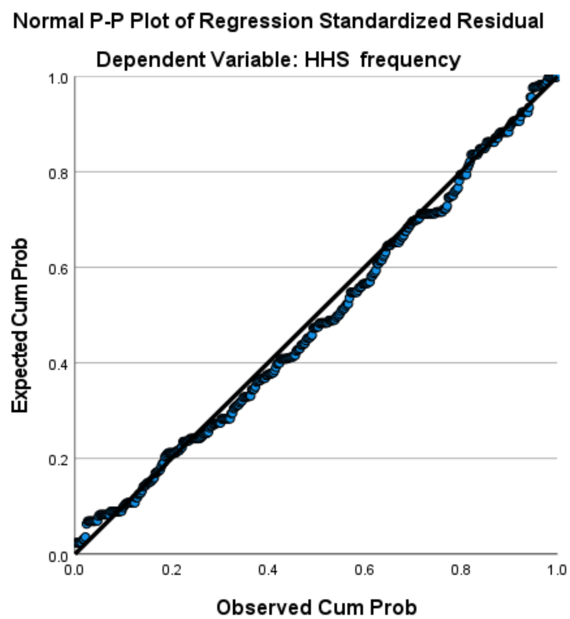
The Household Hunger Scale and Household Dietary Diversity Score p-p plots show that the points are extremely close to the diagonal line, suggesting that the residuals are distributed normally based on the survey findings. The residuals for both variables are roughly normally distributed, according to a histogram that was also used to test for normality.

Figure 0-3 The P-P plot of the Household Dietary Diversity Score



Source: - Household Survey (2022)

Figure 0-4 The P-P plot of the Household Hunger Scale



Source: - Household survey (2022)

The equation of the multivariate linear regression analysis was carried out once it was confirmed that all the presumptions were true. The F-test was used to gauge the model's fitness at the initial stage of this investigation.

The p-value is less than 0.05 at alpha level 0.05 and is considered statistically significant. The F-value of the HDDs was 67.936 and the P value is 0.001, or less than 0.05. (Table 7.8). Regression analysis is, therefore, statistically significant, and the model is regarded as suitable for forecasting HDDS. This indicates that the HDDS is significantly predicted by at least one independent variable in the model.

Table 0-8 The F statistics of the regression for the dependent variable HDDS

Model 1	Sum of Squares	Df	Mean Square	F	Sig.
Regression	1225.21	5	245.042	67.936	<.001
Residual	1421.15	394	3.607		
Total	2646.36	399			

Source: Household Survey (2022)

The fitness of the model and the F-test were used to assess the statistical significance of the regression model for the HHS, in a manner like that used for the analysis of the HDDS.

The independent variables are not significant predictors of the dependent variable, according to the null hypothesis that all regression coefficients are equal to zero, which was put to the test using the F-test. The alternative hypothesis is that the model is statistically significant and that the independent variables significantly affect the dependent variable if at least one coefficient differs from zero.

The relationship between the independent predictor variables and the dependent variable is clarified by regression analysis for the HHS. The p-value below 0.05 is accepted as statistically significant below the 0.05 alpha level. The F-value and p-value are 48.109 and 0.002 respectively, which is less than 0.05. As a result, the HHS regression model is statistically significant and independent factors significantly affect the dependent variable.

With a significant F-value of 48.109 and a p-value of 0.002, which is less than the alpha threshold of 0.05, the survey data reveal that the regression analysis for the HHS is statistically significant (as shown in Table 7.9). This shows that the HHS can be significantly predicted by at least one independent variable in the model.

In general, both the HDDS and HHS regression models were found to be statistically significant and fit for predicting the respective dependent variables. These results provide a significant understanding of the link between the independent predictor variables and the dependent variables and can be utilised to base predictions on this relationship.

Table 0-9 The F statistics of the regression for the dependent variable Household Hunger Scale.

Model 5	Sum of Squares	Df	Mean Square	F	Sig.
Regression	416.702	5	83.34	50.436	<.001
Residual	651.048	394	1.652		
Total	1067.75	399			

Source: Household Survey (2022)

After conducting all the tests and checking the fitness of the regression models, the predictor-independent variables were identified by examining the corresponding t-values and their significance. This was done to determine which independent variables significantly predict the dependent variable.

For the dependent variable HDDS, the t-values for the total crop produced, the sum of purchased food groups and the income from crop sales were found to be statistically significant at an alpha level of 0.05, as their corresponding p-values were less than 0.005. However, the t-values for total livestock units (TLU) and income from animal, animal by-products and other asset sales were not statistically significant, since their corresponding p-values were greater than 0.005, specifically 0.701 and 0.976, respectively (as shown in Table 6.6).

The standardised coefficients for the total crop produced by the predictor variables, the sum of food groups purchased and the income from crop sales were found to be 0.299, 0.189, and 0.381, respectively. The intercept value was found to be 3.073. These results indicate that the predictor variables total crop produced by the predictor variables, the sum of food groups purchased and income from crop sales have a significant positive influence on HDDS, while TLU and income from animal, animal by-products and other asset sales do not significantly predict HDDS.

Similarly for the dependent variable HHS, at alpha 0.05 the t-values of all independent variables except the sum of purchased food groups are statistically significant because their corresponding value is less than 0.005 (Table 7.6.). Therefore, the predictor variables are income from crop sale, total crop produced, total livestock unit, HDDS and income from animals, animal by-products and other assets sold. The standardised coefficients of each predictor variable are indicated in Table 7.6.

The standardised coefficients of the independent predictor variables for the HDDS were calculated based on the findings of the regression analysis. When considering the impacts of the other independent variables in the model, these coefficients show how much impact each independent variable has on the dependent variable.

The multivariate linear regression model is changed to include the standardised coefficients to use these data to produce predictions for the HDDS. This allows for the estimation of the HDDS based on the values of the predictor-independent variables. By entering the values for an independent variable, the equation can be used to predict the value of the dependent variable for a predictor variable. In general, regression analysis is used to understand the relationship between predictor-independent variables and the dependent variable.

$$HDDS = 3.073 + 0.299\,X1 + 0.189X2 + 0.381X3 + \epsilon$$

Where: -

X1= total crop produced

X2= sum of the purchased food groups

X3= income from crop sell

Є = residual standard deviation (error)

Therefore

- For every single unit increase in HDDS, the total crop produced increases by 0.299, with other predictors X2 and X3 kept constant.
- For every single unit increase in HDDS, the sum of purchased food groups increases by 0.189, with other predictors X1 and X3 kept constant.
- For every single unit increase in HDDS, the income from crop sales increases by 0.381, with other predictors X1 and X2 kept constant.

For the dependent variable HHS, a similar analysis was conducted to identify which independent variables significantly predict the HHS. At an alpha level of 0.05, the t-values were examined to determine which independent variables have a significant influence on HHS.

Based on the results of the survey, the t-values for the income from crop sales, total crop produced, total livestock units (TLU), the household diet diversity score (HDDS) and the income from animal, animal by-products and other assets were found to be statistically significant, as their corresponding p-values were less than 0.005. However, the t-value for the total number of food categories purchased was not statistically significant because its associated p-value exceeded 0.005.

The standardised coefficients were determined to be -0.179, -0.299, -0.206, -0.208 and 0.106 for the predictor variables total crop produced, income from crop sold, HDDS, TLU and income from animal, animal by-products, and other assets, respectively. The intercept value was found to be 3.523. These results indicate that the predictor variables income from crop sale, total crop produced, TLU, and HDDS have a significant negative influence on HHS. However, income from animal, animal by-products and other assets have significant positive influence on HHS, while the sum of purchased food groups does not significantly predict HHS.

In summary, this examination offers valuable insight into the connection between predictor-independent variables and HHS, which can be utilised to forecast based on this association. When calculating the standardised coefficients for the independent predictor variables in the regression analysis of the HHS (HHS), these coefficients can be used to formulate a multivariate linear regression equation to predict the HHS. To do this, the standardised coefficients are substituted into the equation, along with the corresponding values of the predictor-independent variables. This enables the calculation of the HHS using the predictor variables' values. By entering the suitable values for each independent variable, the formula can be utilised to forecast the corresponding dependent variable value for a specific set of predictor variables. The multivariate linear regression formula serves as an effective method for predicting the HHS by examining the connections between the independent predictor variables and the dependent variable, which is established through regression analysis.

$$HHS = 3.523 - 0.179X1 - 0.299X2 - 0.208X3 - 0.206X4 + 0.106X5 + \epsilon$$

Where: -

X1= total crop produced

X2= Income from crop sell

X3 = total livestock unit

X4= HDDS

X5= Income from the sale of animals, animal products, and other assets sold

Therefore

- For every single unit increase of HHS, the total crop produced reduces by 0.179, with other predictors X2, X3, X4, and X5 kept constant.
- For every single unit increase of HHS, the income from crop sell reduces by 0.299, with other predictors X1, X3, X4, and X5 kept constant.
- For every single unit increase of HHS, the total livestock unit reduces by 0.208, with other predictors X1, X2, X4, and X5 kept constant.
- For every single unit increase in HHS, the Household Dietary Diversity reduces by 0.206, with other predictors X1, X2, X3, and X5 kept constant.
- For every single unit increase of HHS, the total income from animals, animal by-products, and other assets sold rises by 0.106, with other predictors X1, X2, X4 and X5 kept constant.

Based on the findings of the regression analysis for both the HDDS and the HHS, it can be concluded that several independent variables are significant predictors of smallholder rural household food security outcomes.

These predictors include total crop produced, income from crop sales, sum of purchased food groups, total livestock units (TLU), HDDS, and income from animals, animal by-products, and other assets. By integrating the HDDS and HHS predictors, it becomes clear that these independent variables play a crucial role in determining the food security outcomes of small-holder rural households. Therefore, these findings highlight the importance of addressing these key predictors in efforts to improve the outcomes of food security for rural smallholder households.

Since the dependent variable, the HCSI score did not satisfy all the assumptions for regression analysis with the independent predictor variables, it was analysed using an independent sample t-test. Before the analysis, FGD was conducted to identify the behaviour of rural smallholders when there is a shortage or lack of resources or food in the kebeles of the sample district of the Wolaita Zone. Coping strategies are cognitive and behavioural tactics used to manage crises, conditions and demands that are judged as distressing. Strategies (or action sets) are used by an agent to restore its well-being in stressful situations. The coping strategies indicated here describe what happened during the last seven days of the data collection month in 2022. In addition, respondents were asked what they do when faced with food shortages or lack of food for their families. After identifying short, medium, and long-term strategies, those that occurred within the aforementioned last seven days were identified and compared with the behaviours identified in the coping strategy index field manual (Tian et al., 2013).

The coping behaviour identified during male and female FGD in sample kebeles of Wolaita Zone, male focus group participant from Damot Gale-Buge kebele responded that:

> ‘When we do not get better income, in times of crisis, for example, if there is a female sheep, we sell the calf, by reducing the diet we eat during production, by eating different food from the food we eat when there is enough food’ (Participant 12, Male FGD_ Damot Gale-Buge).

Similarly, other participants describe that:

> ‘When there is not enough food, I use this strategy to deal with the problem by going out to the city to do labour and earn money to buy food, selling the animals at home, going to relative's house to borrow money and buy food, by going to the house of moneylenders with long-interested money, by going to a relative's house to beg food or money’ (Participant 7, Male FGD _Damot Gale-Buge) .

When the stress or shock prolongs and stays present for a long period, the coping mechanism will change accordingly, and more serious measures will be utilised.

Both women and men focus group participants will employ these strategies, if this crisis continues.

> 'If the problem becomes more permanent, I use strategies to get food by selling items in the house. If it is very difficult, selling some things at home and going to the market to get food, begging for food, by working in the fields of peasants who have large land and wealth, bringing out the produce of the house that was safely kept at home before and selling it to the market, earning money and buying food, going to a family/relative's house/ and borrowing food or money, by getting long-term money by mortgaging land with interest' (Participant 10, Female FGD_Damote Gale-Buge).

Female focus group participants were able to help themselves and their families by gathering charcoal, picking wood, making cobblestones, loading stones, and performing day labour at the irrigation site when the farmer was short of food or money. Furthermore, participants agreed with the strategies discussed before and added that: 'by mowing grass and selling it on the roadside, extracting sand' (Participant 3, female FGD_ Abela Abaya- Abela Mareka). Moreover, 'by letting our children drop out of school' (Participant 2, Female FGD_ Abela Abaya-Abela Mareka). Therefore, these are some of the main coping strategies implemented by women in Abaya-Abela Mareka. The coping strategies implemented are also variable for rural households that participate in irrigation and who do not. Therefore, according to the findings of this research, it is crucial to note those engaged in irrigation are resilient to shocks.

Coping strategies indicated during the male and female FGDs in Abela Abaya-Abela Mareka, Damot Woyde - Adecha, Boloso Sore-Gurumo Koisha and Humbo-Ampo Koisha kebeles were summarised as follows: Going to investors for daily work to retain food and receiving monthly or daily payments; earning food or money by renting someone else's land; going to the forest and collecting wood and selling them to buy food; going to different organisations and doing security; doing various labour jobs; participating in labour in the market; cultivating the land together with a man and by borrowing food or money from a merchant (for example, if they lose food this year, and they borrow 100 kg of maize from a merchant, they will give 200 kg next year). However, women and men using the irrigation system resist better than non-users. Women and men who are non-users of irrigation have to depart to the irrigation area and do collective farming and participate in various agricultural works on the irrigated fields (For example, digging up and harvesting onions, digging potatoes, harvesting maize). Therefore, rural smallholders implement the aforementioned coping strategies in the Wolaita Zone, southern Ethiopia, during the shortage of food and money. The coping behaviour identified was related to the field manual and found similar. Therefore, owing to the similarity between the identified coping behaviours and those of the field manual, they were used for quantitative analysis (Table 7.10).

Table 0-10 Coping strategy behaviours and their weight of severity.

Behaviours	Weight given for the behaviours
Rely on less preferred and less expensive foods	1
Borrow food, or rely on help from a friend or relative	2
Purchase food on credit	2
Gather wild food, hunt, or harvest immature crops	4
Consume seed stock held for next season	3
Send household members to eat elsewhere	2
Send household members to beg	4
Limit portion size at mealtime	1
Restrict consumption by adults for small children to eat	2
Feed working members at the expense of non-working members	2
Reduce the number of meals eaten in a day	2
Skip entire days without eating	4

Source: Household survey (2022) and (Tian et al., 2013)

The Household Coping Strategy Index is a relatively simple and quick tool that correlates well with more complex measures of food security. It involves asking households a series of questions about how they cope with a shortage of food for consumption, resulting in a simple numeric score ranging from 0 to 7.

The severity of each coping strategy was also considered, with a weighting system of 1 to 4. The sum of the frequency of each specific behaviour multiplied by its respective severity was calculated for all the listed behaviours related to the location in question. In the research, the mean HCSI score of the population was calculated taking the sum of all HCSI scores and dividing it by the total number of households assessed. Therefore, the use of HCSI offers crucial knowledge on the coping mechanisms households employ to deal with food scarcities, ultimately helping to develop a more complete understanding of the state of food security within the examined population.

In the sample of rural households, households that use the SSI system demonstrated a lower weighted HCSI variable. The mean score for this group was 3.7300, with a standard deviation of 8.78310. On the contrary, the group of households that did not use the SSI system had a higher mean score of 7.8800 and a standard deviation of 7.77547 (as shown in Table 7.11.).

Table 0-11 Weighted HCSI of respondents.

	N	Mean	Std. Deviation	Std. Error Mean
SSI Users	200	3.73	8.7831	0.62106
SSI non-users	200	7.88	7.77547	0.54981

Source: Household Survey (2022)

The results of Levene's test indicate that the p-value is 0.000, which is below the defined level of 5%. This indicates that Levene’s test is significant and the null hypothesis of equality between variances of the sample is rejected. Therefore, it can be concluded that variance equality cannot be assumed.

A t-test for independent samples was conducted, with no equal variance assumed. The results in Table 7. 12 showed that there was a statistically significant difference between the means of the two groups, with a t-value of -5.003 (df= 392.233) and a p-value of 0.00 in a 95% confidence interval of [-5.78074, -2.51926].

Table 0-12 Independent sample t-test of the weighted HCSI of respondents

	Levene's Test for Equality of variance		t-test for Equality of Means							
					Significance				95% Confidence Interval	
	F	Sig.	t	df	One - sided p	Two-sided P	Mean Difference	Std. Error Difference	Lower	Upper
Equal variance assumed	12.12	0.00	-5.00	398	0.000	0.000	-4.15	0.82946	-5.7807	-2.5193
Equal variance not assumed			-5.00	392.23	0.000	0.000	-4.15	0.82946	-5.7807	-2.5193

Source: Household Survey (2022)

The results offer valuable insight into the distinctions between the two groups, indicating the possible existence of factors related to SSI utilisation that contribute to variances in coping mechanisms. The variation in scores indicates that SSI users possess more efficient coping mechanisms to manage food scarcity due to improved access to water for irrigation and increased agricultural production. The findings provide important information on the relationship between SSI use and household food security outcomes and may have implications for future interventions aimed at improving food security in similar contexts.

7.2.1 Income Generation

This section discusses the contribution of SSI to income generation such as income from farm and non-farm sources, as well as owned non-productive assets. In Wolaita Zone, rural smallholders produce crops and animals and generate income by selling these agricultural products. The surplus production that exceeds the consumption needs of the household is supplied to the local market. Based on the survey findings, the group of SSI users had higher values for the variable "income from annual crop production sold by sample rural households" (with a mean of 11,220.56 and a standard deviation of 7,771.08) compared to the group of non-users of SSI (with a mean of 4,439.15 and a standard deviation of 3,804.33) (as shown in Table 7.13).

SSI impacted the money from annual crop production by rural smallholders. ThaT SSI users had a higher mean value for the variable "income from annual crop production sold by sample rural households" shows that they had better access to water, which can result in higher crop yields and higher-quality crops. SSI users had better market access and sold crops at higher prices to earn income.

Table 0-13 Income generated from crop production by sample households in 2021.

	N	Mean	Std. Deviation	Std. Error Mean
SSI User	200	14221	7771.08392	549.49861
SSI non-user	200	4439.2	3804.32712	269.00655

Source: - Household survey (2022)

Levene's test yielded a p-value of 0.000, which is below the established significance level of 5%. Therefore, Levene's test is considered statistically significant, and the null hypothesis is rejected, indicating that there is no equality between the variances of the two samples. In other words, Levene's test for variance equality reveals that equal variances cannot be assumed. A t-test for independent samples (with unequal variances) indicated a statistically significant difference between the two groups, with a t-value of 15.988 (df=289.203), a p-value of 0.00, and a 95% confidence interval of [8577.19, 10985.53] (Table 7.14).

Table 0-14 Independent sample t-test of the income of the respondents generated from the sale of crops during 2021.

	Levene's Test for Equality of variance		t-test for Equality of Means							
					Significance				95% Confidence Interval	
	F	Sig.	t	df	One - sided p	Two-sided P	Mean Difference	Std. Error Difference	Lower	Upper
Equal variance assumed	82.00	0.00	15.99	398	0.000	0.000	9781.36	611.81	8578.6	10984.2
Equal variance not assumed			15.99	289.20	0.000	0.000	9781.36	611.81	8577.2	10985.5

Source: Household Survey (2022)

For total household income, an analysis was conducted on income generated from animals, animal by-products, and non-productive asset sales. The results indicate that the group of SSI users had higher values for 'Income generated from animals', animal by-products and other non-productive asset sales by sample rural households' (with a mean of 11741.73 and a standard deviation of 7997.40) compared to the group of non-users of SSI (with a mean of 5619.09 and a standard deviation of 6808.65) (Table 7.15.)

Table 0-15 Respondents' income from animals, animal by-products and non-productive asset sales.

	N	Mean	Std. Deviation	Std. Error Mean
SSI User	200	11742	7997.4	565.5
SSI non-user	200	5619.1	6808.65	481.44

Source: Household Survey (2022)

According to Levene's test, the p-value is 0.005, which is below the established significance level of 5%. Levene's test is considered statistically significant, and the null hypothesis is rejected, indicating that there is no equality between the variances of the two samples. Levene's test for variance equality reveals that equal variances cannot be assumed. A t-test for independent samples (with assumed non-equal variances) indicated a statistically significant difference between the two groups, with a t-value of 8.244 (df=388.120), a p-value of 0.00, and a 95% confidence interval of [4662.46, 7582.83] (Table 7.16).

Table 0-16 Independent sample t-test of income from animals, animal by-products, and non-productive assets

	Levene's Test for Equality of variance		t-test for Equality of Means							
					Significance				95% Confidence Interval	
	F	Sig.	t	df	One - sided p	Two-sided P	Mean Difference	Std. Error Difference	Lower	Upper
Equal variance assumed	7.839	0.005	8.24	398	0.000	0.000	6122.65	742.68	4662.6	7582.7
Equal variance not assumed			8.24	388.1	0.000	0.000	6122.65	742.68	4662.5	7582.8

Source: Household Survey (2022)

The 116 FGD participants, 25 (21.6%), 73 (62.9%) and 18 (15.5%) responded by very high, higher, and medium, respectively. Therefore, the finding emphasises the potential benefits of SSI in improving rural smallholder lives by increasing their income-generating ability through increased crop production and sales.

The source of income in sample kebeles is variable. Smallholders in Wolaita Zone engaged in farm products, non-productive asset sales, and other off-farm activities to generate income. The activities included salary/wage employment, small business ventures, and remittances from local and international sources. According to the survey results, 64 households (23.0%) of SSI users and 49 households (18.4%) of non-users were engaged in some form of small business activity. Additionally, two households (0.7%) of users and ten households (3.7%) of non-users relied on daily wage labour to supplement their income. Moreover, 12 households (4.3%) of users and eight households (3%) of non-users received income from remittances, which were sent by their relatives living both locally and internationally (Table 7.17). These remittances come in the form of money or items and are sent by household members to support their parents and families back home.

In summary, the survey results highlight the importance of non-farm activities in enhancing the income and livelihoods of rural smallholders in Wolaita Zone. These activities provide additional sources of income that can help to diversify household income streams and reduce dependence on farm income. Additionally, it can help boost the local economy by creating new jobs and business opportunities and can provide a safety net for households during periods of low agricultural productivity or income.

Table 0-17 Income sources respondents in the study area

Income sources [a]	Users			Non-users		
	Responses		Percent of Cases	Responses		Percent of Cases
	N	%		N	%	
Salaries/wages	2	0.70	1.00	10	3.70	5.00
Any small business	64	23.00	32.00	49	18.40	24.50
Remittances	12	4.30	6.00	8	3.00	4.00
Farm products sell	200	71.90	100.00	200	74.90	100.00

Total	278	100.00	139.00	267	100.00	133.50

a. Dichotomy group tabulated at value 1.

Source: - Household Survey (2022)

Qualitative analysis

Irrigation and Income Generation

According to the head of the agricultural office from five sample kebeles, irrigation has contributed well to revenue. Before irrigation, they used to earn income twice a year, i.e., in spring and autumn, when there is rain. However, since irrigation water is available all year, people can produce up to three rounds a year, helping them earn income in addition to the usual harvest. The market demand for irrigated crops is high because irrigation is produced in a dry form so that they earn a good income. Moreover, farmers were able to use different technologies so that they could make a profit. In the past, owing to the lack of roads, traders could not enter the sample kebeles and buy their products. But now traders are coming to these kebeles and buying the products. Products are being offered to the market owing to vehicle access. So, they are getting enough sources of income from home. Previously, people went to the city to earn money because their income was low. But now, since irrigation is here, farmers can produce and sell onions, chillies, peppers, cabbage, and tomatoes and earn income. Since 2014, they have earned a good income by supplying the wheat provided by the government to a nearby cooperative at market price. Road works have also affected the district city, kebele, and other nearby districts and kebeles. As a result, they sell the cheapest product at a reasonable price. Farmers who sit idle in the summer and dream of earning a large amount of money in the summer earn money now. In addition, farmers in irrigation areas benefited from daily wage employment during building, maintenance, cultivation, and harvest (Abela Abaya-Abela Mareka, Damot Woyde-Adecha, Boloso Sore-Gurumo Koisha and Humbo-Ampo Koisha).

Irrigation has played an important role in ensuring food security for socially disadvantaged sections of society by producing different types of food. By sowing maize of various best seeds, it benefited the people of Damot Gale- Buge kebele in a situation where all the farmers contributed greatly to earn income for himself and the people.

> ‘I made a big change at home by producing tomato, carrot, cabbage on a large scale and offering it to different markets and getting better income. For example, by selling tomatoes and buying a cow; it has become a special source of income for me and my family’ (Participant 2, KII_ Damot Gale - Buge).

Other participants explained the role of irrigation on income of rural smallholders owing to the availability of sufficient irrigation water.

> "We produce different types of crops every time and sell them to the market for family consumption. At various times, irrigation made its contribution to get special income by obtaining new products/seeds of cattle fodder, multiplying it in our farm and offering the feed to our cattle/bull/ and performing the fattening activity we sell livestock to the market. Family food consumption is sufficient, and even the marketing of tomatoes has raised internal income outside of the food supply. Since there are enough bundles of cabbage in the garden, it is very useful for the market.” (Participant 4, KII_ Damot Gale - Buge).

It contributed income so that ‘I can pay the annual tax on money that is sold during the production period. I was able to earn a special income by producing a better product and selling it on the market. Good income was obtained by selling tomato production to traders from Wachamo University in Badauche district’ (Participant 7, KII_ Damot Gale - Buge). The men in the focus group responded that irrigation has stabilised the market by producing surplus production through irrigation. Another thing is that our income has improved by growing different vegetables, and even our wives have helped make the weekly deposit by selling cabbages every week. Animal feed was available adequately since the introduction of irrigation (Participant 1, Male FGD_ Damot Gale-Buge).

Irrigation has contributed well to income. Previously, people went to the city to earn income because their income was low. But now, since irrigation has come, farmers can produce and sell onions, chillies, peppers, cabbage, tomatoes, mangoes, bananas, and avocados and earn income. With this income, they buy bulls, goats and chickens and rear them.

> ‘Previously, people in the area did not breed animals because there was no income owing to lack of surplus production. In 1977, the place was drought affected. Now, because of irrigation, the drought situation has changed, different trees are being planted and the land is mostly covered with permanent and annual crops. Owing to irrigation, the area has become favourable for agriculture and has generated income for users in the area, and it has also brought about climate change for the community living there. Animal feed is also available for the animal’ (Participant 6, KII_ Abela Abaya-Abele Mareka).

According to the participants in Grumo Koisha kebele, key informants from the community of Boloso Sore District and male and female participants in FGD. Since the introduction of irrigation, there has been a great improvement in income. Because of the irrigation that “we used to produce once or twice a year, it has more than doubled in production, quality and productivity, and when we get feed for animals year after year and fattening animals, it has brought a big change in our income. We produce and sell up to three times a year. Also, we fatten the bulls and sell, use, and sell the by-products from the cows, and therefore, we have been able to earn more income” (male and female KII, FGD _ Boloso Sore - Gurumo Koisha)

In addition, key informants and focus group participants in the Damot Woyde District - Adecha kebele, have described the contribution of irrigation to income.

> ‘From 2014, we have made a good income by providing the wheat provided by the government to a nearby cooperative at market price. As a result, we sell the cheapest product at the best price’ (Male and female KII, FGD _ Damot Woyde _ Adecha).

Therefore, according to both qualitative and quantitative findings, rural smallholder irrigation users in Wolaita Zone, southern Ethiopia produce surplus crop production and cultivate their land throughout the year. In addition, the availability of irrigation has contributed to enhance animal production at the household level. Therefore, they generate more income than non-users.

7.2.2 Nutrition and physical well-being

7.2.2.1 Irrigation, nutrition, and health status

In Ethiopia, health policy is designed to provide citizens with access to better health services at affordable prices. To ensure that everyone, including low-income urban households and rural farmers, has access to quality health care, the government has implemented a national health insurance scheme. This service is available to all people in rural areas at a minimum annual cost, to facilitate access to health care services for all.

The government encouraged all rural smallholders to enrol in this health insurance system, which provides free healthcare for any ailment. Because the insurance service is voluntary, people who are not interested can opt out of the registration procedure and receive health care on their own. According to the household survey, a large proportion of SSI users (92%) and non-users (96.5%) had registered for health insurance and could obtain free health care at government health institutions. This demonstrates the government's achievement in promoting increased access to health care for rural smallholders.

In addition, a significant proportion of smallholders reported having incurred healthcare expenses beyond what was covered by the health insurance scheme. Despite incurring additional costs, the survey found that almost all the respondents (97%) had benefited from the income generated through irrigation to cover these expenses. All the FGD respondents have also confirmed their contribution to the role of irrigation in the health status of household members in terms of the food group they consume and income to get access to any health services.

The survey also found that many smallholders had experienced sickness or injury in their households during 2021, with 66% of SSI users and 75.5% of non-users reporting such incidents. However, all members of the sick and injured household were able to receive curative and preventive services from government and private health institutions.

The government's efforts to provide inexpensive healthcare services to rural smallholders through the national health insurance programme have been successful, as evidenced by high enrolment rates and access to free healthcare services. The ability of smallholders to cover increased health care expenses through irrigation income demonstrates the interconnection of several development measures and their potential to improve the overall quality of life of rural communities.

According to survey data, SSI users have lower annual health expenditures than non-users. The mean value for the expenditure on health services use among SSI users was 4410.01 (with a standard deviation of 5800.02), while it was 5760 (with a standard deviation of 4981.61) among non-users (Table 7.18).

This disparity in health spending can have serious consequences for smallholders' well-being and economic stability. Lower health spending among SSI users may imply better access to preventive health care services or that they are more likely to seek treatment at an earlier stage of illness, when expenses may be lower. This can result in improved health outcomes and a lower cost burden for households.

Greater health spending among non-users, on the other hand, may indicate that they are less likely to have access to preventive health care services or that they wait until their disease has worsened before seeking treatment, resulting in greater expenditures. Individuals and households may suffer due to lower health outcomes and a higher financial burden.

The disparity in health expenditures between SSI users and non-users emphasises the benefits of irrigation and other rural development interventions for enhancing rural populations' health and well-being. Interventions lower health care costs and improve health outcomes by promoting more access to preventive health care services and encouraging rapid search for treatment, therefore, contributing to more sustainable and inclusive rural development.

Table 0-18 Group statistics of health services expenditure in 2021.

	N	Mean	Std. Deviation	Std. Error Mean
SSI user	200	4410	5800.02	410.12
SSI non-user	200	5760	4981.61	352.25

Sources: - Household Survey (2022)

Levene's test yielded a significant result with a p-value of 0.024, which is below the defined level of 5%. This indicates that the null hypothesis of equality between variances of the sample is rejected, and it cannot be assumed that the variances are equal.

A t-test for independent samples was conducted, assuming unequal variances. The results of the t-test showed that the difference between the two samples was statistically significant, with a t-value of -2.497 (df = 389.13) and a p-value of 0.006 at a 95% confidence level. The confidence interval was between -2412.92 and -287.07, indicating that there was a significant difference between the means of the two groups (Table 7.19).

Table 0-19 Independent sample t-test of health services expenditure in 2021

	Levene's Test for Equality of variance		t-test for Equality of Means							
					Significance				95% Confidence Interval	
	F	Sig.	t	df	One - sided p	Two-sided P	Mean Difference	Std. Error Difference	Lower	Upper
Equal variance assumed	5.133	0.024	-2.49	398	0.006	0.013	-1350	540.63	-2412.9	-287.1
Equal variance not assumed			-2.49	389.1	0.006	0.013	-1350	540.63	-2412.9	-287.1

Source: Household survey (2022)

The study found that malaria is the most prevalent disease in the study area, followed by Dharia, which is a waterborne disease. The high prevalence of malaria in the area can have significant implications for the health and well-being of the local population, as well as for agricultural productivity and economic development. It can be particularly dangerous for pregnant women and young children.

Dharia, on the other hand, is a water-borne disease caused by the ingestion of contaminated water. It can cause symptoms such as Dharia, nausea and vomiting and can be particularly dangerous for young children and those with weakened immune systems.

The high prevalence of these diseases in Wolaita Zone, southern Ethiopia highlights the need for effective public health interventions to prevent and treat these diseases. This can include measures such as mosquito control, improved water and sanitation infrastructure, and targeted health education and awareness campaigns. Furthermore, the presence of these illnesses has the potential to have broader implications for agricultural production and economic development in Wolaita Zone, southern Ethiopia. Illness and disease can lower production and increase healthcare costs, threatening smallholder livelihoods and undermining rural communities' economic stability.

The prevalence of malaria and Dharia in the research area highlights the need for integrated and sustainable rural development initiatives that prioritise public health and well-being alongside agricultural production and economic success.

Various factors influence food use, including age, health status, food availability, access to preferred foods, and understanding of nutrition. The availability and accessibility of diverse and nutritious foods are especially significant in Wolaita Zone, southern Ethiopia for households with children under the age of five, pregnant or breastfeeding mothers.

The survey found that 41.5% of SSI users and 33.5% of non-users had children under five years of age, and pregnant or lactating mothers in their households. Of these households, 35.5% of SSI users and 25% of non-users reported different consumption patterns for these groups, including regular breastfeeding and provision of supplementary foods until the recommended age. In addition, focus group participants were also asked about their knowledge of the contribution of consuming enough nutritional food to the performance of the school. Twelve (10.3%) do not know but 104 (89.7%) know about the provision of enough quality food to children to improve their academic performance, among 116 participants.

Nutrition knowledge was obtained from various sources, as shown in Table 7.20. The survey found that SSI users and non-users agreed that irrigation had contributed to the availability of various food items, making it easier for them to feed themselves and their children. Furthermore, the availability and accessibility of nutritious food groups on their farms have resulted in dietary adjustments for both smallholders and their family members. This shows that irrigation intervention helps rural communities improve their nutrition and food security.

In summary, the study highlights the importance of promoting nutrition knowledge and access to diverse nutritious foods for households with children under five years of age, and pregnant or lactating mothers. The role of irrigation in facilitating access to such foods underscores its potential as a key driver of sustainable and inclusive rural development.

Table 0-20 Respondents' sources of nutrition knowledge of the respondents

Information sources for nutrition knowledge [a]	SSI Users			SSI non-users		
	Responses		Percent of Cases	Responses		Percent of Cases
	N	%		N	%	
Local Radio	73	17.70	36.70	48	14.80	24.70
Local TV, newspapers, and posters	36	8.70	18.10	1	0.30	0.50
Peers	82	19.90	41.20	51	15.70	26.30
Farmers training centre	104	25.20	52.30	113	34.80	58.20
Health extension agents	73	17.70	36.70	109	33.50	56.20
Funding organisations and NGOs	44	10.70	22.10	3	0.90	1.50
Total	412	100.00	207.00	325	100.00	167.50

a. Dichotomy group tabulated at value 1.

Source: - Household Survey (2022)

Childcare practices

The statement suggests that having knowledge about childcare practices can improve the health status and cognitive abilities of children. The extent of this improvement depends on the knowledge and educational status of the parents. It is also suggested that having this knowledge is important for the future education performance of the children.

To assess the knowledge and interest of the respondents in childcare practices, the researcher asked them about their knowledge and understanding of childcare practices and their importance. The results showed that most of both SSI users and non-users had knowledge and were interested in childcare practices. Specifically, 192 out of 200 users (96%) and 187 out of 200 non-users (93.5%) reported having knowledge and interest in childcare practices. Furthermore, the statement suggests that the availability of irrigation has contributed to improving the health status of the respondents. Specifically, 193 of the 200 user respondents (96.5%) acknowledged that irrigation availability has contributed more to improving their health status. This finding highlights the importance of irrigation in promoting health and well-being among rural communities, particularly those engaged in small-scale agriculture.

The implication of this statement is that knowledge about childcare practices is crucial to improving the health and cognitive abilities of children. Parents who are well-informed about childcare practices are more likely to provide their children with the necessary care and support to promote their development. Additionally, irrigation availability can have a significant impact on the health and well-being of rural communities, particularly in areas where access to clean water is limited. Therefore, policies and programmes that promote access to education and irrigation can have a positive impact on the health and well-being of rural communities.

Irrigation, drinking water, hygiene, and sanitation access in the area.

Pure drinking water is considered as one of the nutrients required for human beings. The survey found that rural smallholders in Wolaita Zone, southern Ethiopia primarily obtain their drinking water from piped tap water on site/yard and public/community taps. All respondents reported that the water source is less than 1000 metres from their residence. However, the frequency of treating the water varied, and some households treated their water always, sometimes, or never, depending on their capacity and knowledge of clean drinking water. The study also found that SSI users were more likely than non-users to treat their drinking water. While both groups employed a variety of methods to treat their drinking water, including chemicals such as chlorine and boiling, SSI users were more likely to get their water from the government and therefore were subject to regular treatment. In terms of sanitation facilities, all rural smallholders were required by national health policy to have pit latrines around their residences and on the roadside for public use. However, none of the respondents had a bathroom or shower in their home and relied on river and tap water to bathe their bodies and wash their clothes.

Moreover, the survey found that SSI users were more likely to use tap water for cleaning purposes, while non-users were more likely to use river water. User groups reported that the income generated through irrigation had helped to support their families in obtaining clean drinking water and sanitation facilities. Furthermore, the study highlights the importance of promoting access to clean drinking water and sanitation facilities for rural communities. This can be achieved through a variety of interventions, including improving the water treatment infrastructure, promoting hygiene and sanitation practices, and increasing awareness of the importance of clean drinking water and sanitation for health and well-being. By promoting access to these necessities, rural development interventions can contribute to improved health outcomes, increased productivity, and more sustainable and inclusive rural development.

Qualitative analysis

Sub-theme: Irrigation, nutrition, and health status

According to five agricultural office heads sampled by Kebeles, irrigation has brought a significant change in the health of the people in the area because people using irrigation eat nutritious food, such as protein, carbohydrates, and immune-boosting foods, not from the market, but from their area or irrigation area. People do not eat foods with the same nutrients on one table but are eating foods with many nutrients on one table and their bodies resist various diseases. It is undeniable that food is the most basic issue for humans, and their health is safe. Therefore, one of the indications is that OTP/malnourished children are found in other non-irrigating areas, but there is not even one in the irrigation area. In the lowland area, many diseases were common. Before irrigation, people run out of food and go to work elsewhere. Many people are sick and whose bodies are swollen. But now they irrigate and get enough food. Maize, teff, sweet potatoes, haricot beans, chickpeas, peppers, carrots, beetroots, and other fruits are eaten from home or the farm without going hungry; so, their health has improved. Consuming foods high in vitamins helps strengthen the body and prevent disease. There were more patients in the past owing to a lack of drinking water, but this condition has already changed. Owing to the lack of roads, pregnant women previously had difficulty getting medical facilities. Because of lack of access, children have a difficult time finding a health professional. As a result, various diseases emerged. Now that there is a road, health experts are coming to their homes and providing medical care to pregnant women. Children also receive various vaccinations. Farmers who have benefited from irrigated areas are healthy using various garden vegetables, and those who cannot afford treatment have gained income and benefited from the support of irrigation development (Abela Abaya-Abela Mareka, Damot Woyde-Adecha, Boloso Sore-Gurumo Koisha, and Humbo- Ampo Koisha).

Irrigation has brought about a great change in the health of the family, which has brought about a change in the quality of animal products consumed such as butter, milk, and meat, for better health. Owing to the availability of irrigation, “we planted sugarcane and got a good harvest; so, we had a better house and prevented our body from frost and cold during the rain seasons and improved my health. I consume vegetable foods such as tomatoes, carrots, carbohydrate foods, which have a great contribution to body health” (Participant 1, KII_Damot Gale - Buge). It created a productive and healthy family and society. It also helped to have better children and family health. Mortality has decreased and reduced the cost of eating better and healthier food. Irrigation has produced a favourable environment for the increase in food availability to children under the age of five and pregnant women.

The availability of nutritious food has led to improved health outcomes, including the prevention of diseases and improved growth in children (Participants - 4, KII_ Damot Gale - Buge).

However, focus group participants had described similarly the role of irrigation in the quality food consumption of women and children and the health of irrigation users in Damot Gale District - Buge Kebele. For example, the death rate that was in the past in kebele has decreased as well as child mortality rate. Mothers consume carrots, tomatoes, cabbage, etc., and their consumption of nutritious food has changed. More importantly, the health of their children has also improved. During childbirth and after childbirth, women have been supported to stay healthy by having close access to medical services and food without any problems. Healthy and strong children can do good work when they consume nutritious food. It also makes them work hard and love work. In terms of creating healthy communities, irrigation intervention in the area has played a better role. As a result, productive citizens have been able to find model and development veterans through irrigation. For example, one of the rich SSI users said:

> 'Due to the presence of irrigation, the number of people who ask for food on the streets and say they are not healthy has decreased. Thanks to God, the health of my family is very good thanks to the availability of foods with better food quality and income. Due to this, I am using medical expenses for my house.' (Participant 2, Male FGD_ Damot Gale - Buge)

Furthermore, the participants in the focus group explained that 'in areas without irrigation, children and mothers get sick from the seventh month to the harvest month of the crop. In irrigation areas, there is production when there is no production in other areas (Participants 9, Male-FGD_ Damot Gale - Buge).

Before irrigation, people were starving because they were hungry and out of food and went to other places to look for work and get sick. They suffer from starvation and malaria because they eat unhealthy food. Their health is affected owing to lack of money and changes in weather. But now, owing to irrigation, they eat different types of food and earn income; so, their health is better.

> 'For example, maize, teff, potatoes, sweet potatoes, chickpeas, chillies, and peppers are foods we consume. In addition, we eat carrots, beetroots and other fruits from our home or farm; so, our health is improved. For example, eye trachoma, Dharia and similar diseases have become better than before due to the availability and consumption of foods such as vegetables and fruits.' (Participant 5, Male FGD_ Abela Abaya - Abela Mareka)

The findings of qualitative and quantitative methods can be summarised as: rural smallholder irrigation users in Wolaita Zone, southern Ethiopia eat foods that give energy, build the body and prevent diseases. More importantly, irrigation has brought about a significant change in the health of pregnant women and children. Disease resistance was also increased. The way they deal with infectious diseases has also improved. In the past there were many diseases in the area, but now their number has decreased. In the past, their productivity was affected by illness and fatigue. Their costs of disease have also decreased. Access to health services, clean drinking water and hygiene has improved. They can go to any health centre and get treatment because they have a higher income. Previously, people died quickly in this location. But, thanks to the food they eat and the money they earn; their health has improved greatly. Furthermore, with the release of irrigation, they have received health-related lessons. They learn how to care for their bodies and are taught that eating nutritious food is essential for their health.

7.2.3 Livelihood strategies

Irrigation and non-productive asset

In Wolaita Zone, most rural smallholders are gradually transitioning from traditional grass roofed houses to modern corrugated sheet-roofed houses. This shift in housing materials is also reflected in changes to the materials used for constructing walls and floors, although the extent of these changes varies based on the household's income and capacity. The household survey conducted in the area revealed that the materials used to construct the walls were wood, mud, grass, cement, and sand. Among SSI users, 197 households (98.5%) used wood+ mud+ grass mix, while two households (1%) used wood+ mud+ grass+ cement+

sand mix, and 1 household (0.5%) used wood+ grass mix. Among non-users, 193 households (96.5%) used wood+ mud+ grass mix and 7 households (3.5%) used wood+ grass mix.

Regarding the materials used to build floors, the household survey showed that the two most common materials used were concrete and mud/cement. Among SSI users, 20 households (10%) used concrete while 180 households (90%) used mud/clay. Among non-users, 14 households (7%) used concrete, while 186 households (93%) used mud/clay.

Finally, the materials used to build the roofs were wood + corrugated iron and wood + grass mix. Among SSI users, 193 households (96.5%) used wood + corrugated iron, while 7 households (3.5%) used wood+ grass mix. Among non-users, 157 households (78.5%) used wood + corrugated iron, while 43 households (21.5%) used wood+ grass mix.

The survey results demonstrate that changes in housing materials and construction methods are more prevalent among SSI users than among non-users. This may be owing to the higher income and capacity of SSI users, enabling them to afford and access modern construction materials. Moreover, according to qualitative findings, '*there are irrigation users in Damot Gale - Buge kebele who have bought land and houses in Shone city by selling various crops such as sugarcane*' (Participant 2, KII_ Damot Gale - Buge).

Furthermore, another key informant participant, Damot Gale Woreda, Buge kebele, has described:

> 'I have earned a good income by selling products produced using irrigation and buying better mattresses, shelves, wardrobes, and televisions. It has helped me live a better life by buying a better bed and a better TV. I have done something permanent for the children by buying land in the city and building a house. I earn my special income by keeping a bull, cow, etc. Moving money for myself and doing good activities' (Participant 5, KII_ Damot-Gale- Buge) .

Similarly, as a community leader said:

> ‘I used irrigation and sold sugarcane in 2014 and sent a child to a higher education institution. Currently, I have been successful selling one quintal of potatoes and earning a high income. I got good results selling tomatoes. It has become a good source of income for me to improve my living conditions and the education of my children. But some farmers with better fields get better results. For example: one of the richest SSI users in Buge kebele is the person who owns the highest land in our kebele. For the wheat irrigated this summer, a higher number of wheat yields has been obtained. Some people bought a house, “Bajaj” car from the income they earned from an irrigation farm. Moreover, some people use income earned from irrigation to educate two or more children in higher education institutions’ (Participant 6, KII_ Damot Gale- Buge).

Similarly, key community leaders and male and female focus group participants agree that irrigation has increased their market participation.

> ‘We earn income by selling the surplus products we produce. As a result, we were able to purchase a variety of properties, such as cars, motorcycles, telephones, televisions, and other household supplies. We have been able to send our children to a better school by offering surplus products to the market. By ploughing the available land three times a year, sowing crops that are cash crops and can be reached in a short period of time, our family, and the irrigation users in the kebele also get better income. In the kebele, most of the farmers' lives have improved as their markets have grown. For example, we have been able to do better by improving our own homes. For example, we have been able to convert what used to be grass into tin, own various properties, help other family members besides ourselves, teach children continuously’ (male and female KII, FDG _ Humbo - Ampo Koisha)

Irrigation and change in food price.

There is a price difference between irrigated and rain-fed crops. According to the heads of the agricultural office of kebele, most of the irrigated crops are horticultural crops. So, they are in high demand on the market and their prices are high. In particular, the income they get from growing vegetable crops such as tomato, cabbage and onion through irrigation is much higher than rainfed. The market demand for vegetables increases during the irrigation season and farmers who produce under irrigation are benefited. Therefore, compared to the price of vegetables produced in the rainy season, the price of vegetables produced in the irrigated season is variable (Abela Abaya-Abela Mareka, Damot Woyde-Adecha, Boloso Sore-Gurumo Koisha, and Humbo-Ampo Koisha).

Sinyolo et al. (2018) highlighted the unequal access to irrigation water between male and female farmers, with men accessing irrigation water more frequently than women in South Africa. Furthermore, they indicate a positive and significant effect of water access on incomes per capita, and that men had higher welfare than women. Similarly, this research finds the variability of non-productive assets between men and female-headed irrigation users in sample kebeles of Wolaita Zone. This could be owing to various cultural, social, and political issues in the area.

Irrigation and Diversity of Employment Status

Rural smallholders in Wolaita have diverse employment opportunities, ranging from agriculture to small-scale trade and private-sector employment. However, according to the survey conducted in sample kebele, most smallholders engaged in three main types of employment: farming, small-scale trade, and private-sector employment.

The results in Table 7.21 revealed that 64 households (24.1%) of SSI users participated in small-scale trading activities, while 49 households (18.9%) of non-users engaged in similar activities. Small-scale trading activities can include the purchase and sale of agricultural products, as well as other goods and services. One key difference between users and non-users is that users often finance their trading activities from their profits, while non-users may need to rely on loans from government institutions to finance their ventures.

Small-scale trading activities provide an additional source of income for rural smallholders and help diversify household income streams. However, as with other off-farm activities, small-scale traders face challenges such as limited access to finance and markets, as well as a lack of knowledge and skills in business management and marketing.

Table 0-21 Respondent Employment type

Employment type [a]	User			Non-user		
	Responses		Percent of Cases	Responses		Percent of Cases
	N	%		N	%	
Farming	200	75.20	100.00	200	77.20	100.00
local trading	64	24.10	32.00	49	18.90	24.50
Private sector	2	0.80	1.00	10	3.90	5.00
Other	0	0.00	0.00	0	0.00	0.00
Total	266	100.00	133.00	259	100.00	129.50

a. Dichotomy group tabulated at value 1.

Source: - Household Survey (2022)

Qualitative analysis

Sub-theme: Irrigation and diversity of employment

According to the heads of Kebele agricultural office, in terms of creating job opportunities, the contribution of irrigation has been varied, helping individuals earn income for themselves and their families by working in irrigation areas with a daily allowance. Moreover, unemployed youth are organised, and those who have fields are creating enough jobs by participating in irrigation works. For example, they are earning income by opening small shops, cultivating onions and cabbage along with those who have no fields, buying motorcycles and providing transportation services to the locals. Some people came from other areas and lived with family and friends and created jobs by doing irrigation work (Abela Abaya-Abela Mareka, Damot Woyde-Adecha, Boloso Sore-Gurumo Koisha, and Humbo-Ampo Koisha).

Key community leaders responded by explaining and adding other employment opportunities, owing to the presence of an irrigation facility in the Damot Gale District - Buge-kebele. They mentioned that households which planted different grass seeds/fodder around irrigation were organised and received high results in the breeding of cattle and fattening activities. In addition, during the maintenance of irrigation facilities, users and non-users earn money through labour work at different times. In addition, they take out harvested crops on trucks (Participant -5, KII_Damot Galev- Buge).

In addition, another community key informant explained the role of irrigation in the diversity of employment:

> 'In 2020/21, I got a good income from tomatoes and now I have some money for my personal business. So, I got opportunities to do my additional work in the market. Since starting irrigation work, I have been able to create employment opportunities for many people. For example, I employ people who sell through my shop and cut sugarcane at the door of the store. There is a donkey cart for me. Many people use this cart: for example, selling flour from the market, and children using donkey carts to load goods have created job opportunities. There is a way to earn more income working together with farmers who have better fields. Produced tomato, carrot and cabbage and brought them to the market as a small trader.' (Participant 7, KII_ Damot Gale - Ampo Koisha).

In 2019, it was able to create high income and job opportunities by planting different types of tobacco and supplying them to the Boditi Tobacco Factory. Furthermore, in 2020, an investor who won a vegetable supply bid as a meal for nearby universities came to our area and created special job opportunities such as various types of labour work. Besides, '*people who bought tomatoes and leafy cabbage from the market and engaged in retailing and offering them to the market as a trader. Affluent farmers have created job opportunities by producing better tomatoes and cabbage and selling them wholesale and in-store when they are not taking them to the market*' (Participant 5, Male FGD_ Damot Gale-Buge). The participant in FDG responded that before '*we used to go to different areas to look for work, but if irrigation work started, we could earn money by cultivating different vegetables and other people participated in work on our farm and contributed to get paid*' (Participant 7, Female FGD_ Damot Gale-Buge).

Therefore, as a summary irrigation has created diverse job opportunities in Wolaita Zone, southern Ethiopia. Since the introduction of irrigation, there has been more profit from small farmland. Irrigation user family members have started to focus on different irrigation works. They are motivated to work by preparing the planting area, watering, picking up ripe crops, etc. Previously, women and children were forced to work and go to other countries in search of work, for example, Arab countries. Now, adult women also have changed their focus on work given their income and are refraining from going to another country in search of work. Young people are creating job opportunities by renting, consolidating, and working together on irrigated land that does not have enough family labour and does not use profit. Moreover, they have also created more employment opportunities by engaging in animal production like chicken farms and beekeeping. In addition, rural smallholders who grow and sell various vegetables bought private motorcycles and 'transport three-legged Bajaj' for their children and provided transportation services to the local people. Some owned open grain mills and made extra income. In addition, youth came from another area and lived with relatives and friends and created jobs by performing day-to-day irrigation works in the area. In addition, youths graduated from different government and private universities who did not get a job, were organised, and grouped to get irrigation land and engaged in it.

Irrigation and cognitive development

In Wolaita Zone, both rural and urban households place a high value on education and strive to ensure that their children receive an education and can compete in the job market. The area is densely populated and the size of the farmland per household is small and fragile. As a result, economic and social conditions in the area can cause children to drop out of school or enrol late.

In the sample kebeles, 159 households (79.5%) of SSI users and 177 households (88.5%) of non-users have children or other family members older than seven years of age. Of these respondents, 13 households (6.5%) of users and 71 households (35.5%) of non-users reported having children who were not enrolled in any educational level, despite being at the age where they should be enrolled according to national policy. Additionally, 98 households (49%) of non-user respondents reported having one or more dropouts in the year 2021.

Maintaining free school fees alone is not enough to encourage parents or children to enrol or stay at school. Children need adequate food, school supplies and materials. The SSI users were provided more essentials than non-users, as presented (Table 7.22). Improving access to education and reducing dropout rates requires a multifaceted approach that addresses the root causes of dropout, such as poverty, lack of access to essential resources and limited awareness of the importance of education. This includes investment in education infrastructure, policies and programmes that promote access to essential resources, and community-based interventions that raise awareness of the benefits of education and encourage parents and children to prioritise education.

Table 0-22 Additional school aid fulfilled by the respondents to their children.

additional school aids [a]	Users			Non-users		
	Responses		Percent of Cases	Responses		Percent of Cases
	N	%		N	%	
School uniform	147	24.70	88.00	103	27.30	55.40
Exercise book, pen, and pencil	159	26.80	95.20	177	46.90	95.20
Class books	25	4.20	15.00	3	0.80	1.60
Additional reference books	50	8.40	29.90	6	1.60	3.20
School fee	72	12.10	43.10	32	8.50	17.20
Residential and transport	48	8.10	28.70	17	4.50	9.10
Food and clothing	93	15.70	55.70	39	10.30	21.00
Total	594	100.00	355.70	377	100.00	202.70

a. Dichotomy group tabulated at value 1.

Source: - Household Survey (2022)

The quality of education is a critical factor in ensuring that children receive a meaningful and impactful education. Several factors can influence the quality of education, including the availability of qualified teachers and well-equipped school materials. In Wolaita Zone, rural smallholders often send their children to well-organised government and private schools to access quality education.

About 72 households (12.1%) of SSI users and 32 households (8.5%) of non-users reported sending their children to private schools and paying school fees to access better education. Private schools have more resources and better-equipped facilities than government schools, resulting in a better quality of education for students. However, private schools are more expensive, and less accessible to families with limited financial resources.

Improving the quality of education in rural areas such as Wolaita will require targeted investments in education infrastructure, teacher training and support, and access to educational resources and materials. Furthermore, policies and programmes that encourage the establishment of high-quality government schools and improve access to quality education for all students, regardless of their financial means, will be critical to addressing educational inequalities in the area.

Adequate and quality food for children is essential for their physical and cognitive development, as well as their academic performance. Children who consume sufficient and nutritious food tend to attend school regularly and perform better academically than those who do not. On the contrary, children who go to school on an empty stomach may experience reduced cognitive function, fatigue, and lack of motivation, which can negatively impact their academic performance.

Adequate and quality food to children is crucial for academic performance and overall well-being. Thef SSI users and non-users did not provide enough food to their children before and after school. Specifically, 131 households (65.5%) of SSI users and 70 households (35%) of non-users reported providing adequate food to their children, while the rest do not provide enough food. Thus, some children may go to school without breakfast or lunch, hence negatively impacting academic performance and overall well-being.

SSI users were more likely to provide adequate and quality food to their children compared to non-users. Thus, SSI played a role in increasing household food security and improving access to nutritious food for children.

Parental involvement is a crucial factor in the academic success of children. In Wolaita, both SSI users and non-users monitored their children's academic progress. About 174 households (87%) of SSI users and 135 households (67.5%) of non-users monitored their children's academic progress.

The survey also asked about the academic performance status of the respondents' children. The results (Table 7.23) showed that a higher proportion of SSI users (63.5%) reported an increase in their children's academic performance compared to non-users (47.5%). Thus SSI plays a role in improving the academic performance of children, due to increased household income and access to resources that support children's education, such as adequate food and school supplies. The focus group were asked about the contribution of irrigation to school involvement. Among 116 FGD participants, 101 (87.1%) confirmed confirmed "yes" while 15 (12.9) disagreed.

Table 0-23 Respondents' self-evaluation of their children's academic performance

	User		Non-user	
	N	%	N	%
Increasing	127	63.5	95	47.5
Decreasing	4	2	6	3
Fluctuating	19	9.5	49	24.5
Remain the same	6	3	27	13.5
Not Applicable	44	22	23	11.5
Total	200	100	200	100

Source: - Household Survey (2022)

Small-scale irrigation plays an important role in improving household food security and increasing income for rural smallholders. However, the impact of SSI on the fulfilment of children's food demands and required school expenditure is an important consideration. To assess this impact, SSI user respondents in the sample kebeles were asked to rate the contribution of irrigation to children's food demands and required school expenditures.

According to the survey results, 109 households (54.5%) of SSI users reported that irrigation increased their ability to meet their children's food demands and required school expenditures. About 66 households (33%) reported that irrigation increased their ability to meet needs, while 25 households (12.5%) reported that the impact of irrigation on the fulfilment of needs fluctuated.

Table 0-24 Respondents' education level

	Users		Non-users	
	N	%	N	%
No schooling	56	28	69	34.5
Grade 1	3	1.5	6	3
Grade 2	7	3.5	6	3
Grade 3	12	6	0	0
Grade 4	11	5.5	24	12
Grade 5	9	4.5	14	7
Grade 6	15	7.5	16	8
Grade 7	12	6	10	5
Grade 8	17	8.5	12	6
Grade9	11	5.5	10	5
Grade10	12	6	25	12.5
Grade 12	8	4	0	0
Certificate	0	0	8	4
Diploma	22	11	0	0
Degree	5	2.5	0	0
Total	200	100	200	100

Source: - Household survey (2022)

The Ethiopian government recognised the importance of adult literacy courses and non-formal education programmes in promoting education and reducing literacy rates. In Wolaita Zone, non-formal education programmes have been provided to rural smallholders who have had no prior schooling. The household survey revealed that a small proportion of both SSI users and non-users had attended adult literacy courses and non-formal education programmes. Specifically, 26 households (13%) of SSI users and 14 households (7%) of non-users reported attending these programmes.

The survey results also showed that SSI users were more likely to use the income generated from their irrigation activities to improve their education and the education of their family members. This suggests that SSI helps improve access to education and support the educational aspirations of rural smallholders. As a result, SSI users were found to be more educated than non-users, as presented in Table 7.24. In summary, promoting adult literacy courses and non-formal education programmes can be an effective strategy to increase education and reduce literacy rates in rural areas like Wolaita.

SSI is an effective strategy to improve food security in households and improve access to nutritious food for children in Wolaita Zone and other rural areas of southern Ethiopia. SSI and other income-generating activities supports education by increasing household income and access to resources for education in areas where poverty and limited access to education are challenges.

Irrigation, children's schooling and academic performance.

Children change their academic achievements if they get enough nutritious food. In addition, it leads to balanced growth and good education reception and participation. On the other hand, it prevents children from dropping out of school. According to five sample kebele agricultural office heads, especially during the long dry season, children drop out of school. However, in the irrigation area children of irrigation users do not drop out of school, they get breakfast, lunch, and dinner properly. Before the introduction of irrigation, rural smallholders in this area had a hard time raising children owing to the lack and shortage of resources and food. They did not meet their needs. But now, since irrigation has started, they are getting more produce from small farmland, and they are getting enough income. So, children eat their fill, get enough food, and do not drop out of school because of hunger. As they eat quality food and enough, their results are getting better. Families are also sending children to school without concern. Even their health was not harmed. Parents can now earn enough skills and money to educate their children. Because the community leads a good life, they send their children to adjacent towns to attend good schools. Before the irrigation project in Kebele, pupils dropped out of school because they could not afford to buy notebooks and pencils for their families, and they did not have food when they returned from or went to school (Abela Abaya-Abela Mareka, Damot Woyde-Adecha, Boloso Sore-Gurumo Koisha, and Humbo- Ampo Koisha).

Key community informants in Damot Gale District - Buge kebele explained that irrigation has brought about a significant change in children's education and performance.

> ‘Generally, children got their food properly and made them go to school without worrying about their studies. Without missing school, I was able to buy necessary school materials like notebooks, pencils, uniforms, and other clothing, and they attended school properly. Children have been successful in their studies because they have been protected from various diseases/deaths caused by lack of food. The family income from irrigation allowed me to send children to nearby schools. Their emotional skill has also increased, and they participate actively in class and outside. By using the income from irrigation, it has helped me, especially since 2010, to send two children to another high school to attend their education by paying fees’ (Participant 3, Damot Gale - Buge).

Another key informant also explained the participation and performance of the children in the school in the irrigation area: ‘*For example, in 2012, my son was good and got better results and became competitive by passing from class to class by going to school on time without missing school. My children are good in their studies*’ (Participant 5, KII_ Damot Gale-Buge). Moreover, ‘*Irrigation assisted people who dropped out of school and went to the city in search of work to succeed in their education.*’ (Participant 6, KII_ Damot Gale- Buge)

Similarly, different key community leaders and focus group participants described the role of irrigation in children's school participation and performance.

> ‘In 2014, I ended up teaching two children in the first grade and the 11th grade, as well as a second daughter in the 12th grade. It has done significantly better in

terms of providing the family's food needs. I have benefited from buying better chicken breeds and breeding them to earn more income at less cost' (Participant 4, KII_ Damot Gale - Buge).

Besides, one of the focus group participants indicated, '*Rather than making me earn better, I made them study from government to private schools. It has made it better in educational results. It also led to the creation of competitive children.*' (Participants 6, Male FGD_ Damot Gale - Buge). This point was also encouraged by other participants, '*our economic capacity has increased, it has created opportunities for students to go to better schools. It allowed them to complete their study by purchasing additional helpful reference books*.' (Participants 10, Male FGD_ Boloso Sore - Grumo Koisha). '*Before irrigation construction, our children used to drop out of school in March, but since irrigation work came, our children have not dropped out of school owing to food and resource shortages. They are constantly learning their lessons. Their results are getting better.*' (Participants 3, Female FGD_ Abela Abaya - Abela Mareka)

In addition, Humbo District, key community leaders, Ampo Koisha kebele, and FGD participants explained the contribution of irrigation to the participation and performance of children's education.

> 'I was able to make children learn their education by sending them to teach in areas where they get a better education. I make them go to school as soon as they are old enough, make them go to school on time, and attend their classes. Before irrigation, many children in our area could not learn. But now, since irrigation has come, many children are learning. In our time, our fathers could not teach children, but now our children have learned to reach a good place and have a change in mind' (Participant 3, KII_ Humbo - Ampo Koisha).

> 'Because of my husband's death, I could not teach children, but now I am teaching children since irrigation came in. My children's interest in learning is improving day by day. They are paying good attention to their studies. All children are successful in their studies. Most of our children are becoming successful by entering government and private universities.' (Participant 5, KII_ Humbo - Ampo Koisha).

> 'Before this, there is no child who finishes studying in our village or in our village. Because many people don't earn. But now everyone is earning, and everyone is teaching children. They are becoming better people and more productive. As a result, the attention given to education by the people of Kebele has changed' (Participant 7, KII_ Humbo - Ampo Koisha).

The Damot Woyde District, Adecha kebele FGD participants have also raised the same issues as other participants:

> "We were renting land in contracts to get income to educate children and now we get a lot of produce from a small field, and we have enough income. No child drops out of school due to hunger or getting sick" (Participant 11, Male FGD, Damot Woyde- Adecha).

These results, therefore, suggest that SSI have a positive impact on household food security and income, which, in turn, contribute to meeting children's food demands and required school expenditure. This is particularly important in areas like Wolaita, where food insecurity and limited financial resources can impact children's health and academic outcomes. Therefore, promoting SSI and other sustainable agriculture practices is an effective strategy to improve household food security and income, which contribute to support parental involvement in education by increasing household income and access to resources that can support children's academic success.

Irrigation and individual autonomy of rural smallholders

In Ethiopia, policies, rules, and laws related to rural development aim to ensure that small-scale farmers have the right to claim access to public provisions, such as irrigation systems, which can support their agricultural activities. However, there are challenges in the implementation of these rights, which can lead to frustration and disappointment among smallholders.

According to survey results, a significant proportion of SSI users (97%) and non-users (96%) had used their right to claim access to public provisions. However, several respondents reported that they were unhappy with the decision-making process, which they perceived as long and unfair. As a result, some farmers had opted not to use their right to claim access to public provisions.

The challenges in the decision-making process could be owing to various factors, such as bureaucratic inefficiencies, lack of transparency and corruption. These issues can undermine the effectiveness of rural development policies and reduce the benefits that smallholders can derive from public provisions.

To address these challenges and ensure that smallholders can effectively claim their right to access public provisions, it may be necessary to streamline the decision-making process, improve transparency and strengthen accountability mechanisms. This could involve measures such as simplifying application procedures, increasing public participation and improving monitoring and evaluation systems. By improving the implementation of rural development policies and ensuring that smallholders can effectively claim their rights, Ethiopia can promote more inclusive and sustainable rural development.

Participation in public institutions is an important means of empowering rural smallholders and improving their food security outcomes. By participating in public committees and other forms of collective action, smallholders can gain access to information, resources and opportunities that can help them improve their agricultural practices, increase their productivity, and improve their livelihoods.

Membership in public committees can also enhance smallholder knowledge and skills, as they are exposed to new ideas, technologies, and approaches to agricultural development. This can help them improve their own practices and contribute to the success of development interventions in their communities.

In the context of irrigation, membership in water users' associations and committees can play a particularly important role in promoting sustainable and equitable management of water resources. By participating in these bodies, SSI users can contribute their indigenous knowledge and experience, as well as their perspectives and needs, to the development of irrigation policies and programmes. This can help ensure that irrigation interventions are tailored to the specific needs and circumstances of local communities and that they are managed in a way that is equitable and sustainable over the long term.

According to the results of the survey, SSI users were found to be highly active in participating as members of different rural public institutions and committees. This suggests that there is strong demand and interest among smallholders in engaging in collective action and contributing to the development of their communities. By leveraging this interest and promoting greater participation in public institutions, Ethiopia can strengthen its rural development efforts and improve the food security outcomes of its smallholders.

Table 0-25 Respondents' membership in different rural based committees and representations

HH membership in the community [a]	Users			Non-users		
	Responses		Percent of Cases	Responses		Percent of Cases
	N	%		N	%	
Kebele committee	31	7.40	17.10	18	7.10	10.10
Community representation	44	10.50	24.30	35	13.80	19.70
Water users' association	127	30.20	70.20	0	0.00	0.00
Church committee	69	16.40	38.10	60	23.70	33.70
Community based organisation	35	8.30	19.30	32	12.60	18.00
Any civil meetings	115	27.30	63.50	108	42.70	60.70
Total	421	100.00	232.60	253	100.00	142.10

a. Dichotomy group tabulated at value 1.

Source: - Household survey (2022)

Based on the findings, it can be inferred that the introduction of irrigation has contributed to a greater understanding and involvement of rural smallholders in the planning, implementation, and administration of development activities. This suggests that irrigation has played a positive role in improving the participation of rural smallholders in development efforts.

In Wolaita Zone, rural smallholder households typically involve family members in the resource allocation and decision-making process. However, the degree of participation varies between households depending on factors such as the level of education and awareness. According to the survey results, a significant proportion of SSI users (39%) and non-users (36%) reported that resources are allocated, and decisions are made jointly with their spouse and all family members. However, a sizable proportion of SSI non-users (62%) reported that the household head makes decisions and allocates resources alone. This suggests that the introduction of irrigation may have a positive impact on the level of participation and decision-making power of women and other family members within households.

The survey found that both SSI users and non-users were highly engaged in community life, with 98.5% and 93% of respondents, respectively, reporting above-average participation (Table 7.26). In addition, focus group participants were also asked if their public participation was affected by external forces such as government laws, terms, and conditions. Therefore, among 116 respondents, 52 (48%) responded 'yes' and 64 (55.2%) responded 'no'. This suggests that participation in irrigation and other development activities may also contribute to a greater sense of community involvement and participation among smallholders.

Table 0-26 Respondents' participation in community life

Social participation rate	User		Non-user	
	N	%	N	%
Very good	93	46.5	71	35.5
Good	97	48.5	93	46.5
Average	7	3.5	22	11
Poor	3	1.5	14	7
Total	200	100	200	100

Source: - Household Survey (2022)

Finally, all SSI users were informed that the availability of irrigation in the study area had contributed to an increase in public decision-making and participation in the community. This highlights the potential of irrigation and other rural development interventions to promote greater participation and participation among smallholders and to foster more inclusive and sustainable development outcomes.

7.2.4 Rural development policy

The Ethiopian government has implemented a range of measures to improve the agricultural system and improve food security for rural communities in Wolaita Zone, with the involvement of both NGOs. The projects focused on agriculture, education and health and are part of an integrated strategy to improve the quality of life for rural smallholders. Although these activities are available to all rural smallholders, certain forms of support, such as emergency aid, direct cash assistance, and school feeding programmes, are targeted at the vulnerable. These programmes aim to help vulnerable smallholders to meet their basic needs.

SSI users were actively engaged in development activities, but non-users were beneficiaries of emergency aid, direct cash assistance and school feeding programmes (Table 7.27). Thus introduction of irrigation promoted food security and reduced the need for emergency aid among smallholders.

Table 0-27 Rural development activities supported by governments and NGOs in the study area.

Additional government and NGOs support [a]	User			Non-user		
	Responses		Percent of Cases	Responses		Percent of Cases
	N	%		N	%	
Animal production	15	7.40	11.10	25	7.20	14.50
Nutritional food production	25	12.30	18.50	7	2.00	4.00
Children school material	8	3.90	6.00	72	20.70	41.60
Free health service	72	35.30	53.70	113	32.60	65.30
Agricultural input	81	39.70	60.40	48	13.80	27.70
Direct cash	0	0.00	0.00	63	18.20	36.40
Emergency food aid	0	0.00	0.00	4	1.20	2.30
School feeding support	0	0.00	0.00	7	2.00	4.00
Small scale trading	3	1.50	2.20	8	2.30	4.60
Total	204	100.00	152.20	347	100.00	200.60

a. Dichotomy group tabulated at value 1.
Source: Household Survey (2022)

Irrigation and other government-related rural policies supports.

The Ethiopian government has designed and implemented various activities and support policies related to rural smallholders to improve their food security. According to the kebele agricultural office head in all sample kebeles, for the summer irrigated wheat that has been going on since recently, the government provided farmers with the necessary inputs, such as NPS and UREA, for the development of wheat seed. On the other hand, to support this development, low-cost tractors and combine machines were facilitated. Furthermore, the government subsidised and facilitated access to water pumps with irrigation supplies and accessories, improved vegetable and other cereal crop seeds, improved poultry and livestock bread and agricultural chemicals to improve the production and productivity of rural smallholders. More importantly, complete agricultural packages were provided with loan support. It helped rural smallholders get complete credit support for their agriculture business. It also provided various training and professional support in all three seasons. Damaged irrigation canals have been repaired. Construction of concrete irrigation lines, followed by the construction of night storage for water storage. Irrigated sample kebeles connected to the district town and other neighbouring districts and kebeles through rural road works. Additionally, a school has been established in the area. Non-irrigation users in kebele are supported by a safety net and other programmes (Abela Abaya-Abela Mareka, Damot Woyde-Adecha, Boloso Sore-Gurumo Koisha, and Humbo- Ampo Koisha).

Some community key leaders and focus group participants agreed, strengthened, and added additional support given in the rural community of Damot Gale district - Buge kebele. Besides the above-mentioned support 'Research on cabbage, tomato production and fishery were conducted in conjunction with university scholars from various higher education institutions. Therefore, farmers got better skill, production, and income' (Participant 3, KII_Damot Gale – Buge).

> 'At different times, we successfully crossbreed with the seeds of foreign cattle or better dairy seeds. The school in our kebele has raised the level from eighth to 12th grade and has greatly supported the children to attend their studies at home by reducing the expenses. By planting various clean drinking water plants in a

nearby place, various water-borne diseases have been reduced. Therefore, it reduced costs and time and child labour.' (Participant 5, KII_ Damot Gale – Buge).

'We received support for pest control medicine and spraying. The government has supported us by facilitating combiners to collect quality products and provide them to the nearby cooperative associations. Work in creating market links to sell our products by connecting with cooperatives' (Participant 7, KII_ Damot Gale - Buge).

'Experts from the government were monitoring summer wheat irrigation agronomic activities such as wheat sowing, land preparation, weed monitoring, wheat seed fertilisation, for example, DAP, UREA, and pest control monitoring. In 2013 we were supported to use the best seeds and fertilisers, by 50% advance payment and 50% long-term payment' (Participant 4, Male FGD_ Damot Gale - Buge).

Irrigation schemes offer the government an opportunity to support rural farmers and improved participation of irrigation users in development activities and initiatives in the irrigated area of Wolaita Zone.

7.3 SUMMARY

The impact of SSI on the outcomes of rural smallholder food security is presented in this chapter. The findings indicate that the use of SSI is a predictor of the outcome of food security. SSI improves household food security and income, and meets children's food needs and school expenditures. Income generated from irrigation was used to improve the education of household members. Promoting irrigation increased rural smallholder participation in the decision-making and development activities and reduced the need for emergency aid and hunger in Wolaita zone. Promoting irrigation is an effective strategy to improve food security in households and improve access to nutritious food for children in rural areas like Wolaita. Irrigation contributed to the life and livelihood of rural smallholders, in Wolaita zone. The Ethiopian government must design and implement activities and to support sustainable agricultural practices like irrigation, and rural smallholdings to improve their food security outcomes.

CHAPTER 8

FACTORS AFFECTING RURAL FOOD SECURITY OUTCOMES

8.1 INTRODUCTION

This chapter presents the findings of qualitative and quantitative studies on factors affecting the outcomes of rural smallholder food security. A multinomial logit model is used to analyse the perceptions of respondents towards SSI schemes. It explains the explanatory variables such as farm size, education level, household size, gender, farming experience, extension services, crop production, income from crop sales, income from animals, animal by-products, non-productive asset sales, and irrigation access. It also indicates the findings from qualitative analysis. Finally, qualitative and empirical findings on the determining factors that affect rural smallholder food security outcomes, specifically in Wolaita Zone, are explained.

8.2 QUANTITATIVE ANALYSIS

The study used multinomial logistic regression to identify predictors that have an impact on the HDDS and the HHS. Since the dependent variables in the regression should be nominal or ordinal, the two outcomes of household food security were converted to a nominal scale. The HDDS was divided into three categories: low diversity (0-3), medium diversity (4-5) and high diversity (>6 or 6). The HHS was further classified as non- or mild hunger (0-1 score), moderate hunger (2-3 score), and severe hunger (4-6 score).

The analysis used a set of predictor variables, including farm size, education level, age, household size, sex, farming experience, extension service use period, irrigation access, and total income from crop sales and other assets. These independent variables were categorical and continuous. The size of the farm and the size of the household were continuous and used as covariates in the analysis. Similarly, irrigation access and respondent sex were used as covariates, with respondent type categorised as either user or non-user. The remaining predictor variables were used as factors in the analysis and a main effects model was selected.

For the HDDS dependent variable, the 400 cases were categorised into three categories: 25 (6.3%) fell into the low diversity category, 145 (35.8%) medium diversity category and 232 (58.0%) higher diversity category. Most households had a higher level of dietary diversity, a positive outcome for food security.

For the HHS dependent variable, respondents were grouped into three categories: 241 (60.3%) were non- or light-hungry, 77 (19.3%), moderately hungry, and 82 (20.5%) severely hungry. Most households had moderate to severe hunger, hence the need to improve food security outcomes.

In the analysis of the dependent variable HDDS using multinomial logistic regression, the fitness of the model was evaluated by calculating the chi-square statistics. The chi-square value obtained was 440.229, indicating the overall goodness of fit of the model. The p-value associated with the chi-square statistics was less than 0.5, indicating that the model is statistically significant (Table 8.1).

There is a relationship between the dependent variable (HDDS) and independent variables included in the final model. Independent variables, such as farm size, education level, age, household size, sex, farming experience, extension service use period, irrigation access, and total income from crop sales and other assets, are predictors of the HDDS.Thus, the model is a valid and reliable framework for assessing the predictors of dietary diversity score of the household. Identifying which factors are strongly associated with dietary diversity, can inform interventions for improving food security outcomes in rural smallholder households.

Table 0-1 Model fitting information of Household Dietary Diversity score

Model	Model Fitting Criteria			Likelihood Ratio Tests		
	AIC	BIC	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	651.94	659.92	647.94			
Final	319.71	543.23	207.711	440.23	54	0

Source: - Household Survey (2022)

To evaluate the fitness of the model, a goodness of fit test was performed. These tests include Pearson's and deviance statistics, with p-values greater than 0.05 indicating that the model is a good fit. Based on the analysis, the Pearson statistic yielded a value of 240.551, and the deviation statistic yielded a value of 185.515. Both statistics had a p-value of 1, indicating that the model is a good fit. Furthermore, the analysis generated pseudo-R-squared measures, including Cox and Nell (0.667), Nagelkerke (0.814) and McFadden (0.642). These measures indicate that the model accounts for between 64.2% and 81.4% of the variance, representing decently sized effects.

These findings suggest that the model is a valid and reliable tool to examine predictors that impact HDDS. With a good fit and decent effects, the model can help inform interventions aimed at addressing food insecurity in rural small-holder households.

The likelihood ratio test revealed that certain independent variables were significant predictors of the dependent variable HDDS. These significant predictors included the type of respondent or access to irrigation (user and non-user), the sex of the respondent, the highest level of education in the household and the age category of the respondents. This indicates that these predictors contribute significantly to the final model and have a strong impact on the score for dietary diversity of the home. Variables, such as farmland size, household size, extension service use period, and farm experience, were not significant and did not contribute significantly to the final model. Therefore, they are not predictors of HDDS in Wolaita Zone (Table 8.2).

Irrigation contributes to the dietary diversity of households and nutritious diets among rural smallholder households. The model fitness of the multinomial logistic regression was evaluated for the dependent variable of the HHS using the chi-square statistics. The analysis revealed a chi-square value of 525.597 with a corresponding p-value less than 0.5, indicating a significant relationship between the dependent variable and the independent variables included in the final model.

Table 0-2 likelihood ratio tests of independent variables to predict the dependent variable HDDS.

Effect	Model Fitting Criteria			Likelihood Ratio Tests		
	AIC of Reduced Model	BIC of Reduced Model	-2 Log Likelihood of Reduced Model	Chi-Square	df	Sig.
Intercept	319.711	543.233	207.711[a]	0	0	
Respondent type	774.012	989.551	666.012	458.3	2	0
Respondent sex	387.125	602.664	279.125	71.414	2	0
People in the household including adults and children	317.654	533.193	209.654	1.943	2	0.379
Households highest level of education	398.272	510.033	342.272	134.56	28	0
Age category of the respondent	328.903	512.51	236.903	29.192	10	0.001
Extension services utilisation period	307.088	490.695	215.088	7.377	10	0.689

The chi-square statistic is the difference in -2 log-likelihoods between the final model and a reduced model. The reduced model is formed by omitting an effect from the final model. The null hypothesis is that all parameters of that effect are 0.

a. This reduced model is equivalent to the final model because omitting the effect does not increase the degrees of freedom.

Source: Household Survey (2022)

Independent variables, such as farm size, educational level, age, household size, sex, farming experience, extension service use period, irrigation access, and total income from crop sales and other assets, were found to be significant predictors of the HHS. The model is a valid and reliable tool to examine the predictors that affect the hunger score of the household.

Table 0-3 Model fitting information of Household Hunger scale

Model	Model Fitting Criteria			Likelihood Ratio Tests		
	AIC	BIC	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	722.5	730.48	718.495			
Final	376.9	744.11	192.898	525.6	90	0.000

Source: Household Survey (2022)

To evaluate the fitness of the model for the HHS dependent variable, goodness of fit tests was performed. These tests include person and deviance statistics, with p-values greater than 0.05 indicating a good fit for the model. Based on the analysis, the deviance statistic yielded a value of 177.690, with a p-value of 0.999, indicating that the model is a good fit. Furthermore, the analysis generated pseudo-R-squared measures, including Cox and Nell (0.731), Nagelkerke (0.861) and McFadden (0.694). These measures indicate that the model accounts for between 69.4% and 86.1% of the variance, representing decent-sized effects.

The findings suggest that the model is a valid and reliable tool to examine the predictors that impact the HHS. With a good fit and decent effects, the model can help to inform interventions aimed at addressing food insecurity in rural small-holder households. Identifying which factors are associated with hunger, policymakers and practitioners can develop targeted interventions to improve food security outcomes.

The likelihood ratio test was conducted to determine the significance of the independent variables in predicting the dependent variable HHS. The analysis revealed that certain independent variables were significant predictors of HHS. The predictors included the type of response or access to irrigation (user and non-user), the sex of the response, the highest level of education in the household, the period of extension utilisation, the income from the sale of crops, and the farming experience of the respondents. The predictors contribute to the final model and impact on the scale of household hunger.

However, variables, such as the size of the farmland, the size of the household and the age of the respondents, were found to be not significant and did not contribute to the final model. Therefore, they are not predictors of HHS in the sampled kebeles, as shown in Table 8.4.

Table 0-4 likelihood ratio tests of independent variables to predict the dependent variable HHS.

Effect	Model Fitting Criteria			Likelihood Ratio Tests		
	AIC of Reduced Model	BIC of Reduced Model	-2 Log Likelihood of Reduced Model	Chi-Square	df	Sig.
Intercept	376.898	744.113	192.898[a]	0	0	
Respondent type	387.353	746.585	207.353	14.455	2	0.001
Respondent sex	404.699	763.931	224.699	31.8	2	0
Households highest level of education	417.276	672.73	289.276	96.378	28	0
Extension services utilisation period	415.192	742.492	251.192	58.294	10	0
Income from crop sell	519.897	727.454	415.897	223	40	0
Farming experience	391.856	727.139	223.856	30.958	8	0

The chi-square statistic is the difference in -2 log-likelihoods between the final model and a reduced model. The reduced model is formed by omitting an effect from the final model. The null hypothesis is that all parameters of that effect are 0.

a. This reduced model is equivalent to the final model because omitting the effect does not increase the degrees of freedom.

Source: Household Survey (2022)

Access to irrigation reduces hunger among small-holder rural households in Wolaita Zone, southern Ethiopia. Irrigation improves food security outcomes by reducing the scale of hunger in households.

Access to irrigation (user and nonuser), sex, education level, extension utilisation period, crop sales income, and farm experience of rural smallholders are key determinants of the food security outcomes in Wolaita Zone.

The analysis of the HDDS dependent variable revealed that 232 (58.0%) of the respondents had a higher diversity of food, which exceeds the sample of SSI users. About 143 (35.8%) of the respondents had a medium diversity of food.

When combined, 374 (93.5%) of the respondents had a medium to higher diversity of food, which is beyond the sample of SSI users.

For the HHS dependent variable, 241 (60.3%) of the respondents experienced low hunger, and 77 (19.3%) experienced medium hunger. When these two categories are combined, 318 (79.5%) of the respondents were exposed to medium to lower hunger.

These findings suggest that the surplus of production in the irrigation area has contributed to the local supply or market in Wolaita Zone. In other words, surplus production has led to greater access to a diverse range of food products in the sample kebele of Wolaita Zone.

In general, these findings have important implications for policymakers and practitioners working in the field of food security. By focusing on improving access to irrigation and promoting sustainable agricultural practices, it may be possible to improve the outcomes of food security and improve the livelihoods of small rural households.

8.3 QUALITATIVE ANALYSIS

Challenges and factors that affect crop production

The challenges and factors that affect crop production explained by all key informants and the focus group participants in five sample kebeles were summarised under two broad categories. These are climate change and a poor crop production system. Key issues described about climate change are untimely rain, frost, excessive heat from the sun, land erosion, and fertility loss caused by high rainfall and floods. Various crop pests and outbreaks of diseases, such as lethal necrosis disease of maize, stem-cutting pests, beetles, termites, locusts, tomato beetles, butterflies, tomato, and cabbage disease, were among the major pests, insects, and diseases. In addition to different bird species, night animal attacks such as foxes, wild animals such as monkeys, and theft by children at night were also added as factors that affect crop production. The effect of climate change has also caused the incidence of pests, insects, and diseases in the Wolaita Zone, southern Ethiopia.

Participants discussed issues related to the broader category of poor crop production systems. These include not ploughing land enough and in time, failure to perform fallowing and crop rotation, not getting agricultural resources on time and quality, lack and shortage of improved seed, and failure to provide requested improved seed varieties and other inputs. Examples include providing maize BH to Pioneer, not using recommended amount and types of crop seeds, shortage of fertilisers, increase in price of agricultural inputs, rising prices of pesticides, weeds not removed and prevented on time, not using pesticides, not using the type and number of agricultural technologies that the crop needs according to the agro climatic zone. In addition, other factors such as decreasing land fertility, reduction of agricultural land due to urbanisation, low monitoring, and support of production methods are the challenges of food security of rural land in Wolaita Zone. Besides, lack of proper knowledge on efficient irrigation water use (sometimes not irrigating water even if it is available), irrigation agronomy, established by-laws, and training farmers inadequately is also a problem that reduces the crop production in the sample kebele of Wolaita Zone. In addition, sustainable market links, improper road construction, land handling and saltiness, and failure of farmers to properly accept expert advice are also among the factors mentioned by community key informants and focus group participants in five sample kebele (Humbo-Ampo Koisha kebele, Damot Woyde- Adecha kebele, Boloso Sore-Gurumo Koisha kebele, Abela Abaya-Abela Mareka kebele, Damot Gale-Buge Kebele).

8.3.1 Animal feed production

Animal production in the Wolaita Zone in southern Ethiopia is highly dependent on feed or fodders available from grassland and post-harvest rainfed and irrigated crop residue. In addition to grazing land, the post-harvest rainfed and irrigated crop residue listed during the FGDs held in five kebeles comprise: Sorghum cane, maize leaf, teff straw, corn cane, pasture, false banana leaf, sweet potato leaf, sugar cane, haricot bean straw, etc. (Buge, Gurumo Koisha, Adecha, Abela Mareka, Ampo Koisha)

The amount of animal feed or fodder in Damot Gale District, Buge Kebele is decreasing. Factors that are described as a reason for the reduction of animal feed or fodder is the frequent occurrence of fodder-damaging pests and diseases, the absence of fresh fodder seeds and climate changes. The increase in the market price of fodders resulting from urbanisation of agricultural and fodder fields or grazing land. Female and male FGD participants in Damot Gale-Buge kebele and Abela Abaya-Abela Mareka kebele emphasised these issues: '*Due to the increase in population and urbanisation, most of the land is used for settlement*' (Participant 10, Female FGD_Damot Gale- Buge). Moreover, climate change affects the amount and spatial distribution of precipitation. This situation was observed in the Abela Abaya District - Abele Mareka kebele, '*there is not enough rain, and there is an increase in drought*' (Participant 11, Female FGD_ Abela Abaya-Abela Mareka). The production of animal feed was affected to a different degree between districts according to their altitude. Lowland areas are highly affected than mid- and highlands.

Shortages of water and insufficient rainfall are climate change-related issues also discussed in Boloso Sore-Gurumo Koisha, Humbo-Ampo Koisha and Damot Woyde-Adecha woredas, respectively. Other factors that both male and female group participants mentioned, were concerned about not planting fodder seeds, the lack of knowledge about the benefits of fodder, a lack of care and attention to fodder development, and the lack of alternative types of fodder (i.e. fodder seed supply problems, stock borer, grasshopper, non-separation of grass grazing land, excessive animal husbandry, lack of pasture, preparation and storage of fodder hay, etc.)

8.3.2 Use of agricultural inputs

According to five kebele agricultural office heads, absence or lack of improved seed and agricultural chemicals such as pesticide agencies near them, increase in the price of inputs or price inconsistency are the major factors that affect the use of agricultural inputs. Therefore, not getting them in time in terms of type and quantity is a challenge. Other pitfalls include farmers' capacity to have the money to use the resources when the price gets increased, quality problems, for example, expired improved seeds and fertiliser, and weather disturbances during the distribution time, constrain the use of agricultural inputs. Improved seeds and fertilisers are distributed for the usual seasons, i.e., "Belg" and "Meher" not for the irrigation season. During the irrigation season, the irrigators need more vegetables, seeds, and chemicals. Therefore, it is difficult to find the quantity and type they need; so, getting vegetable seeds and chemicals from other areas is common (Humbo-Ampo Koisha, Damot Woyde-Adecha, Boloso Sore-Gurumo Koisha, Abela Abaya-Abela Mareka Damot Gale-Buge Kebele).

National and regional operational gaps in delivering agricultural inputs on time, and the increasing cost of inputs at the country and regional level were the major factors that hindered the use of agricultural inputs in the Wolaita Zone, southern Ethiopia. The capacity of cooperatives is weak to avail all agricultural services promptly. Inputs that came at different times do not reach the farmer but do reach the merchant. Most of the best seeds are in the hands of traders, and sometimes traders in the market sell expired seeds and pesticides. This exploitation by traders also affects the use of agricultural inputs in the sample kebele. The lack of agricultural fields and oxen to plough the field also determines the use of agricultural inputs. Furthermore, rural smallholders spend their income on various economic, social, and political issues that also affect the financial capacity of rural smallholders in the Wolaita Zone. Therefore, as to the respondents, the government should set prices that focus on the poor, now the poor and the rich are treated at equal prices. Moreover, the government should also fulfil properly and hand over its responsibilities to the needs of the rural farmers (Humbo-Ampo Koisha, Damot Woyde-Adecha, Boloso Sore-Gurumo Koisha, Abela Abaya-Abela Mareka, Damot Gale-Buge).

Participants in focus groups were also questioned if the lack of financial and credit facilities, as well as the scarcity of income, had an impact on the usage of agricultural inputs like better seed and fertiliser, etc. Therefore, among 116 focus group participants, 71 (61%) of the participants agreed that there is a problem to get credit services nearby.

8.3.3 Participation in irrigation water use

Irrigation water and scheme administration require the effective participation of irrigation users. However, some variable challenges and factors affect user participation. According to five kebele agricultural office heads, the main challenge of irrigation users that affect the participation in irrigation water administration in Wolaita Zone was the failure to develop a sustainable operational and implementation system in each irrigation scheme. In each irrigation scheme, users lack knowledge of rules and regulations. They were not subject to the law. The enforcement of the law was challenging (Humbo-Ampo Koisha, Damot woyde-Adecha, Boloso Sore-Gurumo Koisha, Abela Abaya-Abela Mareka, Damot Gale-Buge).

Each irrigation scheme had a water users' association and four different committees. These are the main committee, the water distribution committee, the conflict resolution committee, and the audit and regulatory committee. The roles and responsibilities of each committee are different. Furthermore, each water user association has its by-law designed by participating irrigation users. According to key community informants and focus group participants, various problems are observed and discussed regarding the performance and decisions of these committees. The committees in each five water user associations lack unity and regular meetings. The committees mostly use water for themselves and their relatives. The failure of the water committee to work together with users on water distribution, unscheduled use of water for different crops, and not monitoring the field regularly have created problems during decision-making. Failure of the committee to present the problems to the user every time and lack of transparency is a challenge as well as not punishing those who have caused damage, unfair punishment and accepting bribes to deliver irrigation water. Water user committees are less motivated. Therefore, irrigation users do not come to meetings when they are required to discuss problems. Rural smallholders who use irrigation tend to have personal interests rather than common interests. Sometimes they do not participate in communal work. Moreover, they lose unity, do not come to the meeting, use water without a programme, and do not participate in cleaning the irrigation water canal on time (Humbo-Ampo Koisha, Damot Woyde-Adecha, Boloso Sore-Gurumo Koisha, Abela Abaya-Abela Mareka Damot Gale-Buge).

The water and irrigation and agriculture offices are commonly responsible government bodies for the construction, administration of irrigation schemes and agricultural extension services, but they do not spend time discussing with users and water users' associations regularly. They have low coordination between each other, for example: the two offices do not discuss and make appropriate administrative decisions. Furthermore, the kebele administration and the leaders do not pay the necessary attention and strengthen the association of the water user. Furthermore, the lack of regular training for users and committees in the decision-making process is also a challenge related to irrigation use and management. Thus, the water association committee lacks adequate training on water distribution, maximising of shares, and use of rules and regulations. Therefore, the association committees of water users do not provide training to users, hold joint discussions with the concerned department together with users, do not maintain structural problems and other activities that could improve the capacity of irrigation water. Owing to the foregoing reasons, irrigation users were less aware of water use management and did not participate in cleaning and maintenance work (KII, FGD_ Humbo-Ampo Koisha, Damot Woyde-Adecha, Boloso Sore-Gurumo Koisha, Abela Abaya-Abela Mareka, Damot Gale-Buge).

8.3.4 Sustainable food availability.

Sustainable availability of food remains a challenge for both female and male households in rural communities in the Wolaita Zone, southern Ethiopia. According to the FGD of both genders, the major factors challenging the availability of food in the Wolaita Zone comprise the decreasing fertility status of agricultural land, the reduction of agricultural land owing to soil salinity and urbanisation of agricultural land, especially, in Buge kebele (Damot Gale District), increasing population density, the increased price of improved seeds and fertilisers and an increase in the price of food supply at the national level. In addition, the problem of instability, shortage of supply owing to the higher prices of agricultural products on the world market and global level price instability, the reduction in production and productivity, climate change, the increasing prices of farm oxen to plough in time, lack of fodder and drying up, lack of resources, the outbreak of crop disease, and pests and limited credit service are some of the challenges.

Male and female group respondents in five sample kebeles (Buge, Gurumo Koisha, Adecha, Abela Mareka, Ampo Koisha) explained the situation more by relating the situation to water administration, decision-making processes and capacity. Therefore, water user association committees are not providing equal water to all land, not providing water to remote users. They are also not providing the improved seeds at the right time, which consequently leads to loss of money. Moreover, absence of market connection for the obtained product (crop), lack of stable political situation, shortage of water, improper preparation of fields, improper use of shifting cultivation, improper weed control, and improper use of agricultural technologies are factors that affect the availability of food in Wolaita, zone. Furthermore, insufficient use of resources in terms of available land, failure to use the improved seeds, lack of sufficient best practices, and not harvesting at the right time are the major challenges to the sustainable availability of food.

8.4 SUMMARY

This chapter aimed to identify factors affecting rural smallholder's food security outcomes. The study used multinomial logistic regression to identify predictors that have an impact on the Household Dietary Diversity Score (HDDS). The predictors included access to irrigation (user and nonuser), the sex of the respondent, highest level of education in the household and the age category of the respondents. The likelihood ratio test was conducted to determine the significance of the independent variables in predicting Household Hunger Scale (HHS) Analysis revealed that certain independent variables were significant predictors of HHS.

The predictors included access to irrigation (user and non-user), the sex of the response, the highest level of education in the household, the period of extension utilisation, the income from the sale of crops, and the farming experience of the respondents. Access to irrigation contributes to the improved household dietary diversity and reduction of hunger among small-holder rural households in Wolaita zone, southern Ethiopia.

The factors challenging the availability of food in the Wolaita zone comprise the decreasing fertility status of agricultural land, the reduction in agricultural land due to soil salinity and the urbanisation of agriculture, especially, in Buge kebele (Damot Gale district), increasing population density, the increased price of improved seeds and fertilisers and an increase in the price of food supply at the national level. Climate change is also among the major factors that affects rural smallholder's food security outcomes and the efficiency of SSI in Wolaita zone. Irrigation scheme administration and water users' association capacity and biassed decision-making in water distribution and conflict management were also among the factors that challenge rural smallholders in Wolaita zone, southern Ethiopia. Designing strategies and policies that address constraints would improve food security outcomes in Wolaita.

CHAPTER 9

DISCUSSION

9.1 INTRODUCTION

This chapter focuses on the contribution of knowledge of the thesis under the capability theory framework. Specifically, it examines the role of small-scale irrigation (SSI) on rural smallholders' food entitlement, basic capability, and the capability to be food-secure in promoting sustainable agricultural practices and enhancing food security outcomes. In addition, the chapter gives a detailed review of irrigation's involvement in increasing food security outcomes across four dimensions: food availability, access, utilisation, and stabilisation. The chapter discusses these dimensions in relation to each of the objectives, nutritional capability approach framework and compares the findings against the existing literature on the topic. Finally, the chapter summarises the study's key findings, responds to the research question, discusses the study's limitations, and makes recommendations for policymakers, planners, and practitioners to improve the role of SSI in improving food security outcomes for rural smallholders. The chapter focuses on the context of Wolaita Zone, Southern Ethiopia and Ethiopia as a whole.

9.2 SMALLHOLDERS' FOOD ENTITLEMENT

9.2.1 Food Production

Food entitlement includes food availability and accessibility. The role of irrigation on food availability is discussed in this section. Food can be available through food production, purchase, gift, and aid. However, in this section, only food availability through agricultural production and purchase are discussed. Agricultural food production includes crop and animal food production. Crop and animal food production can be improved by various factors. Major variables identified as factors for crop and animal production and productivity increase are elaborated, compared to irrigation users and non-users. Total people in the household, family size (comprising only children), total livestock unit, number of beehives, total land cultivated, income, available productive assets, production skill gained (such as training) and use of agricultural technologies (artificial and man-made fertiliser, pesticide, herbicide, crop rotation and intercropping) are identified as variables that affect food production. Beyond crop and animal production, the role of irrigation in the utilisation and possession of these productive and non-productive assets is also discussed.

Rural food production depends on the available labour force in the household. Intensive agricultural activities require an adequate and cheap labour force. The rural labour force can be available from home and hiring. The productive family member in the rural household is considered a labour force to perform their agricultural food production. According to the household survey, the mean number of children for users (M=4.53) and non-users (M=4.59) is almost equal. In rural areas, besides children at the productive age, any relative who resides in the household is also considered as a labour force and supports rural households in any agricultural activity. The mean of people living in the household for users (M=6.77) and non-users (M=6.73) is also relatively equal in the sample kebeles. However, non-user households have a maximum of 10 people while user households have a maximum of 14. This indicates that there is a difference between users' maximum number of labour force and non-users. Furthermore, the result of the qualitative analysis indicates that SSI user groups employ additional labour forces from non-users' households, kebele, woreda neighbouring kebeles and woreda. Therefore, besides the available labour force, SSI users hire additional labour forces for their farm activity than non-users. Similarly, according to Ahmed et al. (2017); Gbete & Fengying (2016b); Gebrehiwot & Mesfin, (2015); and Gebru et al., (2019a), previous studies confirm the influence of available family size in rural household food production. The availability of irrigation contributes to irrigation users' rural smallholders in hiring and availing the maximum number of family members as a labour force in their homes to enhance food production.

Irrigation increases the diversity of crop types produced in small plots of land. The results of both qualitative and quantitative analysis indicate that after irrigation intervention, a diverse range of crops are grown in the sample Wolaita zone kebeles, including various vegetables, cereal crops, root crops, fruits, and spices. Previous studies (e.g. Graciana, 2011; M'nabea, 2013; Jason & Francis, 2016) have indicated the cultivation of diverse irrigated crops such as maize, rice, French beans, sweet potatoes, watermelons, bananas, vegetables, fruits, and others in irrigation areas. Moreover, Issahaku, 2018 and Jason & Francis, 2016 have also assessed the role of irrigation in increasing the diversity of crops per small farmland. Under rain fade agriculture, the types of crop growing are dependent on the agroclimatic zone of the area. However, if there is adequate water available, crops growing only in the highlands can be cultivated in the lowlands. According to this study, wheat was previously cultivated in the highland area of Wolaita. But, after proper training and variety selection irrigation users farmers in lowlands of Wolaita zone cultivate "Wheat". This finding confirms the potential of irrigation to produce highland crops in the lowland areas.

Irrigation increases total crop produced per year, and productivity and reduces production loss. According to the quantitative analysis, the total crop amount harvested by the SSI user and non-user groups. The findings show that the mean value of the total amount of crop harvested by the SSI user group (M=96.9967) is greater than the non-user group (M=26.9680). Similarly, the qualitative analysis confirms the result, irrigation enabled rural smallholders to produce crops throughout the year, better yield per hectare and reduced production loss. Previous studies also indicate the role of irrigation on crop output yield or quantity (Issahaku, 2018; Jebelli et al., 2016; Nethononda et al., 2014; Usman, 2015; Worqlul et al., 2018). Moreover, Bruce et al. (2019) and Jason and Francis (2016) have further assessed the improvement of rice and pepper production in irrigation areas. Beyond the increase in crop production per unit area, this study further confirms the increase in crop intensity due to irrigation agriculture in Wolaita. By producing short season crops and using irrigation technology, rural smallholders harvested more crops and quantity per year. Crop production loss due to low and lack of rainfall reduced the harvest loss or reduction in irrigated areas of Wolaita zone.

Irrigation contributes to animal production. The SSI users had higher mean values for the variable "Total Livestock Unit" compared to the group of non-users. The qualitative analysis results also indicated the availability of irrigation schemes in the area has contributed to the improvement of livestock production. Previous studies assessed the livestock and oxen ownership between SSI users and non-users and found that users had better ownership than non-users (Eshetu and Young-Bohk, 2017; Chazovachii, 2012a). This study extends research beyond livestock production and includes beekeeping activities. Apiculture activities require the availability of flowers and water nearby. The mean value of the variable "number of beehives" for SSI users is significantly higher than non-users. The availability of irrigation water and flowers from diverse crop types played a role in beekeeping activities and increasing honey production. The availability and consumption of honey have a significant effect on human nutrition. Livestock and beekeeping can be supported by improving the accessibility of water resources. This research extends the role of irrigation to beekeeping and production of honey in the Wolaita Zone, which is not assessed in the previous studies.

Rural smallholders' endowments contributed to rural food production. The quantitative analysis of this study indicates SSI user groups have exhibited higher mean values for the variable "total land cultivated" (M=2.3350) than non-users. Moreover, rural smallholders in irrigated areas use more warehouses, farm implements and transportation assets than non-users. Among 116 focus group participants, 98 (84.5%) concurred that irrigation positively affected the farm and non-farm assets they owned. In previous studies only Chazovachii (2012a) depicted the acquisition of assets such as scotch carts by farmers in rural communities owing to utilisation of SSI. In rural smallholders' endowment beyond productive assets (mentioned above like labour force, livestock owned) and income variables, this study extended its assessment to the variables of land size, warehouse, farm implements, and transportation assets.

Food entitlement is also discussed in rural smallholders' production possibilities in irrigated areas. Rural smallholders' production possibility is assessed the variables like production skills and agricultural technologies like improved seed, artificial and natural fertilisers (DAP, Urea and NPS), pesticides, herbicides, and insecticides used. As of the survey, 86.7% and 65.5% of non-users and users received one or more training workshops on crop production, respectively. About 10.37% of respondents obtained training from other non-organisational sectors and 89.63% from the government sector. These respondents claimed, the training had a favourable impact on their crop production, with 79.5% of non-users and 61% of users. A study by Nadeiwa and Koring (2017) confirms the increase of agricultural production skills after the introduction of irrigation among rural smallholders. It is necessary to offer varied and regular training on crop production and topics linked to food security to strengthen rural farmers' ability to adopt advanced agricultural technologies and improve their knowledge and abilities. Offering training opportunities helps rural smallholders to accept new agricultural techniques and technology, ultimately promoting sustainable agricultural growth and food security. Rural smallholders in the irrigated area of Wolaita zone changed crop production practices and increased agricultural food output by gaining knowledge and skills due to irrigation intervention. However, the study shows rural farmers in Wolaita Zone need training despite the availability of existing training opportunities. The study recommends additional research to confirm the findings in different contexts.

Irrigation agriculture enhances the use of agricultural inputs. The quantitative findings showed SSI user group had higher mean values for the variables total DAP, UREA, pesticides, herbicides, insecticides, and different improved seeds used in the 2021 production year than non-users' group. Similarly, the qualitative analysis demonstrates the increased use of agricultural input by users than non-users. For the summer irrigated wheat that has been going on since recently, the government has provided the farmers with the necessary fertilisers such as NPS and UREA for the development of wheat seed. On the other hand, to support this wheat development, the government of Ethiopia has facilitated irrigation pumps, tractors, and combiner machines at low cost. The government has also provided various types of training, vegetable seeds, agricultural chemicals, expert placement for monitoring supervision and professional support in all three seasons. The change in agricultural input utilisation due to irrigation intervention were not assessed by previous studies. Therefore, the availability of irrigation has improved the utilisation of agricultural inputs and attracted the assistance of the government to get the potential of irrigation in Wolaita Zone, southern Ethiopia. Furthermore, the study recommends further research in various contexts to the role of irrigation intervention towards agricultural input utilisation in rural smallholders.

The findings of this study are consistent with the previous research. Previous studies focused on the role of irrigation in the variables of crop diversity, yield, productivity per small farmland and income in different contexts. This indicates that the role of irrigation in the other food security outcome indicators is not studied under variable settings. Previous studies use one and two variables to analyse the contribution of irrigation to food security. One study assessed the relationship between production skill improvement and irrigation. However, this study used more than two variables to understand the role of irrigation in food availability. Labour force, household family size, people in the household, total livestock unit, crop diversity, total land cultivated, production skills and agriculture technology use were discussed in detail about irrigation and food availability. This study includes on food entitlement which were not considered in previous studies in assessing the role of irrigation in food availability and entitlement. Thus, providing farmers with access to irrigation technologies and related resources increases food production, availability and enhances food entitlement in rural communities of Wolaita zone, southern Ethiopia.

9.3 SMALLHOLDERS' BASIC CAPABILITY

9.3.1 Food Diversity

The relationship between irrigation and basic rural smallholders' capability change is discussed in this section. This basic change in capability is measured by identifying the relation between irrigation and food availability, accessibility, and stability. However, to examine the findings about the specific objective of the research only food accessibility or food diversity consumed by rural smallholders in Wolaita Zone is discussed in this subsection. On the contrary, the change in hunger, education, health, and participation of rural smallholders in decision-making and community life of rural smallholders are discussed in irrigation intervention in Wolaita Zone, southern Ethiopia in section 9.4.1.

Irrigation has a significant contribution to rural smallholders' dietary diversity. Based on the quantitative survey results, SSI-user households had higher values for household dietary diversity than non-user households. The mean Household Dietary Diversity score (HDDS) for SSI users was 8.63 but it is 4.94 for non-users. This shows SSI users eat a greater range of foods from different food groups. The qualitative analysis also shows SSI users enjoy a more variety of healthy diets. Previous studies done by Balana et al (2020); Passarelli et al (2018) and Worqlul et al (2018) have also confirmed the association of SSI, as a single agricultural intervention, with dietary diversity and nutrition.

Evidence from Damot Gale, Abela Abaya, Boloso Sore, Humbo, and Damot Woyde districts all show the significant positive impact of irrigation on food production, diversity, availability and security. Before irrigation was introduced, SSI users faced challenges such as limited food supply, famine, and the need to buy food from other places. However, after the introduction of irrigation, the availability and variety of food greatly improved, allowing families to eat to their needs and even sell surplus products to nearby markets. The contribution of SSI to macro- and micronutrient-rich food consumption found a significant role in the consumption of nutritionally rich food groups such as vitamin and mineral rich food groups. Moreover, like this study, Nadeiwa and Koring (2017) discovered most irrigation users were able to provide food for their families, grow crops for consumption, and supply nutritious vegetables. Similarly, previous research done in rainfed agriculture confirms, market-oriented agriculture enhances yields and food security by increasing rural households' dietary diversity, because they can easily purchase other foods to supplement their own production (Ochieng, 2014). On the other hand, previous research done by Ahmed et al., (2014); Hussain and

Thapa, (2012); Shumetie and Alemayehu, (2019) and Wondimagegnhu and Bogale, (2020) focus only on the caloric intake of rural smallholders' households. Therefore, they cannot assess the consumption of other macro and micro-nutrient-rich foods due to irrigation. The findings of this research emphasise the potential benefits of SSI in boosting food access and dietary diversification for rural smallholders, ultimately leading to improved nutrition and health outcomes in Wolaita Zone.

The findings of this research are consistent with previous studies. The systematic literature review showed few studies sought to understand the role of SSI in the diversity of food consumed by rural smallholders. One article (Passarelli et al., 2018) noted the relation between small-scale irrigation and rural smallholders' diverse food group consumption. However, four articles attempted to understand the relationship between irrigation and rural households' caloric intake. Moreover, previous research was conducted using only quantitative methods, while this study mixes both qualitative and quantitative findings. It also includes the findings identified by the systematic literature review to improve the understanding of SSI's role in rural smallholder caloric intake, which is not used in this research as an indicator. This integration depicts the contribution of SSI in food accessibility and diverse food group consumption of rural smallholders. The findings show the need for further research using other indicators of food security outcomes, such as the food consumption scale. Previous research did not include the role of irrigation in changing the pattern of macro and micronutrient rich food consumption in rural smallholders in different contexts adequately.

Irrigation has a role in increasing the diverse food production, consumption, and economic capacity of smallholder rural households. The systematic literature review showed the increase in income and on-farm food production had a positive impact on caloric intake of rural individuals. Small-scale irrigation contributed to the improvement of rural smallholders' caloric intake and change in diverse food consumption patterns including macro and micronutrient rich food types. Thus, SSI has a role in the basic and nutritional capability of rural smallholders in Wolaita zone, southern Ethiopia.

9.4 SMALLHOLDERS' CAPABILITY & FOOD SECURITY

9.4.1 Irrigation and smallholders' food security outcomes

The role of small-scale irrigation in all four food security dimensions is discussed in this section. The change in rural smallholders' capability to be food secure is assessed under these dimensions. The capacity of rural smallholders to improve food entitlement, utilisation, and stability is also presented. Food entitlement and utilisation alleviate rural smallholders' hunger, cognitive and health situation. Food stability is related to individual autonomy to produce and consume diverse food sustainably and in diverse environments, political, and cultural situations. Rural smallholders' hunger situation is also discussed by looking at changes in rural smallholders' quantity of food produced and consumed. Food utilisation and stability are described by caloric intake, sex, and age. The food utilisation and stability are also assessed according to the existing laws, rules, norms, climate conditions and frequency of natural disasters. Some of the mentioned concepts are discussed in the above section to some extent and are explained further in this section. Therefore, the role of irrigation in nutrition, health status, physical well-being, cognitive development and lives of rural smallholders in Wolaita is discussed in detail.

Irrigation has a significant role in changing rural smallholders' household dietary diversity and hunger scale. According to the result of the regression analysis, independent variables such as total crop produced, the sum of purchased food groups, and income from crop sales are predictors of rural smallholder household dietary diversity in Wolaita zone, southern Ethiopia. The regression result also indicates, as HDDS increased by one unit, the total crop produced, the sum of purchased food groups, and income from crop sale increased by 0.299, 0.189 and 0.381 units respectively. On the other hand, HHS is related inversely to the total crop produced, income from crop sales, total livestock unit (TLU) owned by the household, and HDDS in Wolaita. However, HHS is directly related to income from animals, animal by-products and other asset sales in the Wolaita zone. Therefore, according to the regression result, as HHS increases by one unit the total crop produced, income from crop sale, total livestock unit (TLU), and HDDS, decrease by 0.179, 0.299, 0.208 and 0.206 units respectively. On the contrary, as the HHS increases by one unit, the income from animals, animal by-products and other asset sales increases by 0.106 units. As HHS increases rural smallholders in Wolaita do not sell their crop produced, rather use it for home consumption. Thus, the income from crop sales decreases. They sell animals, animal by-products and other assets to get income. Thus, the variable “income from animal, animal by-product and other assets sale” shows a positive increment. The consumption of animal products decreases; thus, their dietary diversity also decreases. Moreover, according to a household survey, SSI users have fewer instances of hunger and food insecurity than non-users. Previous studies have not used the linear multivariate regression method to identify the determining independent variables of acute food security outcomes indicators (HDDS and HHS) in irrigated areas. Therefore, this research grounds further studies to identify multiple determining independent variables using acute food security outcome indicators as a dependent variable.

Irrigation increases the economic capacity of rural smallholders. The income generated by SSI users from surplus crop sales is greater than non-users. The quantitative finding of this study has shown that the group of SSI users had higher values for the variable "income from annual crop production sold" (M=11,220.56, SD= 7,771.08) compared to non-users’ group (M= 4,439.15, SD= 3,804.33). Moreover, SSI users had also higher mean values for the variable "Income generated from animals', animal by-products, and other non-productive asset sale” (M=11741.73, SD=7997.40) compared to non-users’ group (M= 5619.09, SD= 6808.65). Furthermore, the qualitative analysis has also indicated the role of irrigation in improving the income of rural smallholders. Previous studies have confirmed the adoption of SSI technology in boosting net farm income, especially when paired with the right crop varieties (Assefa et al., 2019; Ayele, 2019; Astatike, 2016; Ahmed et al., 2014; Ayele et al., 2013; Bruce et al., 2019; Chazovachii, 2012a; Eshetu & Young-Bohak, 2017; Graciana,2011; Hadgu, 2020; Issahaku, 2018; M'nabea, 2013; Nadeiwa & Koring, 2017; Shumetie & Alemayehu, 2019; Worqlul et al., 2018). This indicates most of the studies focus on the economic feasibility from crop sales in irrigation areas. However, none of the previous studies have considered the income generated from the sale of "animals', animal by-products, and other non-productive assets”. Therefore, the study extends the existing knowledge by including this variable as an income source in irrigated agricultural systems and understands the role of irrigation in the diversity of other income sources. Therefore, it puts a foundation for further research on the role of irrigation in rural smallholders' income source diversity.

Irrigation has contributed to the diversity of employment. The availability of irrigation schemes has created various job opportunities in the area. Rural smallholders in Wolaita have diverse employment opportunities, ranging from farming to small-scale trade and private-sector employment. According to the survey conducted, most smallholders engaged in three main types of employment: farming, small-scale trade, and private-sector employment. The survey result revealed 64 households (24.1%) of SSI users participated in small-scale trading activities, while 49 households (18.9%) of non-users engaged in similar activities. Similarly, qualitative findings of this study have also indicated, that owing to the employment opportunities created from irrigation, youths reduced migration and got jobs nearby. A previous study done by Issahaku (2018) also indicated in his study, irrigation intervention reduced youth out-migration. Therefore, irrigation has a role in the diversity of employment in Wolaita. Irrigation also reduces the migration of youths to find daily wages far from their community and increases the diversity of jobs in the rural area of Wolaita. Since very little research is done to understand the role of irrigation in reduction of rural youth migration, further studies are recommended in different contexts.

Non-user farmers generate income from irrigation projects available nearby. According to the household survey, ten households (3.7%) of non-users relied on daily wage labour to supplement their income. Moreover, the qualitative analysis indicates both users and non-users have earned money from daily wage labour during the maintenance and rehabilitation of irrigation schemes. Individuals came from other areas (neighbouring kebeles and woredas), lived with relatives, and created jobs by doing irrigation work and getting daily wages by engaging in irrigation activities. Previous study conducted by Bosch and Zeller (2019) in rainfed area has also confirmed the income generated from wage labour at the jatropha crop plantation project has contributed to increasing rural smallholders' dietary diversity. So, the results highlight the importance of off-farm activities in enhancing the income and livelihoods of rural smallholders in Wolaita. These activities provide additional sources of income that help diversify household income streams and reduce the dependence on farm-based income. They also strengthen the local economy by generating new jobs and business possibilities and act as a safety net for people in times of low agricultural revenue or productivity. Therefore, the wage payment owing to daily work in irrigation areas has contributed to a livelihood for youths in the rural area of Wolaita, southern Ethiopia. This topic also needs further research in various contexts.

Irrigation has a significant role in changing rural smallholders' food entitlement and utilisation. Food entitlement and utilisation varies owing to food price variation in the market and seasonality. The qualitative analysis of this research depicts the price difference between irrigated and rainfed crops. Most of the irrigated crops are horticultural crops. So, they are in high demand in the market and their prices are high. In particular, the income rural smallholders get from growing vegetable crops such as tomato, cabbage and onion through irrigation is much higher than rainfed. The market demand of vegetables increases during the irrigation season, and the farmers who produce under irrigation are benefited. The introduction of irrigation has had a positive impact on crop distribution, allowing greater food availability in Wolaita, during the dry season. Compared to the price of vegetables produced in the rainy season, the price of vegetables produced in the irrigated season is higher in Wolaita. Income generated during the dry season by SSI users is greater than non-users. Therefore, SSI users increase their financial capacity even in the dry season and are resilient to seasonal food price changes. Previous studies do not indicate irrigation users' resilience to seasonal food price fluctuation. Thus, the research can be used as a springboard to further study the role of irrigation in the food price fluctuation resilience of smallholder’ irrigation users.

Irrigation has enhanced rural smallholders’ resilience to changes in non-food services prices. Price changes to get health, education services and agricultural inputs is considered as non-food services price variation in the research. Currently, non-food service prices are fluctuating. The prices of health services are always increasing in Wolaita. The survey data shows that the annual health expenditure of SSI users is lower compared to non-users. Specifically, the mean value for health services use expenditure among SSI users is 4,410.01, while for non-users it is 5,760. This difference in health expenditure has important implications for the well-being and economic stability of smallholders. Lower health expenditure among SSI users indicates they have better access to preventive health care services or are more likely to seek treatment at an earlier stage of illness, when costs may be lower. This leads to better health outcomes and reduces the financial burden on households. On the contrary, higher health expenditure among non-users suggests they are less likely to have access to preventive health care services or delay seeking treatment until their condition has worsened, leading to higher costs. This results in poorer health outcomes for individuals and households, as well as increased financial strain. The qualitative analysis further indicates the increase in disease resistance of rural smallholders using irrigation due to their improvement of economic capacity and consumption of adequate and quality food throughout the year and use of health service at an early stage. The government of Ethiopia has policy support for rural smallholders through a health insurance service program. However, due to implementation problems of health insurance services rural smallholders are obligated to get advanced health services in private health institutions during injury and sickness. This situation exposed non-user smallholder farmers to higher health expenditure. On the contrary, although there is price fluctuation in health services, owing to the income generated from irrigated agriculture, users are resilient to health service price changes at any time. Moreover, the quantity and quality of food consumed and knowledge of nutritional food consumption like vegetables and fruits has also contributed to the reduction of the health expenditure by SSI users. Previous studies do not indicate the relationship between irrigation intervention, nutritional capacity change, and resilience to health service price fluctuation of rural smallholders in irrigated areas. Therefore, this finding could be a foundation for the resilience of rural smallholders to health services price fluctuations.

The education policy of the country mandates children not to pay school fees until Grade 10 in government schools. Therefore, rural smallholders have access to education services nearby. However, those families who can pay the school fees in private schools can send children to these private institutions. In contrast to the policy, all educational levels are not available near to all rural smallholders. Therefore, rural smallholders are obligated to pay for the transportation, accommodation costs, food and other education expenses for their children. To get these private and public-school services outside their village, rural smallholders should expend money for various expenses. Moreover, these services cost differently every year. According to the household survey result, the mean education expenditure of SSI users is greater than non-users. Furthermore, qualitative respondents have also indicated the increase in expenditure of students for the fulfilment of various school materials and resources. Consistent with this finding, Chazovachii, (2012a) has found the positive contribution of the SSI to cover school fees. Therefore, this result indicates irrigation in Wolaita Zone, southern Ethiopia has a role in supporting rural smallholders' education expenditure owing to the income earned from the sale of surplus agricultural products and other income sources due to agricultural activities. This finding can be used as additional evidence to previous findings and further study.

Rural smallholders have become more resilient to fluctuations in the price of agricultural inputs due to irrigation. According to the qualitative analysis, the increase in the price of inputs or price inconsistency and not getting them in time in terms of type and quantity, has affected crop production in Wolaita Zone, southern Ethiopia. However, although there is an increase in price of agricultural inputs, rural smallholder irrigation users use more agricultural inputs than non-users. Therefore, the findings indicate earlier the exchange condition of irrigation users has increased than non-users. So, irrigation has contributed to the improvement of irrigation users' exchange capacity. This finding can be mentioned as among the contributions to the existing knowledge.

Irrigation has contributed more for adoption of different agricultural technologies and developed effective coping strategies during shortage of food and income. So, food entitlement of rural smallholders is further discussed using food stability strategies in an irrigated area. Food stability strategies, like coping strategies and adaptation (any farm activities) implemented, are discussed in this research. This research has confirmed the adoption of raw planting and use of various agricultural technologies like improved seeds, fertilisers, irrigation pumps, and diversion schemes. The crop production in rural smallholders is improved by adopting these different agricultural technologies. Therefore, the coping capacity of irrigation users has changed due to adoption of irrigation technologies in Wolaita.

Food acquisition capacity and coping strategies varied across smallholders. According to the quantitative result households utilising the SSI system demonstrated a lower weighted HCSI. The mean score for this group was 3.7300. In contrast, the group of households not using the SSI system had a higher mean score of 7.8800. The variation in scores indicates SSI users might possess more efficient coping mechanisms to manage food scarcity owing to enhanced access to water for irrigation and increased agricultural output. Moreover, these results offer a valuable understanding of the distinctions between the two groups, indicating the possible existence of factors tied to SSI utilisation that contribute to the variances in coping mechanisms and food security outcomes. Like this research, Koczberski et al (2012) and Ochieng et al (2015b) have highlighted how a consistent income and market-oriented agriculture gives a strong sense of stability that offsets the deficiencies of food variability, and diversity, helps to diminish hunger and set effective coping behaviours. However, this concept was not assessed enough by the previous researchers. Therefore, it could be counted as an additional contribution of this research to the existing knowledge in Wolaita context.

Food utilisation varies depending on the sex, age of the individual, health status, education level, and economic capacity. It entails the consumption of food through adequate diet, clean water, sanitation, and health care to reach a state of nutritional well-being where all physiological needs are met. This brings out the importance of non-food inputs in food security (Russell et al., 2011). Moreover, it includes the diet quality, diversity of food consumed, nutritional knowledge, cultural and religious beliefs about food products in the area. Therefore, understanding the consumption pattern change among women, men, and children (above and below five years old) is critical to describe the role of SSI in rural smallholders' food utilisation. Owing to time and finance constraints, this study does not measure the amount of food consumed by rural smallholders individually according to their age and sex. However, using the qualitative method, both women- and men-headed households are interviewed to explain their views on the change in consumption pattern of food among various age groups and sex in the sample kebele. According to the findings, 18.2% of the respondents are female household heads who are responsible for food preparation. On the other hand, of the total respondents, 81.8% are male-headed households, who are adults and ate the food in the household on the previous day. Moreover, it was found that most of the respondents fell under the age category of 35 to 44, followed by those aged 45 to 54. This suggests that the sample is skewed towards the middle-aged population. Therefore, 96.25% of the respondents are under productive age implying most of the respondents are in the age range where they are likely to be actively engaged in the workforce and contributing to the economy. Therefore, this age group requires adequate and quality food to be productive. Qualitative analysis results confirm irrigation has boosted both men's and women's diverse food consumption, and even children under (five). These age and sex groups get foods like various vegetables, mangoes, avocados, and bananas, as well as grains which are important for human health. Children suffer from hunger and disease has changed.

Pregnant women also have access to healthier food than they had earlier. This qualitative finding indicates the change in the consumption pattern of rural smallholders in Wolaita. Therefore, although it requires further and detailed study, according to the view of the respondents, SSI has changed the community's diet intake and nutrition for all members of the rural smallholders, including children (under and above 5 years old), pregnant women, and men.

According to the findings of the systematic literature review of this study, previous studies do not focus on the role of irrigation in food utilisation of individuals within the household and outside under different sex and age groups. In other words, the intra and inter-distribution of food in the household and the community is not yet studied in the households of irrigated areas. However, on the contrary, previous studies conducted by Gebru et al. (2019b) and Doocy et al. (2017) have found participation in the vegetable business results in higher food availability and access but lower food variety and diet diversity scores. On the other hand, participation in vegetable business only has less impact on per capita kilocalorie consumption and child anthropometric measures of food security (Gebru et al., 2019b). Similarly, Doocy et al. (2017), concur has concluded improvements in agricultural production alone are unlikely to significantly change child nutritional status—a health outcome with a complex, multilevel causal chain. Therefore, Tapela (2012) argues the role of SSI in commercial agriculture under different contexts needs further study to strengthen or disprove the like results. Similarly, this research also recommends further research using quantitative data to understand the role of SSI in rural smallholder food utilisation under various ages and sexes. Using chronic food security outcomes indicators like child anthropometric measures (Weight to Age and Age to Height) and Body Mass Index would give more reliable data in addition to this qualitative research in irrigated areas.

Irrigation has improved rural smallholder nutritional food production and consumption knowledge. Owing to the availability of irrigation schemes in the area various governmental and NGOs provide training on nutritional food production and consumption. Rural smallholders' nutritional knowledge has shown improvement. The survey result indicates in the study area, cultural and religious beliefs do not prohibit smallholders from using the food types they produce. The qualitative finding also confirmed this result. Therefore, irrigation has contributed to the food utilisation of rural smallholders in Wolaita Zone, southern Ethiopia.

Irrigation has contributed positively to health, physical and cognitive development of children in irrigated areas. The survey conducted shows SSI users and non-users do not provide enough food to their children before and after school. However, more SSI users provide quality food for their children than non-users. Irrigation has increased SSI users' ability to fulfil their children's food demands and required school and health expenditures. Small-scale irrigation users (73.5%) reported an increase in their children's academic performance compared to non-users (46.5%). Similarly, the qualitative analysis has also indicated an increase in student enrolment and academic performance in the irrigated area of Wolaita Zone. Therefore, irrigation has significantly improved children school enrolment and academic performance in Wolaita zone, southern Ethiopia owing to improved, sustainable food availability, consumption of adequate and quality food, and income generated. This finding is not researched by previous studies. Therefore, it needs further study and gives the foundation for the next studies in irrigated areas.

Irrigation has contributed to rural smallholders’ health status improvement. The improvement of rural smallholders in health status is discussed through reviewing access to health services, resistance to the main diseases, self-reported health status and access to drinkable water and sanitation. According to the qualitative analysis, irrigation has answered various people's health problems and food needs. At the family level, irrigation agriculture responded to the food demand of women and youth. By producing various garden vegetables, and offering, and selling food to the market, irrigation has brought a convenient environment for rural smallholders to get the type of food they want from the market unless they cannot get from their farm products. Therefore, better nutrition has been made possible by consuming more than two meals a day. Besides, community and individual food shortages have improved in irrigated kebeles. The number of people who get sick due to lack of food in kebele has decreased. This made individuals in the sample kebele healthy and improved the health situation. On the contrary, the study has also found malaria is the most prevalent disease in the sample kebeles, followed by Dharia, which is a water-borne disease. The high prevalence of malaria in the area has implications for the health and well-being of the local population, as well as agricultural productivity and economic development. Similarly, previous research has also confirmed malaria as a major disease occurring in irrigation areas (Asayehegn, 2012). However, although these diseases affect the rural smallholders, owing to access to food and other resources, SSI users are more resistant to diseases and access preventive measures than non-users in Wolaita Zone, southern Ethiopia. Therefore, this research confirms the role of irrigation in rural smallholders' health status, but it needs further study in a variable context.

Access to drinking water, sanitation and hygienic practices of individuals depend on the capacity and education level of the household. The survey found rural smallholders in Wolaita primarily obtain drinking water from piped taps, water on site/yard and public/communal taps. Moreover, the study revealed SSI users are more likely to treat drinking water with chemicals like chlorine and boiling methods than non-users. In terms of sanitation facilities, all rural smallholders are required to have pit latrines around residences and along the roadside for public use. However, none of the respondents had a bathroom or shower in their house and relied on river and tap water to clean their bodies and clothes. According to the quantitative survey, SSI users are more likely to use tap water for cleaning purposes, while non-users are more likely to use river water. User groups have reported the income generated through irrigation had helped to support families in obtaining clean drinking water and sanitation facilities. Owing to increase in the financial capacity, irrigation users have enhanced their basic capacity to get clean drinking water, sanitation, and hygienic practices more frequently than non-users. Like this finding, previous research done by Chazovachii, (2012a), confirmed the implementation of SSI has managed to supply water throughout the year to rural smallholder communities. Therefore, although it needs further study under different contexts, SSI has contributed to access to pure drinking water throughout the year, improving sanitation and hygiene in rural communities.

The concept of food stability refers to both the availability and access dimensions of food security under different social, economic, environmental, and political contexts (Russell et al., 2011). Irrigation has contributed more to the food availability and access in Wolaita. Moreover, the afforestation activity and planting of perennial fruit crops have also changed the climatic condition and generated income throughout the year in the irrigated area of Wolaita. Similarly, previous research done in rain fade agriculture, confirms a consistent income gives a strong sense of stability that offsets the deficiencies of food availability and helps to diminish hunger (Koczberski et al., 2012). The qualitative result also has indicated reducing the need for relief grain from the government. Likewise previous study confirms rural smallholders in irrigated areas eat three meals a day with their families and did not rely on relief food (Nadeiwa and Koring, 2017). However, based on the quantitative finding of the research a significant proportion of both SSI users and non-users had experienced such shortages or losses of resources owing to natural disasters. This result indicates more non-users are affected by natural disasters than users. Specifically, 150 (75%) out of 200 SSI users and 190 (95%) out of 200 non-users reported experiencing such events, while the remaining respondents reported not. Therefore, although it requires further study, the availability of SSI has increased the resilience of irrigation users and non-users to the occurrence of natural disasters at the individual level and food stability in rural smallholders in Wolaita.

Southern Ethiopia region is vulnerable to natural disasters. The frequency of natural disaster occurrence could be within ten years or less. Prolonged drought or a lack of precipitation is a potential scenario for the disasters. In other words, if the region were to experience a prolonged period of drought or inadequate rainfall, it could lead to severe food and income shortages or losses. The respondents have suggested the region as prone to food and income shortages or losses, which could be exacerbated by natural disasters. Increasing population, demand for expansion of agricultural land and deforestation of conserved cultivable lands in the region are critical problems. This deforestation activity further favours climatic change. Eventually, the consecutive effect of deforestation and increase of population cause adverse climatic change. The adverse climatic change, reduction in ground level water and increasing population also lead to reduction in river discharge. Irrigation users at the end of the command area are affected due to river discharge reduction. The finding highlights the importance of preparedness and mitigation efforts to address the needs of vulnerable populations in Wolaita. Therefore, integrating irrigation with sustainable developmental activities could reduce the occurrence and effect of natural disasters in the Wolaita Zone and southern Ethiopia region. This finding can be supported by further research mixing quantitative and qualitative methods.

Food entitlement, utilisation and stability are dependent on rural smallholders' autonomy. The government of Ethiopia has provided the right to individual autonomy to participate and benefit from any public provisions. According to survey results, a significant proportion of SSI users (97%) and non-users (96%) had utilised their right to claim access to public provisions. However, several respondents reported they are dissatisfied with the decision-making process, which they perceived to be long and unfair. As a result, some farmers had opted not to use their right to claim access to public provisions.

Small-scale irrigation users have depicted the contribution of irrigation to public decision-making and participation in the community. The survey found both SSI users (98.5%) and non-users (93%) are highly engaged in community life. The qualitative analysis has also confirmed the increased participation of irrigation users in community activities. Therefore, in the context of irrigation, membership in water users' associations and committees has played a particularly important role in promoting sustainable and equitable management of water resources. By participating in these bodies, SSI users have contributed their indigenous knowledge and experience, as well as their perspectives and needs, to the development of irrigation policies and other agricultural programmes in Wolaita.

Participation in irrigation and other development activities contributes to a broader sense of community engagement and participation among smallholders. This study highlights the potential of irrigation and other rural development interventions to promote greater participation and engagement among smallholders. Therefore, irrigation has impacted the food availability, accessibility, utilisation, and stability of rural smallholders in the irrigation area of Wolaita Zone and southern Ethiopia.

The findings of this subsection are consistent with previous literature. Food security outcomes components not researched by previous scholars should be further studied to keep the consistency of the result in different contexts using other food security outcomes indicators comprehensively. The variables discussed in this chapter are framed under nutritional capability approach. All the variables indicated in Chapter 4; Table 4.13 are included in the analysis. They consist of variables which are not covered by previous researchers. Moreover, all the concepts indicated in Chapter 2; figures 2.2, 2.3 and 2.4 are also discussed under the framework of human development theory and nutritional capability approach. This theory and approach made the researcher understand the role of irrigation to the multidimensional concept of food security indicated in the conceptual framework of the study and able to identify the variables which were not used by previous researchers easily. Therefore, irrigation has transformed the way of life of rural smallholders, economic opportunities, improved food security outcomes, and nutritional capability of rural smallholders in Wolaita Zone, southern Ethiopia.

9.5 FACTORS AFFECTING FOOD SECURITY OUTCOMES

The food security of rural smallholders relies on agriculture. Food security is challenged and affected by different factors. According to the quantitative analysis, the predictors of rural smallholder dietary diversity include the access to irrigation (user and non-user), the sex of the respondent, highest level of education in the household and the age category of the respondents. Gbete and Fengying (2016b) identified the age of the household as a factor in agricultural production. Multinomial regression showed that the predictors of household hunger score are access to irrigation, the sex of the response, the highest level of education in the household, the period of extension utilisation, the income from the sale of crops, and the farming experience of the respondents. The income level of rural smallholders was identified as determining food security in previous studies (Ahmadzai & Aryobi, 2021; Bashir et al, 2013). The findings from these analyses indicate access to irrigation, household head sex, and education level of the rural smallholders as the common determinants of HHDS and HHS. Previous research by Gebru et al. (2019a), identified the availability of irrigation schemes as a factor to attain rural smallholders' food security. The empowerment of women improved farmers' skills in agriculture and contributed to food and nutrition security (Murugani & Thamaga-Chitja, 2019). The level of education of the household was classified as a factor in rural food security (Bashir et al 2013; Eshetu & Young-Bohk, 2017; Gbete & Fengying, 2016b; Getinet & Lorato, 2020; Sarker & Itohara 2010). This research categorised the respondents into three categories of HDDS and HHS before conducting the multinomial regression, which is different from previous research. Previous studies did not use HDDS and HHS as dependent variables to identify the determining factors. This study used diverse dependent variables to identify determining factors of acute food security outcomes than previous studies.

Furthermore, according to qualitative findings, the main factors challenging the food security outcomes in the Wolaita Zone comprise the decreasing fertility status of agricultural land, the reduction in agricultural land owing to soil salinity and urbanisation of agricultural land, increasing population density, climate change, increasing price of improved seeds, fertilisers, and food supply at the national level. Like this qualitative finding previous studies by Adeniyi & Dinbabo (2020); Ayele et al. (2013); Eitzinger et al. (2014) and Shumetie and Alemayehu (2019 have indicated moisture stress brought on by climate change as a factor changes crop productivity, exacerbate food security and poverty levels in rural families. Ahmadzai and Aryobi (2021) have also shown food price change as a factor in food security. Therefore, this result is consistent with previous studies and indicates the role of any agricultural intervention like irrigation in rural smallholders' food security outcomes.

Separate multinomial regression analysis for HHS and HDDS is done. Then the result is mixed to get the common factor. The multinomial regression analysis to the dependent variable HHS indicates that variables, such as the size of the farmland, the size of the household and the age of the respondents, are found to be not significant and did not contribute to HHS. Furthermore, Variables, such as farmland size, household size, extension service use period, and farm experience, are not significant and did not contribute to HDDS. This indicates that farmland size owned by rural smallholders and household size do not significantly affect both HHS and HDDS of rural smallholders in the Wolaita zone. However contrary to this finding previous research e.g. Ahmadzai and Aryobi (2021); Ahmed et al., (2017); Gbete and Fengying, (2016b); Gebrehiwot and Mesfin, (2015); Gebru et al., (2019a) and Sarker and Itohara (2010) have identified farmland owned as a factor to food security. Moreover, family size is indicated as a factor that influences the agricultural production and food security status of rural households (Ahmadzai & Aryobi, 2021; Gbete & Fengying, 2016b; Gebrehiwot & Mesfin, 2015; Gebru et al., 2019a; Sarker & Itohara, 2010). However, like this study, previous studies e.g. Bashir et al. (2013) and Shumetie & Alemayehu (2019) have indicated family size harms both food security and the absolute poverty status of households. These findings depict the determining factors are different in different contexts and to the concept of food security outcomes. Therefore, according to the findings of this research, the variables owned farmland and household family size do not affect the HHS and HDDS of rural smallholders in Wolaita zone, southern Ethiopia. In other words, the food security outcome of rural smallholders in Wolaita Zone, southern Ethiopia is not determined by the owned farmland and household family size.

In summary, previous scholars focus on the factors affecting food availability and accessibility more but not on food utilisation and stability adequately. The findings of this study are more consistent with the results of previous studies. However, the effect of family size of the household and owned farmland size on food security outcomes needs further studies under different contexts. Especially in rural households having below national and regional average land size. The result related to owned farmland size is different and contrary to previous studies. The independent sample t-test indicates the variation in own farmland size between SSI users (M=0.7240) and non-users (M=0.7818) is insignificant. Moreover, the mean owned land size of rural smallholders in the Wolaita zone does not contribute significantly to the HDDS and HHS. Therefore, unless high agricultural intensifying activities are integrated, only the harvest from the owned farmland size does not contribute to increasing household dietary diversity and reducing hunger. The farmland owned by rural smallholders in Wolaita is highly fragmented. Thus, access to irrigation technologies is a significant contributor to intensified agricultural activities. Irrigation is necessary to improve food security outcomes in rural communities where owned rural farmland is highly fragmented.

9.6 CONCEPTUAL CONTRIBUTION

The food utilisation and stability concept of food security has not yet been studied adequately to the roles of irrigation intervention on rural smallholder farmers' food security outcomes. To analyse the food security outcomes concept, all the dimensions of food security should be assessed specific to the contribution of the intervention. Previous studies used theories and approaches that allow them to assess only one of the food security components, not all the dimensions. The food security outcomes concept is broader than a single food security dimension or concept. Human development theory and nutritional capability approach allow the researcher to assess all the food security concepts comprehensively. According to the systematic literature review finding, this theory and approach were not used by previous researchers. On the contrary, they employed variable approaches to food security analysis like the food availability approach, the basic needs approach, the income-based approach, the sustainable approach, and the entitlement approach (Burchi & De Muro, 2016). Therefore, this research extends the existing concepts of food security by including outcomes and using Human development theory and nutritional capability approach as a dominant framework.

Food security comprises four dimensions. These are food availability, access, utilisation, and stability. Food can be available from different sources such as food production, purchase, gift, and aid individually. Globally, regionally, nationally and at community level it can be available from stocks and imports. The study unit of this research is household. However, it also includes the individual and community levels. The research finding relates food availability from own food production and purchase. However, foods from rural smallholders' stocks which are from their food production and purchase are included in the research. Food from gifts, aid and imports are not included in the analysis.

Food can be accessed from production, market, transfers, and loans. Market purchase is dependent on food price and available cash at the household level. Cash at the rural household level depends on the availability of cash crops, wages, employment, and other income-generating activities. Food transfers and loans can be done by community, NGO, and community support food banks. Food transfer and loans are a common coping behaviour in Ethiopia. Food consumed from transfer, loan, government salary, and income from non-farm activities is not included in the study. Food accessed from own production and market purchase are included in the analysis.

Food utilisation is determined by sex, age, dietary intake, health status and quality of care. Dietary intake is related with food access, intrahousehold food allocation, and food availability. Health status is determined by access to social services and available infrastructure.

Food stability is the fourth key concept of food security. The role of irrigation on children's school enrolments and educational achievements. Quality of care is influenced by individual knowledge, time allocation and cultural practices. Access to drinking water, sanitation and hygienic practices can also be affected by the income and knowledge of individuals. The influence of irrigation intervention on household knowledge, time allocation and cultural practice changes is also included in the study. Food stability can be affected by climatic conditions, natural disasters, individual autonomy, and decision-making capacity. Moreover, it is also affected by community, natural, capital, and human resource availability. Natural, social and policy environments also influence the stability of food.

Food security outcomes are the major concept of the study. It includes the nutritional status, physical well-being, cognitive development, and lives of the rural smallholders. Moreover, it comprises all four food security dimensions and the concepts indicated under each.

Food security outcomes concept is analysed for rural smallholders with less than the average national farmland size (< 2ha). The role of small-scale irrigation intervention (less capital-intensive technology) was analysed for rural smallholders' food security outcomes. This study extended the existing concepts described under each food security dimension to the most fragmented farmland-size rural communities by adding the concept of outcomes. This was not done by previous studies as confirmed by the systematic literature review. Therefore, integrating the concept of food security outcomes into less capital-intensive SSI technologies and the most fragmented farmland-size rural community is the major conceptual contribution of this study.

9.7 METHODOLOGICAL CONTRIBUTION

Convergent parallel mixed design is employed to analyse the role of irrigation in rural smallholders' food security outcomes. The pragmatic paradigm is the philosophical basis for mixed-methods research. Participating and not participating in small-scale irrigation was used to infer the improvement of rural smallholder food security outcomes. The study utilised cross-sectional data for quantitative analysis and data from the last ten years for qualitative analysis. The nutritional capability approach was used to analyse the role of SSI in food security.

Methodologically, this study is different from previous research because it mixes the findings from a systematic literature review (SLR) and uses human development theory and nutritional capability approach to understand the concepts indicated under the conceptual and theoretical frameworks of the study. The SLR identified n=139 articles for analysis. Previous studies identified 115 articles for the analysis of food security. These articles were categorised into two groups to review the impact of rainfed (n=74) and irrigated (n=65) agriculture on the food security of small farmers in rural areas. During the search for journal articles, no results were found in both groups for the key term 'food security outcome' in the title. Among the n=65 articles used in the SLR, only two articles used SLR as a methodology to understand SSI on rural small-holder food security. However, four (n=4) articles used general literature review, not systematic. Two (n=2) articles did not mix research methods (qualitative and quantitative). The contribution of this research lies in the systematic review of previous studies and mixing qualitative and quantitative analysis to understand SSI in Wolaita.

In previous studies, the views and experiences of rural smallholders were not adequately captured in quantitative studies. According to the systematic review of the literature among the n=65 journal articles included in the analysis, n=39 (60%), n=9 (13.5%) and n=17 (26.15%) articles are analysed using quantitative, qualitative, and mixed methods, respectively. This indicates that previous studies were largely on quantitative. Few studies mixed both quantitative and qualitative methods. In addition, previous studies do not use human development theory and nutritional capacity approach to analyse food security outcomes and mix them with SLR. findings. Previous studies used HDDS to analyse the contribution of SSI on nutrition and dietary diversity. However, this study integrated HHS and household coping strategy index scores into HDDS. The results are interpreted by mixing the results found from these three acute food security outcomes indicators which are not done by previous studies. Mixing various food security outcome indicators helps to understand multidisciplinary agricultural activities like irrigation. This research is a springboard to further research in methodological aspects in understanding similar topics.

The Southern Nations Nationalities Peoples Region is purposefully chosen among the other administrative regions of Ethiopia owing to its potential for irrigation, population density per square kilometre and food security situation. The Wolaita Zone is one of these zonal administrations of the SNNPR, which is sampled purposefully owing to its potential for irrigation, high population density per square kilometre has very low average landholding (0.25ha) compared to the national average (0.84 ha) and its reputation as a green famine area (CSA, 2021; Rahmato et al., 2013) among other administrative zones of the SNNPR. Five districts are purposely selected from each agroclimatic zone (highland, midland, and lowland) based on the year of construction of the existing SSI scheme, potential for irrigation, population density, and food security situation. The study is conducted in five districts and five irrigation schemes – Boloso Sore, Damot Gale, Damot Woyde, Abela Abaya and Humbo - out of the total of 16 districts.

The simplified Yamane formula is used, assuming a confidence coefficient of 95%, a population proportion of 0.5, and a sampling error of 0.05. A total of 400 participants were included in the household survey. Similarly, previous studies Bjornlund et al. (2019) and Mokari-Yamchi et al. (2020) have used 404 and 402 sample sizes for household surveys. The total number of households in all kebeles is divided into two strata: SSI users and nonusers. Then, a proportionate stratified random sampling is conducted to select the sample households for each group. To identify these households, the researcher obtained a list of households in each peasant association from the kebele administration office through an official request letter, and a list of small-scale beneficiaries was obtained from each water user association.

The study used a stratified snowball sampling method to select participants for FGDs. SSI users are divided into male and female groups, and study participants for each group of FGD are selected based on age categories ranging from 18 to 24, 25 to 34, 35 to 54, 55 to 64, and above 65 (Ndinda & Adebayo, 2021). Two respondents are selected from each age category, resulting in ten to 12 participants per FGD during data collection. Two FGDs are carried out in each district, for a total of ten (10) homogeneous FGDs throughout the study. The number of participants available during the discussion are 116 participants. The maximum number of focus group discussions conducted in a previous similar study is 15.

Key informant participants are chosen through purpose- and snowball sampling methods at their weekly meetings. Community leaders are selected based on their knowledge and experience. Seven community leaders are selected from each of the five kebeles, resulting in a total of 35 team leaders. Additionally, agricultural office heads at the kebele level are interviewed, with five individuals selected from the sample kebeles. The heads of the agricultural office of the kebele level are purposefully selected to provide their expert opinions on the research topic. Totally 40 key informants participated in this study. Previous studies interviewed a maximum of 120 key informants in the area.

The findings of the systematic literature review reveal that previous researchers used household surveys alone, and otherwise comprising a mix of qualitative and quantitative data collection instruments to examine the relationship between SSI and food security outcomes, as well as the impact on smallholders. Document review alone and with field surveys are also used. Among qualitative data collection tools Focus Group Discussions (FGD), and Key Informant Interviews (KII) are frequently used in conjunction with quantitative data collection instruments. This research has employed household survey, FGD, KII, and document review including a systematic literature review. The research is done using the maximum sample size of each research tool until data saturation. Furthermore, this research mixes the systematic literature findings from n= 139 journal articles with the findings from quantitative and qualitative data, which is not done by previous studies. The maximum sample size indicated in previous studies is used in the single analysis method. This research has implemented all data collection instruments such as household survey (n=400), focus group discussion (n=10/116 participants), key informants' interview (n= 40), and systematic literature review (139). The total sum of these participants from all these tools is greater than the previous studies' sum. The difference to previous research is the total sum sample size and the inclusion of all instruments in the study. Previous studies have missed one or two data collection tools and are biassed toward household surveys.

In this study, initially, a systematic literature review is conducted, and the findings are analysed and interpreted using descriptive statistics. Next, both quantitative and qualitative analyses are implemented and interpreted by mixing the findings. In this research, HDDS, HHS and HCSI for each sample household are calculated and used as dependent variables to analyse food security outcomes due to the intervention. Previous studies have interpreted the result using descriptive and inferential statistics like this research and implemented only HDDS (Passarelli et al., 2018). Multivariate linear regression and multinomial regression have been implemented to identify the determinant factors of the food security outcomes, which is not employed by previous studies.

The validity, reliability and rigour of the study was ensured using various indicators like triangulation of findings from surveys, FGDs and interviews. Recent research journals from 2010 to the present were reviewed and related to the study findings. Triangulation was used to maintain conformability and relate findings to previous work. External validity was assessed to determine applicability in different contexts. The study considered natural resource availability and sustainability in different environments. A mixed methods approach was used, with qualitative and quantitative data collected simultaneously. Questionnaires were translated between English, Amharic and the local “Wolaitigna” language to ensure comprehension. A pilot test was conducted to improve the understanding of key terms by locals. FGD participants provided consent and discussions were recorded, transcribed and translated carefully. Reliability was ensured through independent verification and translation of transcripts. Thematic analysis was performed on the cleaned and organised qualitative data. This study uniquely translated instruments across three languages, unlike previous local studies.

9.8 AGRICULTURE AND IRRIGATION

Ethiopia has many large surface and underground water resources (MoFED, 2003). The country has opportunities, such for commercialising the production of fruits, vegetables, and ornamental plants. The country has opportunities in animal production because it is the leader in Africa in terms of livestock production (Wendimu, 2021). Crops account for 60% of the sector's output, followed by animal production (27%), and other sources (13%) (Welteji, 2018). The favourable climate, agro-ecology, access to land, and water resources favour the production and consumption of diverse crop and animal food groups in rural communities. To manage these resources integrated and appropriate agriculture and water policies and regulations are required. The federal government has policy that is under implementation. Although most of the work has already been done, more that can be done to enhance the policy (MoFED, 2003).

Water resource management policy was designed in 2003 for the first time. It is integrated with other related rural development policies. Professionals were assigned and started to support agricultural, water conservation and irrigation programmes at the kebele level. The initiatives did not improve utilisation of water resources or alleviate the sector's capacity limitations.

The policy encouraged improvement of the agronomic techniques of the farmers. Agricultural operations embrace greater use of water. The use of runoff and flood water for irrigation can be encouraged by promoting straightforward technology. Small-scale irrigation technologies can be developed and managed by farmers. Another option is to build a medium dam and divert the river. By providing people with some technical and financial help through credit services, it is possible to mobilise people and develop water resources. Moreover, the existing policy promotes the construction and profitable operation of hydroelectric dams by private investors. A similar approach to policy stimulates and promotes private involvement in irrigation dam building. As a result, there aren't many issues with the current government strategy.

The water resources management policy was designed independently and extracted from the rural development policy. It consists of three primary policy sections: water supply and sanitation, irrigation, and hydropower. The policy aims to strengthen and promote all national efforts to maximise the effective, egalitarian, and optimal use of Ethiopia's existing water resources for considerable socio-economic growth in the long term. It is important to understand the development, use, preservation, and conservation of water resources are interdependent and guarantee related activities. Related activities such as hydraulic structures, watershed management, drainage, and irrigation are coordinated. Sanitation, water supply and sanitation activities are also coordinated to ensure proper development, use, preservation and conservation of water resources.

The overall objective of the irrigation policy, which falls under the category of water resource management policy, is to maximise the potential of irrigated agriculture. It aims to maximise the potential of irrigated agriculture to sustainably and efficiently produce food crops and the raw materials required for agro-industries. The policy also aims to achieve this while maintaining the fertility of the production fields and the foundation of water resources. All specific aims also support the nation's large-, medium-, and small-scale infrastructure development and distribution in an environmentally sustainable, equitable, and efficient manner. It does offer complete integration with the overarching framework of the nation's goals for socioeconomic growth, especially the ADLI (Agricultural Growth Led Industrialization) Strategy. Irrigation policy is also created within the framework and domain of total water resource management. It is acknowledged as an intrinsic part of the water sector. Thus, irrigation technology development, promotion, distribution, and administration are controlled by other sub-policies.

The current irrigation policy encourages the creation of suitable and reasonably priced technology for the planning, building, implementing, running, and maintaining of irrigated schemes. However, its full potential has not yet been realised. There has been a lack of attention given to this policy, even though it encourages the development of suitable and sustained institutional structures for the management of irrigated agriculture. The policy also encourages the development of capacity in the areas of human resources, new technologies, engineering, and financial management. Water must also be readily available, accessible in the proper quantities, and available when needed. Therefore, for agriculture to develop rapidly and independently, a dependable supply and management system for drinking and irrigation water is required. To date, policymakers and aid organisations have placed a strong emphasis on using modern farm technologies as Ethiopia's only source of agricultural growth (Welteji, 2018). However, current technologies are so expensive that only a small number of farmers in a small portion of the country can afford them (Welteji, 2018). As an experienced professional and researcher, practically a major emphasis has been placed on drinking water supplies, sanitation, and hydropower policies. However, irrigation policy does not receive special attention as to its potential and contribution to the national, household economy and food security outcomes. Therefore, it should be treated independently as a single policy and include detailed policy issues such as how to subsidise rural smallholders with modern, less capital-intensive irrigation and farm technologies. Irrigation development regulations, guidelines, manuals, codes, and standards have to be also designed.

Rural area food security depends heavily on access to food production and entitlements which rely on access to resources (like land, labour, finance, water, and energy etc.). Food entitlement of rural smallholders is highly dependent on access to water resources. The lives of rural smallholders depend on agriculture which is highly dependent on the availability of water resources through various means and from various sources. Rural smallholders in Africa countries, especially in Ethiopia are food insecure and their economy is dependent on agriculture. Moreover, Ethiopia’s agricultural sector is highly diverse and subject to change owing to varied factors such as climate and population growth. It is rainfed and hence, any irregularity in weather conditions has adverse welfare implications. The level and variability of rainfall are important determinants of persistent food insecurity and vulnerability. Consequently, competition for available land, water, energy, and agricultural inputs, poses pressures on the rural population's livelihoods and food security outcomes.

Agricultural projects' availability and efficiency to support the technical problem of rural farmers and food security in rural areas is a challenge (Madzivhandila & Masenya, 2014). McIntyre and Hendriks (2018) state that to help members of impoverished rural communities develop a more grounded and localised understanding of food insecurity. It is necessary to jointly diagnose the issues about their food security. This involves gathering data on the social, political, and cultural factors that impact nutrition outcomes and shape experiences of hunger. Usman Oladimeji et al, (2020) have also indicated in their study that intercropping and mixed cropping is the most common strategy adopted by farmers in mitigating land degradation. Therefore, policies related to rural smallholders' food security outcomes such as agriculture, health, education, drinking water, gender empowerment and entrepreneurship should be integrated and structured under a sustainable monitoring and evaluation system. These policies should be geared towards promoting sustainable development and reducing poverty in the rural area of the country.

Therefore, the following are the researcher's recommendations based on the study's findings for policymakers and practitioners. Small-scale irrigation practices need to be environmentally sustainable. It is crucial for improving long-term food security outcomes. Avoiding negative environmental impacts and gender disparities in access to irrigation technology pose a serious barrier in many rural communities. Smallholder irrigation in rural regions can benefit greatly from the participation of business sectors. Here are some methods that the public and private sectors can help promote smallholder irrigation in rural areas. To solve these concerns, policymakers can explore the following strategies:

- Promote sustainable agricultural practices: Sustainable agricultural practices, such as crop rotation of rainwater harvest, intercropping and water-efficient irrigation techniques, are very important. They have variable benefits in improving food security outcomes and reducing the environmental impact of agriculture. Therefore, small-scale irrigation should be integrated with these techniques to protect against the effects of climate change, disease, and pests.

- Invest in irrigation infrastructure: Small-scale irrigation schemes play an important role in improving the food security outcomes of small farmers in rural areas. However, its expansion in the Wolaita Zone, southern Ethiopia, is very limited. Therefore, although the investment in irrigation schemes requires a large amount of capital, significant investment should be made in building a new SSI scheme in a rural area insecure for food. Small-scale irrigation investments can be available at a low capital cost and are friendly to smallholders. Furthermore, since some existing SSI schemes need to be rehabilitated and maintained, they should get special emphasis and serve their potential. This would improve the ability of small farmers to access water resources for their crop and animal production. Small-scale irrigation technologies beyond diversion such as motor pumps, micro ponds, sprinklers, micro dams, and wells could be used for irrigation and domestic use.
- Provide financial support: Smallholder farmers should enhance their competence and shift from “usual farmers” to “entrepreneur farmers” and commercialise. Therefore, they should get financial support, subsidised, and improve their capacity to get demanded agricultural inputs, private and communal irrigation technologies. This can include providing loans, grants, or subsidies to purchase irrigation equipment or pay for the costs associated with irrigation infrastructure development.
- Strengthen extension services: Training and technical support to rural smallholders in the area is very insignificant in irrigation system design, installation, maintenance, and irrigation agronomy. Therefore, governments and NGOs should strengthen extension services to provide smallholder farmers with the knowledge and skills needed to effectively use irrigation technologies.

- Address gender inequalities: In the Wolaita Zone and southern Ethiopia region, gender inequalities in accessing irrigation technologies and related services need further work. Therefore, by promoting women's participation in decision-making processes, providing training and capacity building for women, and ensuring women are required to get financial access and other resources.
    - Conduct gender-sensitive needs assessments: Specific needs and priorities of rural women regarding irrigation technologies, programmes and services should be identified. Therefore, to meet the needs of both men and women farmers' gender-sensitive needs, assessments should be done together with concerned bodies and designed to meet the needs of both men and women.
    - Even though women have the right to participate in all decision-making processes, their participation is still low. As a result, the concerned organisations should reinforce and promote more irrigation technology-related activities by encouraging them to attend community meetings, water user associations and other decision-making bodies.
    - Provision of training and capacity building for women in the area is insignificant. Therefore, the government and NGOs should facilitate and provide frequent training and capacity-building programmes for women to help them acquire the knowledge and skills needed to effectively use irrigation technologies such as training on irrigation system design, installation, and maintenance, as well as business and financial management skills.
    - Although financial services are available, women may not be encouraged to be confident to take the risk and access to financing and other resources. Since irrigation is an intensive activity, it requires finance and other resources like agricultural inputs. Therefore, women should be facilitated and have equal access to

financing and other resources needed to purchase and use agricultural inputs and irrigation technologies.

  - Women are highly exposed to cultural and social norms. The government and NGOs are working to address the challenges owing to culture and social norms. However, its intensity is still shallow. Therefore, they should encourage women through awareness creation and education to challenge gender stereotypes and promote women's rights to access and control over resources.

- Small-scale irrigation practices should be implemented environmentally friendly by promoting efficient water use, reducing soil erosion, and minimising the use of agrochemicals.
  - In the Wolaita Zone, southern Ethiopia, the use of irrigation water is not efficient. The government structure available until Kebele should promote efficient water use. Furthermore, water-saving technologies such as drip irrigation and sprinkler systems are not diversified. Therefore, these water-saving irrigation technologies should be adopted to rural areas and rural smallholders should be trained on how to use and maintain them sustainably. Irrigation water wastage is critical in the area. Therefore, rural smallholders should get frequent training on how to use the available water resources more effectively.
  - Reduce soil erosion: Soil erosion highly affects irrigation infrastructures like dams, canals, night storages etc. Seasonal and untimely rainfalls seriously damage and silt up these structures. Therefore, soil and water conservation activities in the farm and upper catchments of the irrigation structure, such as the use of cover crops, mulching, conservation tillage, fanya-juee, stone bands, gully control etc. This can help to protect the soil and reduce the loss of nutrients and soil fertility.
  - Minimise the use of agrochemicals: Irrigation uses agrochemicals highly to protect herbs, pests, and weeds. These agrochemicals

influence the soil, plant and human body. Therefore, government and concerned NGOs should promote integrating the use of organic and natural pest management techniques with agrochemicals and reduce the negative impact of agriculture on the environment, improve soil health and promote production.

- Adopt integrated water resources management: Water is a highly valuable resource and requires integrated management. In Wolaita Zone, southern Ethiopia although it is not yet scarce and exists, competition between different services like agriculture, industry, and domestic use will create conflict of use in the future. Therefore, to reduce the negative impacts of irrigation on the environment and use it sustainably, it should be integrated. Therefore, concerned governmental bodies should consider this future need while planning for future irrigation scheme expansion.
- Encourage sustainable land use practices: Promoting agroforestry like fruit trees, cash crops etc, biodiversity and maintaining the ecosystem and encouraging sustainable land use practices improve the rural smallholder's income, nutritional food availability and health status through changing the consumption patterns. Therefore, small-scale irrigation should integrate with sustainable land use practices. This would also improve the crop pattern of the rural farms. This can help reduce the negative impacts of agriculture on the environment and improve the resilience of agricultural systems.

- Foster public-private partnerships: Although rural smallholders practise and benefit from small-scale irrigation, private investors are not integrated in Wolaita Zone, southern Ethiopia. Only "Boditi" and "Bilate" Tobacco industries are planted around the Wolaita Zone. Rural smallholders do produce crops according to industry needs. Rural smallholders who are using SSI can provide raw materials for nearby agroindustry. Moreover, private investors are practising irrigation near rural smallholders' irrigation users. However, they are not integrated to share market knowledge and provide raw materials. Integrating and creating a linkage between rural smallholders and private institutions engaged in irrigation would have multiple importance and enhance the competitiveness and shifting of subsistence farming to entrepreneur farming. Policymakers and practitioners should foster public-private partnerships to increase the availability of financing options, technical knowledge, improvement of infrastructure, and availability of expensive agricultural inputs for smallholder farmers. It also improves smallholders' interaction with individuals and companies as a general. In other words, it enhances their individual autonomy and bargaining power.

- Providing financing: Private sector companies and investors can provide financing to smallholder irrigation users and non-users to purchase irrigation equipment like water pumps, get agricultural inputs and create access to irrigation water from diverse sources. This can be by offering loans, grants or items to collect the cost after harvest according to the needs of rural smallholder farmers holding some guarantees.
- Supplying irrigation technologies: Licensed private sector companies and investors can supply irrigation technologies, agricultural inputs such as fertilisers, improved seeds, pesticides, herbicides, farm implements etc for smallholder farmers at appropriate quality, type and reasonable cost. The government should follow and monitor the bureaucratic activities. This would reduce the exposure of rural smallholders to expired and non-quality inputs. Some cooperatives and unions do not properly avail of required agricultural inputs in time. Problems in cooperatives could be compensated and managed by private companies. Therefore, in addition to farmers cooperatives and unions, these private sector companies which are accessible to rural farmers around the community could solve the problem smallholder rural farmers are facing currently. Furthermore, the

government should subsidise these companies to afford their services at the price settled.

- Providing technical assistance: Private sector companies and investors linked with rural smallholders should provide training for the agricultural inputs provided via the company. Moreover, they can support rural smallholders by providing some preliminary training, advice, and capacity building on how to operate and maintain irrigation systems.
- Investing in irrigation infrastructure and creating market linkage: Private sector companies and investors engaged in facilitating and provision of agricultural inputs for SSI users are the primary stockholders who exist near the community, benefit more, and could share the product and transport to better market, could involve in maintaining irrigation infrastructure, such as farm roads, canals, and dams, to improve smallholder farmers' access to water resources and market. Therefore, rural smallholders would get better products, markets, and income. So, policymakers and practitioners should integrate public-private partnerships to advance rural areas.

- Promote and integrate nutrition-based agricultural intervention with irrigation. Overall, the study emphasises the necessity of recognising local communities' particular needs and features for developing successful interventions or policies and multifaceted approaches to improve food security, dietary diversity, and nutrition outcomes. This would improve the health status, change children, women and men's consumption patterns, children's school enrolment and academic performance and enhance food security outcomes and the lives of rural communities. Therefore, nutrition-based training and capacity-building activities are highly important to improve the health and well-being of rural smallholders. So, policymakers and development practitioners should promote and integrate irrigation with awareness activities on the importance of adequate and quality food consumption for children's health and well-being.

- Integrate irrigation with other development activities like drinking water scheme development and treatment, health services etc: Some diseases exist in Wolaita Zone, like malaria and Dharia etc. The findings emphasise the importance of promoting rural populations' access to safe drinking water and sanitation facilities to enhance health outcomes, increase productivity, and promote sustainable and inclusive rural development. Therefore, governments and NGOs should work towards drinking water schemes, and construction of sanitary facilities.
- Integrate irrigation with children's adequate and quality food consumption and childcare activities: Promoting small-scale irrigation and other income-generating activities can be a way to support parental involvement in education by increasing household income and access to resources that can support children's academic success. Moreover, targeted interventions that support access to education and educational resources can help to ensure children's access to quality education, regardless of their family's financial resources. Promoting parental involvement in children's education and encouraging parents to monitor their children's academic progress can be an effective strategy to improve academic outcomes in Wolaita Zone. This may require targeted interventions, such as parent-teacher associations and community-based programmes that raise awareness of the importance of parental involvement in children's education in rural communities.
- In Ethiopia, irrigation policy is integrated into water resources management. But the construction and operational management of SSI is insignificant as to the available water resources and its significant role in rural smallholders' food security. Moreover, the agricultural ministry and water and irrigation ministries and their respective bureau, departments and offices are not highly integrated especially at the region, zone, and district levels. Even other sectors like health and education should integrate with agriculture, water, and irrigation ministries. The policies of these sectors should be

highly integrated to improve the food security outcomes of rural smallholders.

Due to financial and time constraints, the study does not assess the role of irrigation in acute and chronic food security outcomes indicators like food consumption score, anthropometric indicators, and Body Mass Index. Furthermore, other regions, urban area SSI, medium and large-scale irrigation role to rural smallholders' food security outcomes is not included in the analysis. Therefore, further study can be done using this food security outcomes indicator mixing qualitative and quantitative data in the irrigation area.

Therefore, these recommendations help promote rural smallholders to sustainable crop and animal production, sustained agriculture practices, diverse and nutritional food consumption pattern change, improved health status, diverse income generation activities, participation in the community and enhanced individual autonomy practices, access to diverse irrigation technologies and agricultural inputs use, improved children school enrolment and academic performance of rural communities in Wolaita Zone, southern Ethiopia specifically and Ethiopia as a whole.

9.9 SUMMARY

This chapter discussed the contribution of knowledge of this thesis to existing knowledge under human development theory and nutritional capability framework. Specifically, it examined the role of SSI on rural smallholders' food entitlement, basic capability, and the capability to be food-secure in promoting sustainable agricultural practices and enhancing food security outcomes. The chapter detailed the role of irrigation in increasing food security outcomes across four dimensions: food availability, access, utilisation, and stabilisation. The chapter discussed the dimensions under the nutritional capability approach framework and compared the findings against the existing literature on the topic. The chapter responds to the research question, discusses the study limitations, and makes recommendations for policy, planning, and practice to improve the role of SSI in improving food security outcomes for rural smallholders.

The findings of this research are consistent with the previous studies. Previous focused on the role of irrigation in the variables of crop diversity, yield, productivity per small farmland and income in different contexts. This indicates that the role of irrigation in other food security outcome indicators is not studied under variable settings. Previous studies used one and two variables to analyse the contribution of irrigation to food security. One study assessed the relationship between production skill improvement and irrigation and extends to more than two variables. This study used more than two variables to understand the role of irrigation in food security outcomes. Like previous studies, this study compared two groups (SSI users and non-users) to understand the role of irrigation in each variable identified for analysis. Variables like labour force, household family size, people in the household, total livestock unit, crop diversity, income, total land cultivated, wage (payment from any off-farm activities), production skills and agriculture technology use affected the food production and availability of rural smallholders in Wolaita.

Irrigation increased diverse food production, consumption, and economic capacity of rural smallholder households. Irrigation affected the income and diversified income sources. Rural smallholders in the area changed their consumption habits. It changed the dietary diversity of rural communities and showed a positive role in rural smallholders' food consumption. Small-scale irrigation improved rural smallholders' caloric intake and change in diverse food consumption patterns including macro and micronutrient rich food types in Wolaita Zone. It contributed to the basic and nutritional capability of rural the smallholders.

Small-scale irrigation impacted rural smallholders' food utilisation under different age and sex groups, children's school enrolment and achievement, health, resistance to disease incidences, improvement in access to health and education services, drinking water, sanitation, and hygienic practices. SSI impacted food stability of rural smallholders by reducing hunger, changing coping behaviours, increasing the resistance to natural disaster and climatic conditions and improvement in individual autonomy and decision-making capacity. SSI led to food availability, accessibility, utilisation, stability, entitlement, basic capability, capacity to be food secure and food security outcomes in Wolaita Zone, Southern Ethiopia.

Access to irrigation determines the food security outcomes for rural smallholders. Previous studies do not include the concept of food security outcome in their research. The studies focus on the factors that affect food availability and accessibility but do not address the food utilisation and stability concepts. Access to irrigation, sex and education level of the household affect HDDS and HHS in Wolaita Zone. However, the family size of the household and the owned farmland size of the household do not affect HDDS and HHS. Therefore, factors that determine the food security outcomes need to be studied further under different contexts, especially in rural areas having below 2ha.

The factors challenging the food security outcomes in the Wolaita Zone include the decreasing fertility status of agricultural land, the reduction in agricultural land owing to soil salinity and urbanisation of agricultural land, increasing population density, climate change, increased price of improved seeds and fertilisers and an increase in the price of food supply at the national level.

Due to financial and time constraints, the study did not assess the role of irrigation in acute and chronic food security outcomes indicators like food consumption score, anthropometric indicators, and Body Mass Index. Furthermore, other regions of the country, urban area SSI, medium and large-scale irrigation role to rural smallholders’ food security outcomes is not included in the analysis. This study recommends further research in understanding SSI's role in the key concept of food security outcomes in rural smallholders with farmland owned below 2ha using a comprehensive methodological approach. The role of irrigation in acute and chronic food security outcome indicators like food consumption score, anthropometric indicators and Body Mass Index should be studied in fragmented and small rural farm holdings in different contexts. The role of nutritional food consumption on children's school achievements and physical well-being should be assessed further in irrigation areas using both qualitative and quantitative tools.

Other regions, urban area SSI, medium and large-scale irrigation role to rural smallholders’ food security outcomes should be studied.

Policies related to rural smallholders’ food security outcomes such as agriculture, health, education, drinking water, gender empowerment and entrepreneurship should be integrated and structured under a sustainable monitoring and evaluation system. These policies should promote sustainable development, improve smallholders’ food security outcomes, and reduce poverty in the rural areas.

CHAPTER 10

CONCLUSION

10.1 INTRODUCTION

This study examined the role of irrigation in the outcomes of food security for smallholder farmers in Wolaita, southern Ethiopia. The study discussed the role of SSI in food production, diversification of the food among smallholder farmers in and identified the factors that influence sustainable food security outcomes in small-holder rural households in Wolaita. Based on the findings this chapter draws conclusions on the role of irrigation to food entitlement, basic capability, and capability to be food secure. Food availability, accessibility, utilisation, stability, and capability of rural smallholders are discussed under these three nutritional capability approach components. The chapter makes recommendations for Wolaita rainfed and irrigated agriculture system and areas further research.

10.2 FOOD AVAILABILITY

The findings show that before the intervention, the residents grew a diverse range of products, such as cereal crops, root crops, legumes, and others, demonstrating the importance of traditional knowledge and the role of natural resources such as rainfall in the local agricultural system. With irrigation schemes, all five districts cultivated a diverse range of crops than before, including various vegetables, cereal crops, and root crops, indicating the potential for agricultural development and adaptation to changing environmental conditions. The advent of irrigation resulted in a rise in crop alternatives and improved crop types, illustrating the possibility of agricultural diversification and adaptation to changing environmental conditions. The findings confirmed the significance of government aid and training in sustainable agricultural practices like irrigation and benefits of irrigation for smallholder farmers in Wolaita Zone, Southern Ethiopia.

The transition from indigenous to hybrid crop varieties in southern Ethiopia's Wolaita Zone is the consequence of several causes, including contemporary agricultural interventions and the introduction of new technologies like irrigation.

While these initiatives helped to diversify crops and increase food security, they had a negative influence on indigenous biomass preservation. This study emphasises the significance of knowing local agricultural methods and protecting indigenous crop varieties while encouraging long-term agricultural growth. New crop varieties should be introduced with caution, considering the potential detrimental impacts on the local agricultural system and the environment. Preserving indigenous crops for future generations would be essential to use improved seeds to enhance crop production and improve food production in Wolaita Zone, southern Ethiopia.

The use of new agricultural technologies, through irrigation, impacted agricultural productivity in sampled districts and kebeles of Wolaita Zone, southern Ethiopia. Adoption of improved crop and animal species, intercropping methods, row planting technology, and the use of high-quality seeds, soil fertilisers, and chemicals enhanced crop yields and increased farmer revenue. Expert skill training expedited the adoption of new technologies, and knowledge transfer enabled community members to understand and use them effectively. The availability of irrigation schemes and access to various agricultural inputs through government support improved agricultural productivity. The adoption of new agricultural technologies and use of irrigation contributed to agricultural development, and food security.

Irrigation was a supplementary and complementary water resource. It increased crop yields and productivity. Irrigation allowed rural smallholders to diversify variable crop types and produce crops in demand in the market such as vegetables and fruits. Food availability improved because of irrigation, and households produced surplus products for sale in the market. Small-scale irrigation users had higher total crop yields and livestock units than non-users. SSI technology increased crop yields, livestock production, beehives agricultural productivity, and sustainability. Irrigation improved crop production and food availability of rural smallholders in Wolaita Zone, Southern Ethiopia and Ethiopia in general.

10.3 FOOD ACCESSIBILITY

The availability of irrigation enhanced water sources and improved crop and fodder production for their animal production in Wolaita. Small-scale irrigation users buy a wider variety of food groups, have a better HDDS, and possess more livestock units and beehives than non-users. Besides, small-scale irrigation has helped the nutrition of irrigation users by allowing new crops and fruits to be consumed as well as access to a broader range of nutritious foods. Irrigation has also improved animal food diversification in irrigated areas of Wolaita. So, small-scale irrigation has a considerable impact on community food diversity, household dietary diversity, animal production, and beekeeping activities of rural smallholders in Wolaita Zone, southern Ethiopia.

Irrigation improved crop food distribution. The implementation of irrigation had a positive impact on crop distribution in various areas of the southern Ethiopia region and the country. The surplus production of crops was distributed to local and district markets, neighbouring districts, zones and even to Addis Ababa, resulting in greater availability and rural farmers earn money even in the dry season. Challenges such as road problems and market linkage issues were reported as hindrances to crop distribution. Despite limitations, irrigation enabled the development of a variety of agricultural products, including annual crops and cash crops, were delivered to surrounding markets. Small-scale irrigation users had higher income from crops, animals, animal by-products, and other non-productive asset sales, highlighting the potential benefits of SSI in improving the income-generating capacity of rural smallholders. Irrigation improved crop distribution, changed food consumption patterns, and resulted in economic benefits for rural Wolaita Zone, southern Ethiopia. This study highlights the potential of SSI in enhancing food access and dietary diversification.

10.4 FOOD SECURITY OUTCOMES

The household dietary diversity and hunger situation is improved due to irrigation. In Wolaita, total crop produced, sum of purchased food groups, and income from crops sold positively predicted the rural smallholder household dietary diversity.

HHS is related negatively to the total crop produced, income from crop sales, Total Livestock Unit (TLU), and HDDS in Wolaita. HHS is directly related to income from animals, animal by-products and other asset sales. As HHS increases rural smallholders in Wolaita do not sell their crop produced, rather use it for home consumption. Thus, the income from crop sales decreases. Households sell animals, animal by-products and other assets to get income. Therefore, the income from animals, animal by-products and other asset sales increase. As consumption of animal products decreases, the dietary diversity also decreases. Small-scale irrigation users have fewer instances of hunger and food insecurity than non-users.

Irrigation promotes public health, agricultural output, and economic prosperity. SSI users' health service expenditure is lower than non-users, with users paying less for health services. Users have better access to preventive healthcare services and seek treatment sooner. SSI users are not frequently exposed to diseases. Access to quality and adequate food contributed to health and physical well-being. Small-scale irrigation intervention in Wolaita promoted rural populations' capacity, and increased access to health care services, safe drinking water and sanitation facilities. Rural smallholders using irrigation improved their health outcomes and increased their productivity in Wolaita zone, in southern Ethiopia. Irrigation impacted food utilisation, health and physical well-being of rural smallholders through the determining variables.

Rural households utilising the SSI system in Wolaita had lower scores for the HCSI variable, indicating better food security outcomes compared to non-users. SSI users have more efficient coping mechanisms to manage food scarcity, potentially owing to enhanced access to water for irrigation and increased agricultural output. Crop production in irrigated areas is performed three times within a year. Rural smallholders using SSI harvest three times a year than non-users. So, irrigation has a role in diversifying coping strategies for rural smallholders, specifically in Wolaita Zone, southern Ethiopia, and Ethiopia.

Sufficient quality food for children to improve their physical and cognitive development, and academic performance is important. Small-scale irrigation users were better in total crop and animal food produced, income and endowments. Small-scale irrigation users provided adequate and quality food for children than non-users due to increased crops, animal food production and income generation.

Small-scale irrigation users had fewer instances of hunger and food insecurity than non-users. Most households had a higher level of dietary diversity, indicating a favourable outcome in terms of food security. However, a sizable minority of households suffered from moderate to severe hunger, emphasising the importance of efforts to improve food security outcomes.

Irrigation improved of rural smallholders' endowment, exchange condition, production possibilities, food stability strategies, employment status, and individual autonomy in the rural Wolaita Zone. Productive labour force was attracted from neighbouring kebeles, woredas and zones. Productive assets like livestock and other animals, land size for cultivation, warehouses to store crop harvests, owned farm implements, and transportation assets also improved. Irrigation contributed to the quantity of food, types produced and consumed, resilience to climate change and natural disasters. The school enrolment and educational achievement of children changed due to the availability and quality of food consumed. Access to education, health services, drinking water and sanitation improved due to the wealth they own and basic capability change after irrigation intervention. The health status of the rural smallholders in irrigated areas of Wolaita Zone showed improvement. Exchange conditions and conversion factors of rural smallholders are also enhanced owing to irrigation. Wages from irrigation agronomic activities were diverse. Rural smallholders were capacitated to resist price fluctuations of food and non-food goods and services like health, education, transportation and agricultural inputs and tools. Production possibilities like gaining skills and nutrition knowledge were enhanced. The use of agricultural technologies like input, fertilisers, pesticides, and herbicides improved. Moreover, coping strategies, types of employment and rights/legal claims to public institutions were enhanced. Irrigation has reduced the hunger in Wolaita. Rural smallholders' capacity to be food secure in Wolaita is improved owing to small-scale intervention. Therefore, SSI has a positive contribution to rural smallholders' sustainable food production, income, children's nutrition, health status, food stability, school enrolment and academic performance and lives of rural smallholders in Wolaita zone. On the other hand, SSI plays a role in rural smallholders' food security outcomes in Wolaita zone, Southern Ethiopia.

10.5 FOOD SECURITY OUTCOMES.

Access to irrigation, sex of the respondent and education level of the households are the common determinant factors of households' dietary diversity and hunger situation of rural smallholders in Wolaita. These are determinants of rural smallholders in Wolaita. Household dietary diversity is determined by the age category of the respondents. Extension utilisation periods, income from the sale of crops, and farming experience are determinants of household hunger scale. Decreasing fertility of agricultural land and reduction in agricultural land is due to soil salinity, urbanisation of agricultural land, increasing population density, climate change, increased price of improved seeds, fertilisers and food supply at the national level.

Access to irrigation, the sex of the household head, and the education level of the rural smallholders are the common determinants of food security outcomes in Wolaita. However, the family size of the household and owned farmland size does not affect the rural smallholder's HDDS and HHS. Access to irrigation technologies intensifies agricultural activities in areas where rural farmland is highly fragmented. This finding confirms the significance of the research to Wolaita Zone context and the unique contribution to the knowledge.

10.6 NUTRITIONAL CAPABILITY

Small-scale irrigation has contributed to rural smallholders' food entitlement, basic capability, and capacity to be food secure. It has enabled cultivation of crops throughout the year. Irrigation has also improved food access by supporting the incomes, asset ownership, land size, and use of agricultural inputs. It has facilitated the hiring of extra labour. It has increased household dietary diversity, decreased hunger, and improved resilience to food insecurity. Therefore, food entitlement and resilience to price fluctuations of food, healthcare, education, and agricultural inputs have shown improvement in rural irrigated areas of Wolaita.

Irrigation has supported the basic capability of rural smallholders in Wolaita. Food utilisation improved across age/gender as irrigation enhanced nutritional knowledge and consistent access to varied diets meeting physiological needs. Consumption changes and income generated due to Irrigation have helped to get better child health, school enrolment and academic performance by enabling adequate, quality nutrition and fulfilling education/health costs. Irrigation users exhibited better health outcomes through enhanced resistance, preventative access, and diet-based nutrition. It also facilitated cleaner water, sanitation, and hygiene. Irrigation intervention has changed consumption patterns and physical well-being of rural smallholders. Therefore, Irrigation has improved the basic capability of rural smallholders in Wolaita.

Irrigation has played a critical role in enhancing rural smallholders' capability to be food secure in Wolaita. By boosting production, incomes, and nutrition, small-scale irrigation has helped to improve livelihoods and lift rural communities out of food insecurity. Irrigation has impacted all four dimensions of food security - availability, access, utilisation, and stability. Irrigation has also affected the conversion factors of rural smallholders in Wolaita. Therefore, irrigation intervention has contributed significantly to the improvement of nutritional capability and development of rural smallholders in Wolaita zone, southern Ethiopia.

10.7 FURTHER RESEARCH

Food security outcomes are broad and multidisciplinary. Previous studies have tried to understand some of the concepts. Understanding the role of irrigation in these multidisciplinary key concepts needs mixing of research methods and theories. Therefore, the researcher recommends further study areas to understand the role of SSI in rural smallholders’ food security outcomes comprehensively under various contexts.

Due to resource and time limitations, the research is conducted in one region and zone of Ethiopia. Moreover, it includes only SSI, not medium and large irrigation schemes. Urban areas implementing small-scale irrigation areas and rural areas with farmland size above 2 ha are not included in the study. Understanding the role of irrigation comprising all the mentioned areas would enable us to generate all-inclusive conclusions. Thus, further studies on the topic could enhance the understanding of irrigation to food security outcomes. Specific important research areas are assessed by very few researchers. The below mentioned research areas are further recommended by the researcher to be assessed under different contexts.

- The role of irrigation in animal production and apiculture in rural areas.
- The role of irrigation intervention towards agricultural input utilisation in rural smallholders.
- The role of irrigation in the improvement of agricultural, nutritional knowledge and skills in rural communities.
- The role of irrigation in rural smallholders' income source diversification.
- The role of irrigation in changing the pattern of macro and micronutrient-rich food consumption in rural areas.
- The role of irrigation in reducing rural youths' migration and diversification of employment/job opportunities in rural areas.
- The role of irrigation in enhancing rural farmers' health status.
- The role of irrigation on rural farmers' children's school enrolment and academic outcomes.
- The role of irrigation in changing rural farmers' coping behaviours.
- The role of irrigation in improving the resilience of rural smallholders to health, education services and agricultural input price fluctuations.
- The role of irrigation in increasing the resilience of smallholders to food price fluctuations.
- The role of irrigation in supporting rural smallholders' education expenditure.
- The role of irrigation in enhancing drinking water, sanitation, and hygiene access in rural communities.

- The role of irrigation in increasing the resilience of rural farmers to natural disasters.
- The role of irrigation in diminishing rural farmers' hunger.

10.8 RAIN-FED AND IRRIGATION AGRICULTURE

The current agricultural policy and programmes of Ethiopia favour rural smallholders' households to meet their needs and maintain food security sustainably. It gives the right to use natural resources and favours incentives to develop their agricultural production and access rural institutions such as credit, finance, health, education etc. The government has given attention to the implementation of SSI technologies to improve household-level food security in rural areas of Ethiopia. Small-scale irrigation technologies are equally accessible to all rural households.

Sustainable food security outcomes refer to the ability of a community or a household to access sufficient, safe, and nutritious food regularly, without compromising the ability of future generations to meet their own food needs. It also involves addressing the immediate food needs of people while also considering the long-term impact on the environment, economic stability, and social equity. It can be achieved through various means such as increasing agricultural productivity, promoting sustainable farming practices, improving access to markets, strengthening social safety nets, and enhancing the resilience of communities to shocks and stresses. Therefore, it is important to note that achieving sustainable food security outcomes is not a one-size-fits-all approach and requires tailored interventions that consider the specific needs, context and resources of the community or household in question.

Rural smallholders' economy in Wolaita zone is based on agriculture. Rainfed and irrigated agricultural systems are dominantly taking the contribution beyond animal production and small trading. The farmland owned by rural smallholders in Wolaita is highly fragmented. Most of the rural farmers have very small farmland sizes. The agro-climatic condition ranges from highland to lowland. The soil fertility status is favourable for crop production. A mixed agriculture system including root crops such as “Enset'' best explains the agricultural system of the area. Intercropping is also used in the area. Animal production especially small ruminants like shoat, poultry and livestock production is a common rural smallholders’ activity. A small portion of rural farmers practise small trades. Moreover, Wolaita woredas are densely populated. Culturally parents distribute farmlands to their children who get married. Male family members are mandated to get farmland after they get married. Climate change is a major challenge in the area. There are ample rivers and groundwater potential. The surface flood is also available in the area. Wolaita zone rural farmers have strong experience in crop and animal production. Most rural farmers use rain-fed agriculture. Irrigated agriculture is not expanded adequately, according to the water potential available in the area. Most of the rural farmers in Wolaita are food insecure. Therefore, youths migrate from the area to get other job opportunities.

Until recent years, the government of Ethiopia do not give strong policy emphasis on irrigation development to maintain rural smallholders’ food security. The government construct and implement irrigation for cultivating industries' raw materials. The food from this medium and large-scale irrigation scheme is collected to the central state and used for industries. The “Emperiar” and “Derg” regimes construct medium and large-scale irrigation schemes to cultivate raw materials for national industries. During this period two of the schemes are constructed in southern Ethiopia. From these two schemes, Bilate State Farm is constructed in Wolaita zone. Small-scale irrigation has started to be constructed since, EPRDF. However, their distribution is very low and is not supported technically. For the first time, irrigation policy has been designed to integrate with other water-related policies in underwater resource management. However, although, this regime gives attention to SSI and rural farmers' food security, the institutional stability of irrigation was high, not consistent. Irrigation was led by the agricultural and water, mines, and energy ministries differently during EPRDF. This institutional instability was similar to zone and woreda. Similarly, the irrigation sector was structurally in the agricultural department and water, mines, and energy department in Wolaita zone as well as southern Ethiopia. This made the dissemination of irrigation technologies to rural farmers inconsistent. Thus, although medium and large-scale irrigation schemes were constructed earlier during “Derg” regimes. The dissemination of the technology and awareness of rural smallholders on irrigation technologies still need further work in Wolaita and southern Ethiopia.

According to the findings of the research, rain-fed agriculture in Wolaita does not maintain rural smallholders’ food security outcomes. It is highly affected by climate change and population growth. Other sustainable agricultural activities should be integrated with rain-fed agricultural systems. Integrating less capital-intensive SSI technologies in the area has improved the food security outcomes of rural smallholders. Small-scale irrigation has diversified the crop types grown in the area. Small-scale irrigation users in the area have generated more income than non-users and have diverse income sources. They are also resilient to climate change. The consumption habits of individuals in irrigated areas have changed. They consume diverse types of food. Moreover, SSI has contributed more to reducing hunger in the area. However, to the contrary rainfed smallholders produce less due to climate variability and lack of resources. The mean owned land size of non-users rural smallholders in the Wolaita zone does not contribute significantly to the HDDS and HHS. This means unless high agricultural intensifying activities are integrated, only the harvest from the owned farmland size does not contribute to increasing household dietary diversity, reducing hunger, and gaining effective coping strategies. Therefore, the research confirms access to irrigation technologies is a significant contributor to intensifying agricultural activities and improving food security outcomes in rural communities where owned rural farmland is highly fragmented (below 2ha).

Therefore, government, non-government sectors and other development practitioners can help improve the well-being, food security outcomes, and livelihoods of rural smallholder households in Wolaita Zone, southern Ethiopia by improving irrigation access and promoting sustainable agriculture practices. Thus, based on the findings of the research we highlight the following activities to do: -

- To strengthen this finding, further studies should be done on the recommended issues or areas in Chapter 9 in similar communities with fragmented farmland (below 2 ha).
- All the identified sectors should integrate to attain common goals in terms of food security outcomes for rural smallholders.
- In rainfed rural areas, promoting sustainable agricultural practices such as crop rotation, rainwater harvest, intercropping and water-efficient irrigation techniques, and composting are very important.
- In rainfed rural areas, invest in irrigation infrastructure. Small-scale irrigation technologies require less capital and are easy to operate.
- Strengthen the revitalisation of existing irrigation schemes. Existing SSI schemes need to be rehabilitated and maintained, should get emphasis to be revitalised and serve their potential.
- Beyond focusing only on the diversion of rivers, other water resources such as flood and groundwater should be harvested and used for irrigation. Small-scale irrigation technologies such as motor pumps, micro ponds, sprinklers, micro dams, and wells could be used for irrigation and domestic use.
- Both rainfed and irrigated rural smallholders should get financial support and subsidies from the government. Smallholder farmers should enhance their competence and shift from “usual farmers” to “entrepreneur farmers” and commercialise. Farmers should get financial support, subsidises, and improve their capacity to get agricultural inputs, and communal irrigation technologies. This can include providing loans, grants, or subsidies to purchase irrigation equipment or pay for the costs associated with irrigation infrastructure development.
- Both rainfed and irrigated smallholders should be supported through extension services. Training and technical support to rural smallholders in the area is insignificant. Governments and NGOs should strengthen extension services to provide smallholder farmers with the knowledge and skills needed to use irrigation technologies effectively.

- Address gender inequalities in rain-fed and irrigated agriculture. Therefore, by promoting women's participation in decision-making processes, providing training and capacity building for women, and ensuring women financial access and other resources.
- Forest cover in the upper catchments are the source of water. Deforestation of upper catchments reduces the discharge of rivers and level of groundwater. Deforestation favours climate change and fills irrigation canals with silts from upper catchments. Implementing afforestation and soil and water conservation activities on the upper catchment increases the sustainability of the existing irrigation schemes. It changes the climatic situation of the area for rain-fed agriculture.
- Facilitate public-private partnerships in irrigated areas of Wolaita zone, Southern Ethiopia.
- The rainfed and irrigation agriculture system in Wolaita zone is not nutrition-based. Consuming enough, quality and nutritious crops and animal food improves individuals' health, children's school enrolment and academic achievements. Therefore, promote cultivation of crops that can increase micro and micronutrient nutrients. Diversify animal production such as poultry, beekeeping, small dairy farming and fishery production on micro ponds and dams. Produce nutritional fodder production on soil and water conservation structures. Intercropping crops that can be fed for humans and fodder for animals.
- Integrate rain-fed and irrigation agriculture with other development activities like drinking water scheme development and treatment, education, and health services etc.

10.9 METHODOLOGICAL IMPLICATIONS

Food security outcome is a multidisciplinary and broad concept. To understand the multifaceted nature of this concept, the views and experiences of rural farmers on food security outcomes are important. Therefore, equal weight for qualitative and quantitative data analysis should be given. In developing countries like Ethiopia, it is difficult to get documented baseline data before the intervention of any rural development activities and programs to compare the changes. Qualitative sources like focus group discussions, key informants' interviews and document analysis including systematic literature review should be mixed with quantitative sources. Multiple variables should be analysed to understand the relation between any rural development interventions and food security outcomes of rural communities.

Irrigation should be assessed beyond crop production and income generation. It has a diverse role in rural farmers' diverse food consumption and nutrition status. The acute and chronic food security outcomes should be assessed and integrated to get a complete understanding of irrigation roles in rural farmers. The acute food security outcomes indicators are HDDS, HHS, HCSIs and food consumption score. The chronic food security outcomes indicators are Body Mass Index (BMI) for adults and anthropometric indicators like stunting (height for age), wasting (weight for height), underweight (weight for age) and mid-upper arm circumference (MUAC) in children under five ages. Therefore, methodologically to analyse the role of irrigation in rural farmers' food security outcomes, researchers can use this indicator as a dependent variable and analyse multiple independent variables of food security outcomes. Multivariate regression analysis could help to identify the determinant independent variables of food security outcomes.

Furthermore, rural farms can be categorised as food secure and insecure using some food security indicators (like caloric intake). Moreover, using other food security outcome indicators like HDDS, HHS and HCSIs we can categorise rural farmers into three groups. For example, for HDDS, we can categorise rural farmers into highly diverse, medium, and low-diverse food-consuming households. Therefore, multinomial regression analysis would give a clear understanding and status of rural farmers to the concept of food security outcomes. This research grounds further studies to identify multiple determining independent variables for acute and chronic food security outcome indicators as a dependent variable. Methodologically, further research recommended using qualitative and quantitative methods includes:

- The role of irrigation in rural farmers' food security outcomes using food consumption score as the dependent variable.
- The role of irrigation in rural farmers' food security outcomes using anthropometric indicators as dependent variables.
- The role of nutritional food consumption on children’s school participation and achievements in irrigated areas (maybe using student annual class records as quantitative data).

Each component of food security outcomes is also broad. Irrigation can contribute to each component as confirmed in this research. Therefore, further research can be done using multiple variables to understand each component separately and together.

Irrigation and Food Availability: - Food can be available from own food production, purchase, gift, loan, and aid. Globally, regionally, nationally and at community, and individual levels. It can also be available from stocks and imports. Since this study includes only food available from rural farmers’ production and purchase, further studies can include gifts, loans, and aid at global, regional, national and community levels concerning irrigation.

Irrigation and Food Accessibility Food can be accessed through food production, market purchases, transfers, and loans. Cash at the rural household level depends on the availability of cash crops, wages, employment, and other income-generating activities. Food transfers and loans can be done by community, NGO, and community support food banks. Similarly, food accessed from own production and purchase are included in this study, therefore further studies can include foods accessed from multiple different sources.

Irrigation and Food Utilisation Food utilisation is determined by sex, age, dietary intake, health status and quality of care. Dietary intake is related to food access, intrahousehold food allocation, and food availability. Health status is determined by access to health services and available infrastructure. The quantity and quality of food utilised are significant contributors to individual health status and disease resistance. Food utilisation is also affected by the nutrition knowledge of rural smallholders. To understand the role of any similar interventions to food utilisation all the mentioned concepts should be assessed and described adequately. Therefore, further research can be done using these multiple variables.

Irrigation and Food Stability: - Food stability is related to food availability and accessibility, and food utilisation. It can be affected by climatic conditions, natural disasters, individual autonomy, and decision-making capacity. Moreover, it is also affected by community, nature, capital, and human resource availability. Natural, social and policy environments also influence the stability of food. For similar studies understanding these multiple variables from different contexts is required.

Irrigation and Food Entitlement: - Food entitlements comprise rural farmers' endowment, exchange conditions, production possibilities, food stability strategies and employment status. The components described under food entitlements are broad. This information must be included in the analysis to understand similar interventions to food entitlement.

Irrigation and Basic Capability: - Basic capability includes freedom from hunger, having educated, being healthy, and having individual autonomy. Basic capability includes broad concepts.

Further studies need to assess multiple variables and mix both qualitative and quantitative data at equal weight to understand the multidisciplinary nature of food security outcomes. This study employed a convergent parallel mixed methods design using quantitative and qualitative data collected concurrently. This allowed for comprehensive understanding compared to single-method studies. It applied systematic literature review, household survey, FGDs and KIIs with larger sample sizes than previous studies to collect diverse perspectives. Questionnaires were rigorously translated between English, Amharic, and local languages to ensure comprehension and accurate responses from participants. Data was interpreted using descriptive/inferential statistics and thematic analysis under a human development and capabilities framework. This framework was suitable for analysing irrigation's multi-dimensional impacts on food security outcomes. The methods accommodated the local context of small landholdings and irrigation in the Wolaita Zone. Rigorous steps like transcription, back-translation and member-checking enhanced data quality and validity. So, in summary, the study employed robust, culturally sensitive mixed methods with large and diverse samples to provide an in-depth contextualised understanding, addressing key limitations of prior single-method studies. Comprehensive methodology should be used to understand the concept of food security outcomes.

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APPENDIX A: APPROVAL LETTER OF ETHICAL CLEARANCES

COLLEGE OF HUMAN SCIENCES RESEARCH ETHICS REVIEW COMMITTEE

07 June 2022

NHREC Registration #:

Rec-240816-052

CREC Reference #:

64142280_CREC_CHS_2022

Dear Mr. BIRUK SEIFU KOISHA

Decision:

Ethics Approval from 07 June 2022

Researcher(s): Name: Mr. BS KOISHA

Contact details: 64142280@mylife.unisa.ac.za

Supervisor(s): Name: Dr. C. Ndinda

Contact details: cndinda@hsrc.ac.za

Title: The Role of Small-Scale Irrigation on Rural Smallholders Food Security Outcomes in Wolaita Zone of Southern Ethiopia.

Degree Purpose: PHD Thank you for the application for research ethics clearance by the Unisa College of Human Science Ethics Committee. Ethics approval is granted for five years.

The ***low-risk application*** *was reviewed by* College of Human Sciences Research Ethics Committee, in compliance with the Unisa Policy on Research Ethics and the Standard Operating Procedure on Research Ethics Risk Assessment.

The proposed research may now commence with the provisions that:

The researcher(s) will ensure that the research project adheres to the values and principles expressed in the UNISA Policy on Research Ethics.

Any adverse circumstance arising in the undertaking of the research project that is relevant to the ethicality of the study should be communicated in writing to the College Ethics Review Committee.

The researcher(s) will conduct the study according to the methods and procedures set out in the approved application.

Any changes that can affect the study-related risks for the research participants, particularly in terms of assurances made with regards to the protection of participants' privacy and the confidentiality of the data, should be reported to the Committee in writing, accompanied by a progress report.

5. The researcher will ensure that the research project adheres to any applicable national legislation, professional codes of conduct, institutional guidelines, and scientific standards relevant to the specific field of study. Adherence to the following South African legislation is important, if applicable: Protection of Personal Information Act, no 4 of 2013; Children's act no 38 of 2005 and the National Health Act, no 61 of 2003.
6. Only de-identified research data may be used for secondary research purposes in future on condition that the research objectives are like those of the original research. Secondary use of identifiable human research data requires additional ethics clearance.
7. No fieldwork activities may continue after the expiry date **(07 June 2027).** Submission of a completed research ethics progress report will constitute an application for renewal of Ethics Research Committee approval.

Note:

The reference number ***64142280_CREC_CHS_2022*** *should be clearly indicated on all forms of communication with the intended research participants, as well as with the Committee.*

Yours sincerely,

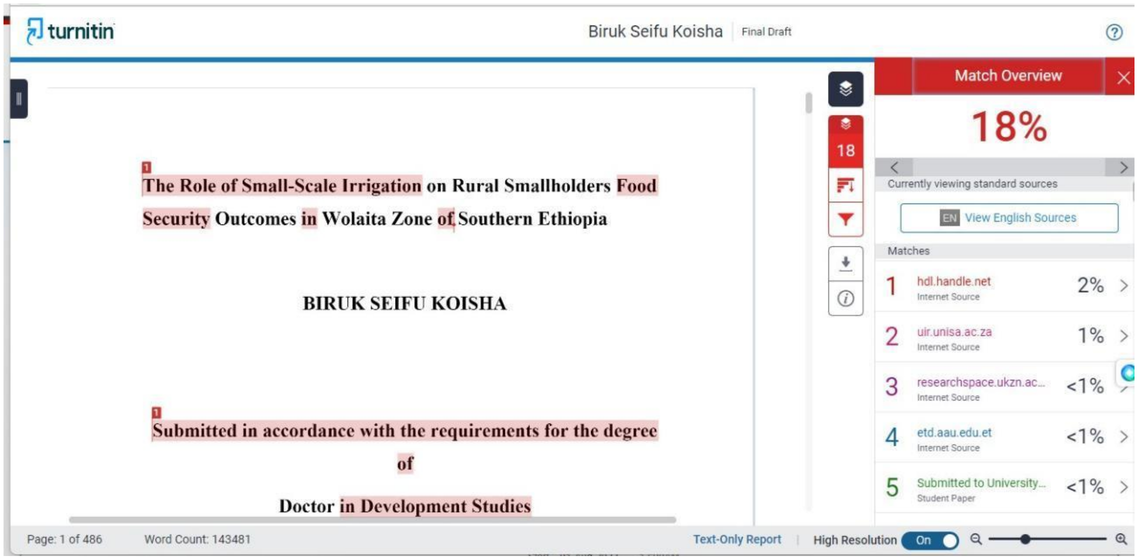
Signature: Signature: PP

Prof. KB Khan
CHS Research Ethics Committee Chairperson
Email: khankb@unisa.ac.za
Tel: (012) 429 8210

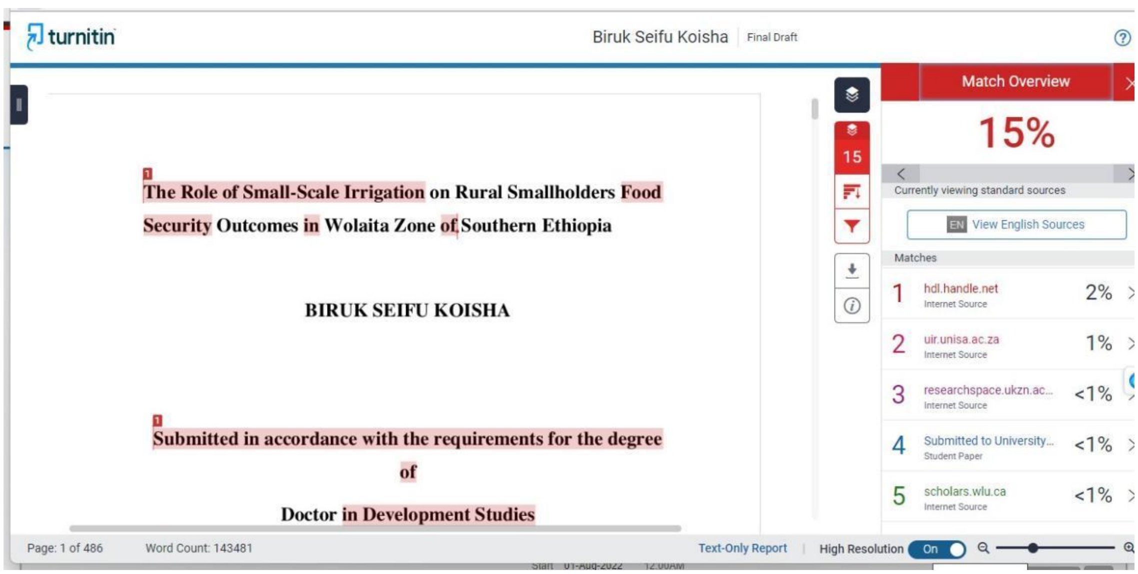
Prof K. Masemola
Executive Dean: CHS
E-mail: masemk@unisa.ac.za
Tel: (012) 429 2298

APPENDIX B: SIMILARITY LEVEL TURNITIN REPORT

Including quotes and bibliography



Excluding quotes and bibliography



APPENDIX C: CONFIDENTIALITY AGREEMENT FORM

Confidentiality Agreement

This agreement is between- Biruk Seifu Koisha, conducting research for PhD at the University of South Africa in the Department of Development Studies, under the supervision of Dr Catherine Ndinda,

hereafter referred to as the "researcher"

and

----------------------------------- hereafter referred to as the "Enumerator/ Statistician"

for

PhD thesis entitled "The role of small-scale irrigation on rural smallholders food security outcomes in Wolaita Zone of Southern Ethiopia."

Research area: - Wolaita Zone, Southern Ethiopia

District (s): - -------------------------------

Peasant association (s): - -------------------

Number of participants to be surveyed: - ----------

Summary of the duty expected to be done by the enumerator/ Statistician:

- To conduct individual interviews/assist the researcher during the FGD.
- To encode, inter collected data and interpret it statistically through SPSS/ Atlas ti8 software.
- Keep the safety and confidentiality of the information collected/interpreted.
- To deliver the correctly filled and completed questionnaires every 3rd day (for enumerators).

I agree to:

1. Keep all the research information (flash drives, notes, transcripts, data, etc.) shared with me confidential. I will not discuss or share the research information with anyone other than the Researcher or others identified by the Researcher.
2. Keep all research information secure while it is in my possession.
3. Return all research information to the Researcher when I have completed the research tasks or upon request, whichever is earlier.
4. For enumerators to conduct 2 individual interviews per day (1 in the morning and 1 in the afternoon) and deliver 6 individual survey questionaries every three days and deliver completely within 10 to 15 days (by completing if the missed data are available).
5. Destroy all research information regarding this research project that is not returnable to the Researcher after consulting with the Researcher.
6. Comply with the instructions of the Researcher about requirements to physically and/or electronically secure records (including storing in a safe location, password protection, file/folder encryption, and/or use of secure electronic transfer of records through file sharing, use of virtual private networks, etc.).
7. Closing any programmes, documents, or data files related to the research study when away from the computer.
8. Not allow any personally identifiable information to which I have access to be accessible. (Unless specifically instructed otherwise in writing by the Researcher).
9. Not make copies of documents and/or data related to the research study unless specifically instructed to do so by the researcher.
10. To pay 75 birrs for enumerators per single complete questionnaire or 150 birrs per day for two completed questionnaires.
11. To pay -------------- birr for statistician up on the completion of the work.

Enumerator/ Statistician:

Name: - ____________________

By signing this form, I acknowledge that I have reviewed, understand, and agree to adhere to the expectations for an Enumerator/Statistician described above. I

agree to maintain confidentiality while performing my duties as an Enumerator/Statistician and recognize that failure to comply with these expectations may result in disciplinary action.

Signature: -_________________

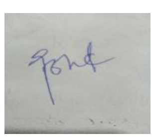
Date: - _____________________

I agree to:

1. Provide detailed direction and instruction on my expectations for maintaining the confidentiality of research information so that the Enumerator/ Research assistant/ Statistician can comply with the above terms.
2. Provide oversight and support to the Enumerator/ Statistician in ensuring confidentiality is maintained in accordance with the access gained to get personal information is protected as of Act*, nr 4 of 2013* (Protection of Personal Information that discloses the necessity of how access was gained) and consistent with the South Africa University Policy on the *Ethical Conduct of Research Involving Humans*.
3. To pay the above-mentioned birr up on the completion of half and full completion of the agreed work.

Researcher: -Biruk Seifu koisha

ID: - 64142280

Signature: 

Date: --------------

APPENDIX D: ATTRIBUTE FORM

KII of OFFICIALS/STAKEHOLDERS

Attribute Form

ATTRIBUTE FORM *(to be completed by the facilitator)*			
DISTRICT	______________	**DATE**	______________
KEBELE NAME	______________	**STARTING:**	______________
FACILITATOR NAME	______________	**FINISHING:**	______________

1. Sex

Male	1
Female	2

2. Age

18 – 24	1
25 - 34	2
35 – 44	3
45-54	4
55- 64	5
65+	6

3. What is your current job title? ______________________

4. For how long you have experience related to rain-fed and irrigation agriculture in the area (kebele/woreda/zone and region)

< 3 years	1
3.1 to 6 years	2
6.1 to 9 years	3
9.1 to 11 years	4
11.1 to 13 years	5

13.1 to 17 years	6
17.1 to 19 years	7
>19 years	8

5. What is the HIGHEST level of education that you have successfully completed?

No Schooling	1
Grade 1	2
Grade 2	3
Grade 3	4
Grade 4	5
Grade 5	6
Grade 6	7
Grade 7	8
Grade 8	9
Grade 9	10
Grade 10	11
Grade 11	12
Grade 12	13
Higher certificate	14
Diploma	15
Bachelor’s degree	16
MSc	17
PhD and above	18

Thank you very much!!

COMMUNITY BASED KEY INFORMANTS

Attribute Form

Participant Number:

ATTRIBUTE FORM *(to be completed by the facilitator)*			
DISTRICT	______	**DATE**	______
KEBELE NAME	______	**STARTING:**	______
FACILITATOR NAME	______	**FINISHING:**	______

1. Sex

Male	1
Female	2

2. Age

18 – 24	1
25 - 34	2
35 – 44	3
45-54	4
55- 64	5
65+	6

3. What is your current living arrangement?

Living with husband/wife	1
Living with others not related	2
Living together with partner	3
Living with children and husband/wife	4
Living with children only (no husband/wife/life partner)	5
Living alone	6
Living with mother, sisters, and brothers	7

4. How many people live in your household -------------------------

5. How many children do you have (biological)? ____________________

6. What is the HIGHEST level of education that you have successfully completed?

No Schooling	1
Grade 1	2
Grade 2	3
Grade 3	4
Grade 4	5
Grade 5	6
Grade 6	7
Grade 7	8
Grade 8	9
Grade 9	10
Grade 10	11
Grade 11	12
Grade 12	13
Higher certificate	14
Diploma	15
Bachelor's degree	16
Do not Know	17
Other (specify)	18

7. Which ONE of the following languages do you speak the most at home?

Oromigna	1
Tigregna	2
Amharigna	3
wolaitigna	4
Guragign	5
Sidamigna	6
Gamugn	7
Kembatign	8
Hadigna	9
siltigna	10
Other (specify)	12

What is your religion?

Assembles of God	01

Full Gospel Church of God	02
Jehovah's Witness	03
Lutheran	04
Seventh Day Adventist	05
Ethiopian Apostolic Church	06
Kale Hiwot Church	07
Hiwot kal Church	08
Islam / Muslim	09
Orthodox	10
Other (specify) ………………………	11
None	12
Refuse to state	13

8. What are the sources of income in your household? You can tick more than 1 answer.

	1 = Yes	2 = No
1. Salaries/wages/commission	1	2
2. Income from a business	1	2
3. Remittances (money received from people living elsewhere)	1	2
4. Pensions (exclude old age state grant)	1	2
5. Grants (include old age state grant here)	1	2
6. Sales of farming products and services	1	2
7. Other income sources e.g., rental income, interest	1	2
8. No income	1	2

9. How would you describe your present employment situation?

Housewife, homemaker, not looking for work	1
Housewife, homemaker, looking for work	2
Unemployed, looking for work	3
Unemployed, not looking for work	4
Work in informal sector, not looking for permanent work	5
Sick/disabled and unable to work	6
Student/pupil/learner	7
Self-employed - full time (40 hours or more per week)	8
Self-employed - part time (less than 40 hours per week)	9
Employed part time (less than 40 hours per week)	10

Employed full time (40 hours or more per week)	11
Other (specify)	12

Thank you very much!!

FOCUS GROUP DISCUSSION

Attribute Form

Participant Number:

ATTRIBUTE FORM *(to be completed by the facilitator and/or the note taker)*			
TYPE OF FGD	1. Male 2. Female	**DATE**	
DISTRICT		**STARTING:**	
KEBELE NAME		**FINISHING:**	
FACILITATOR NAME			
NOTE TAKER NAME			

6. Sex

Male	1
Female	2

7. Age

18 – 24	1
25 – 34	2
35 – 44	3
45-54	4
55- 64	5
65+	6

8. What is your current living arrangement?

Living with husband/wife	1
Living with others not related	2
Living together with partner	3
Living with children and husband/wife	4
Living with children only (no husband/wife/life partner)	5
Living alone	6
Living with my mother, brother, and sister	7

9. How many people live in your household --------------------------

10. How many children do you have (biological)? ____________________

11. What is the HIGHEST level of education that you have successfully completed?

No Schooling	1
Grade 1	2
Grade 2	3
Grade 3	4
Grade 4	5
Grade 5	6
Grade 6	7
Grade 7	8
Grade 8	9
Grade 9	10
Grade 10	11
Grade 11	12
Grade 12	13
Higher certificate	14
Diploma	15
Bachelor's degree	16
Do not Know	17
Other (specify)	18

12. Which ONE of the following languages do you speak the most at home?

Oromigna	1
Tigregna	2
Amharigna	3
Wolaitigna	4
Guragign	5
Sidamigna	6
Gamugn	7
Kembatign	8
Hadigna	9
Siltigna	10
Other (specify)	12

What is your religion?

Assembles of God	01
Full Gospel Church of God	02
Jehovah's Witness	03

Lutheran	04
Seventh Day Adventist	05
Ethiopian Apostolic Church	06
Kale Hiwot Church	07
Hiwot kal Church	08
Islam / Muslim	09
Orthodox	10
Catholic	11
Others	12
None	13
Refuse to state	14

13. What are the sources of income in your household? You can tick more than 1 answer.

	1 = Yes	2 = No
1. Salaries/wages/commission	1	2
2. Income from a business	1	2
3. Remittances (money received from people living elsewhere)	1	2
4. Pensions (exclude old age state grant)	1	2
5. Grants (include old age state grant here)	1	2
6. Sales of farming products and services	1	2
7. Other income sources e.g., rental income, interest	1	2
8. No income	1	2
9. Informal trading	1	2

14. How would you describe your present employment situation?

Housewife, homemaker, not looking for work	1
Housewife, homemaker, looking for work	2
Unemployed, looking for work	3
Unemployed, not looking for work	4
Work in informal sector, not looking for permanent work	5
Sick/disabled and unable to work	6
Student/pupil/learner	7
Self-employed - full time (40 hours or more per week)	8
Self-employed - part time (less than 40 hours per week)	9
Employed part time (less than 40 hours per week)	10

Employed full time (40 hours or more per week)	11
Other (specify)	12

Objective 1: role of irrigation in food production

15. How do you rate your crop production?

Greatly Increasing	1
Increasing	2
Fluctuating	3
Remain the same	4
Reducing	5
Greatly Reducing	6

16. How do you rate your crop productivity per hectare?

Greatly Increasing	1
Increasing	2
Fluctuating	3
Remain the same	4
Reduced	5
Greatly increasing	6

17. Do you have your own animals raised in your home?

Yes,	1
No	2

18. If yes, how do you rate your animal production?

Greatly Increasing	1
Increasing	2
Fluctuating	3
Remain the same	4
Reduced	5
Greatly Reduced	6
N/A	7

Objective 2: role of irrigation in food diversification.

19. Was there any ---------during your yesterday meals?

	1= Yes	0= No
cereals made of cereals (e.g., corn/maize, rice, wheat, sorghum, millet bread, noodles, porridge, biscuits, paste etc)	1	0
roots and tuber (e.g., potatoes, yams, cassava, or any other foods made from roots or tubers)	1	0
vegetables e.g., cabbage, tomato, onion, eggplant, pumpkin, carrot, sweet potato, red sweet pepper	1	0
fruits (e.g., mango, avocado, papaya)	1	0
organ and fresh meat (e.g., beef, lamb, goat chicken)	1	0
egg (eggs from chicken, duck, etc.)	1	0
fresh or dried fish or shellfish	1	0
foods made from beans, peas, lentils, or nuts (dried beans, dried peas, lentils, nuts, seeds)	1	0
cheese, yoghurt, milk, or other milk products	1	0
food/s made with oil, fat, or butter (added to food or used for cooking)	1	0
sugar or honey (soft drinks, sugary foods such as candies, cookies, and cakes)	1	0
food/s such as condiments, coffee, tea, spices, or beverages	1	0
Others (specify)	1	0

Objective 3: role of irrigation in food security outcomes

20. How do you rate the role of irrigation in your income generation?

Very High	1
High	2
Medium	3
Remain the same	4
Low	5
Very low	6

21. Did you fill irrigation has contributed -----

	1=Yes	2= No
To improve the family's resistance to diseases and improve health status	1	2
Change your children's schooling and performance	1	2
To improve the diversity of employment opportunities	1	2
People's individual interaction and community participation	1	2
Food price change	1	2

Farm and non-farm assets.	1	2
To access health, education, credit, and financial services	1	2
To access sanitary, hygiene, water, energy services and sources	1	2
Emerging of other development perspectives in the area	1	2
Other (explain)	1	2

22. If there have been times when you did not have enough food or money to buy food, how did you pass that period?

	1= yes	2= No
Rely on less preferred and less expensive foods?	1	2
Borrow food, or rely on help from a friend or relative?	1	2
Purchase food on credit?	1	2
Gather wild food, hunt, or harvest immature crops?	1	2
Consume seed stock held for next season?	1	2
Send household members to eat elsewhere?	1	2
Send household members to beg?	1	2
Limit portion size at mealtimes?	1	2
Restrict consumption by adults for small children to eat?	1	2
Feed working members of HH at the expense of non-working members?	1	2
Reduce the number of meals eaten in a day?	1	2
Skip entire days without eating?	1	2
Others (specify)	1	2

23. Does the intervention of irrigation contribute to your knowledge or skill on how to grow annual crops, fruits, and vegetables, and animal production on your farmland?

Yes,	1
No	2

Objective 4: - Factors that affect food security outcomes.

		1=Yes	**2=No**

24.	Did your crop production challenge by a shortage of water?	**1**	**2**
25.	Did your animal productivity was affected by a shortage of animal feed or grass?	**1**	**2**
26.	Did your consumption of diverse nutritious food affect by culture, beliefs shortage of food and resources?	**1**	**2**
27.	Did a shortage of food or resources like money was affected your children from school enrolment and their attendance?	**1**	**2**
28.	Did you have knowledge about the contribution of consuming enough nutritional food to children's academic performance?	**1**	**2**
29.	Did your participation in the decision-making processes was affected by external forces like government laws, terms, and conditions?	**1**	**2**
30.	Did your utilisation of agricultural inputs like improved seed, fertilizer pesticide etc? was affected by shortage of income and accessibility problem to financial and credit services?	**1**	**2**

Thank you very much!!

APPENDIX E: KII CHECKLIST

COMMUNITY-BASED KII

2022

The role of Small-Scale Irrigation on Rural Smallholders' food security outcomes in Wolaita Zone of Southern Ethiopia

Dear Prospective Participant

Good morning/afternoon. My name is Biruk Seifu Koisha, and I am conducting research for my PhD at the University of South Africa, under the supervision of Dr Catherine Ndinda. We are conducting research on "The role of small-scale irrigation on rural smallholders' food security outcomes in Wolaita Zone of Southern Ethiopia." This study is expected to collect information on household crop production, crop productivity, food diversity, income, behavioural change to produce, purchase and consume nutritional food, and capability to get and implement the service delivered by rural socio-economic institutions that are useful to improve, nutrition utilisation, physical wellbeing or health status, school enrolment and performance of students within the household owing to the available and consumed quantity and quality of food since the intervention of small-scale irrigation and factors that affect rural smallholders food security outcomes. The process and result of this study would give you knowledge of the potential benefits of the development of irrigation in Ethiopia. Today we would like to ask for your participation and share with us your knowledge and opinions about the roles of small-scale irrigation and smallholders' food security outcomes in this area, with a focus on issues such as the roles of small-scale irrigation on crop production, food diversity and food security outcomes.

To obtain reliable information, please answer the questions that follow as frankly as possible. Your views are important in this research. There are no right or wrong answers. It is your opinion that counts. You have been selected because of your knowledge about small-scale irrigation and food security outcomes in this community. The information you give to us will be kept confidential. You will not be identified by name or address in any of the reports we plan to write.

PARTICULARS OF INTERVIEW

	DAY MONTH	TIME STARTED		TIME COMPLETED			
		H R	MIN	H R	MIN		
First visit	/ / 2022						

STRICTLY CONFIDENTIAL

Name of facilitator (Co-field worker) Signature Date

1/______________ _________ ________

Name of researcher Signature Date

1/__________________ __________ ________

COMMUNITY-BASED KEY INFORMANTS INTERVIEW (KII)

Open-Ended Questioner

Knowledge, Views on the food security outcomes among smallholder irrigation users in Wolaita Zone of Southern Ethiopia.

1. **Role of irrigation in food Production**
   a. What are the indigenous crops grown in your farmland or the kebele before irrigation? Please list and discuss.
   b. How has irrigation affected the cultivation of indigenous crops grown in your farmland or the kebele?
   c. How has irrigation affected the availability of foods in your house or the kebele?
   d. How has the use of irrigation affected the distribution of crops within and beyond this kebele/district?

2. **Role of irrigation in food diversification**
    a. Before irrigation was started in the Kebele, what types of crops and animal foods did people and your family consume?
    b. What types of food were introduced into the diet after the introduction of irrigation in your household and the Kebele?
    c. How has irrigation affected food access and consumption patterns among men, women, children, children under 5 and pregnant women in your household and the kebele?
    d. In what ways has irrigation contributed to the adoption of new agricultural technologies (e.g., new crop and animal varieties) in the area? Give detail.
    e. Apart from supporting irrigation, in what other ways did the government support your household or the people in the Kebele?
3. **Role of irrigation in food security outcomes**
    a. How did irrigation contribute to the income of your household and the people in the Kebele?
    b. How did irrigation affect the health of your household and the people in this area?
    c. How did irrigation affect the schooling and performance of your children and others in the Kebele?
    d. How did irrigation contribute to the diversity of employment opportunities in the household and in the area?
    e. How did irrigation contribute to the sustainable availability of food production in the household and the kebele?
    f. What are the coping strategies implemented when people in the area don't have enough food and money to buy food? Give lists.
4. **Factors influencing smallholders' food security outcomes.**
    a. What are the challenges that affect crop production in your farmland and the kebele?
    b. What are the challenges that affect the production of feeds/fodder for animals in the household and in the kebele?

c. What are the challenges that affect the sustainable availability of food in the household and the kebele?

d. What barriers affect peoples' participation in irrigation water management and the decision-making process in this community?

e. What are the challenges that affect irrigators' utilisation of agricultural inputs like improved seed, fertilizer, pesticide etc? Give detail.

f. What are the cultures, beliefs and conditions that influence the food security outcomes of the people in your household and the kebele? Give details.

5. What do you suggest benefitting more from irrigation and improve the food security outcomes in the area?

Thank you very much!!

KII for OFFICIALS/STAKEHOLDERS

2022

The role of Small-Scale Irrigation on Rural Smallholders' food security outcomes in Wolaita Zone of Southern Ethiopia.

Dear Prospective Participant

Good morning/afternoon. My name is Biruk Seifu Koisha, and I am conducting research for my PhD at the University of South Africa, under the supervision of Dr Catherine Ndinda. We are conducting research on "The role of small-scale irrigation on rural smallholders' food security outcomes in Wolaita Zone of Southern Ethiopia." This study is expected to collect information on household crop production, crop productivity, food diversity, income, behavioural change to produce, purchase and consume nutritional food, and capability to get and implement the service delivered by rural socio-economic institutions that are useful to improve, nutrition utilisation, physical wellbeing or health status, school enrolment and performance of students within the household owing to the available and consumed quantity and quality of food since the intervention of small-scale irrigation and factors that affect rural smallholders food security outcomes. The process and result of this study would give you knowledge of the potential benefits of the development of irrigation in Ethiopia. Today we would like to ask for your participation and share with us your knowledge and opinions about the roles of small-scale irrigation and smallholders' food security outcomes in this area, with a focus on issues such as the roles of small-scale irrigation on crop production, food diversity and food security outcomes.

To obtain reliable information, please answer the questions that follow as frankly as possible. Your views are important in this research. There are no right or wrong answers. It is your opinion that counts. You have been selected because of your knowledge about small-scale irrigation and food security outcomes in this community. The information you give to us will be kept confidential. You will not be identified by name or address in any of the reports we plan to write.

PARTICULARS OF INTERVIEW

	DAY MONTH	TIME STARTED		TIME COMPLETED		
		HR	MIN	HR	MIN		
First visit	/ / 2022						

STRICTLY CONFIDENTIAL

Name of facilitator (Co-field worker) Signature Date

1/_______________ __________ _________

Name of researcher Signature Date

1/___________________ ___________ _________

<u>KEY INFORMANTS INTERVIEW (KII) for OFFICIALS/STAKEHOLDERS</u>

Knowledge, Views on the food security outcomes among smallholder irrigation users and non-users in the Wolaita Zone of Southern Ethiopia.

6. **Role of irrigation in food Production**
    e. What are the indigenous crops grown in the irrigation area before the construction of the small-scale irrigation scheme? Please list and discuss.
    f. How has irrigation affected the cultivation of indigenous crops grown and changed the types of crops grown in the irrigation kebele, district, zone, and region?
    g. Are there any differences in farmland fertility status between irrigation users and non-users? Why?
    h. Is there any productivity difference between irrigated and rainfed crops? Why?
    i. How has irrigation affected the availability of foods in the irrigation kebele?
    j. How has the use of irrigation affected the crop distribution in the irrigation kebele, district, zone, and region?
7. **Role of irrigation in food diversification**
    f. Before irrigation was started in the irrigation Kebele's, what types of crops and animal foods did people consume?
    g. What types of food were introduced into the diet after the introduction of irrigation in the irrigation Kebele's, woreda, zone and region?
    h. How has irrigation affected food access and consumption patterns among men, women, children, children under 5 and pregnant women in the irrigation kebeles', woreda, zone and region?

i. In what ways has irrigation contributed to the adoption of new agricultural technologies (e.g., new crop and animal varieties) in the area? Give detail.
j. Apart from supporting irrigation, in what other ways did the government support the rural smallholders in the Kebele's, woreda, zone and region?

8. **Role of irrigation in food security outcomes**
   a. Is there any price difference between irrigated and rainfed crops?
   b. How did irrigation contribute to the income of the people in irrigation areas?
   c. How did irrigation affect the health of the people in irrigation areas?
   d. How did irrigation affect the schooling and performance of children in the irrigation areas?
   e. How did irrigation contribute to the diversity of employment opportunities in the irrigation areas?
   f. How did irrigation contribute to the sustainable availability of food in the kebele/woreda/zone and region?
   g. What are the coping strategies implemented when people in the area don't have enough food and money to buy food? Give lists.
9. **Factors influencing smallholders' food security outcomes.**
   g. What are the challenges that affect crop production in the kebele?
   h. What are the challenges that affect the production of feeds/fodder for animals in the kebele/woreda/zone and region?
   i. What are the challenges that affect the sustainable availability of food in the kebele/woreda/zone and region?
   j. What barriers affect peoples' participation in irrigation water management, decision-making process, and implementation in irrigation areas?
   k. What are the challenges that affect irrigators' utilisation of agricultural inputs like improved seed, fertilizer, pesticide etc? Give detail.
10. What do you suggest benefitting more from irrigation and improve the food security outcomes in the area?

Thank you very much!!

FOCUS GROUP DISCUSSION GUIDELINES
2022

The role of Small-scale irrigation on rural smallholders' food security outcomes in Wolaita Zone of Southern Ethiopia.

Dear Prospective Participant

Good morning/afternoon. My name is Biruk Seifu Koisha, and I am conducting research for my PhD at the University of South Africa, under the supervision of Dr Catherine Ndinda. We are conducting research on "The role of small-scale irrigation on rural smallholders' food security outcomes in Wolaita Zone of Southern Ethiopia." This study is expected to collect information on household crop production, crop productivity, food diversity, income, behavioural change to produce, purchase and consume nutritional food, and capability to get and implement the service delivered by rural socio-economic institutions that are useful to improve, nutrition utilisation, physical wellbeing or health status, school enrolment and performance of students within the household owing to the available and consumed quantity and quality of food since the intervention of small-scale irrigation and factors that affect rural smallholders food security outcomes. The process and result of this study would give you knowledge of the potential benefits of the development of irrigation in Ethiopia. Today we would like to ask for your participation and share with us your knowledge and opinion on the roles of small-scale irrigation and smallholders' food security outcomes in this area, with a focus on issues such as the roles of small-scale irrigation on crop production, food diversity and food security outcomes.

To obtain reliable information, please answer the questions that follow as frankly as possible. **<u>Your views</u>** are important in this research. There are no right or wrong answers. It is your opinion that counts. You have been selected because of your knowledge about small-scale irrigation and food security outcomes in this community. The information you give to us will be kept confidential. You will not be identified by name or address in any of the reports we plan to write.

PARTICULARS OF INTERVIEW

	DAY MONTH	TIME STARTED	TIME COMPLETED	
		HR MIN	HR MIN	
First visit	/ / 2022			

STRICTLY CONFIDENTIAL

Name of facilitator/Notetaker **Signature** **Date**

1/______________ __________ _________

2/______________ __________ _________

Name of researcher **Signature** **Date**

1/__________________ ___________ _________

Consent acquired from each focus group participant.

Number of participants

FOCUS GROUP DISCUSSION GUIDE

2022

Knowledge, Views on the food security outcomes among smallholder irrigation users in Wolaita Zone of Southern Ethiopia.

11. Role of irrigation in food Production

k. What are the indigenous crops grown in this area before irrigation? Please list and discuss.
l. How has irrigation affected the cultivation of indigenous crops grown in this area?
m. How has irrigation affected the availability of foods in this area?
n. How has the use of irrigation affected the distribution of crops within and beyond this Kebele/ district?

12. Role of irrigation in food diversification

k. Before irrigation was started in the Kebele, what types of crop and animal foods did people consume?
l. What types of food were introduced into the diet after the introduction of irrigation in the Kebele?
m. How irrigation changed access to food and consumption patterns among men, women, and children under 5 and pregnant women?
n. In what ways has irrigation contributed to the adoption of new agricultural technologies (e.g., new crop and animal varieties) in the area? Give detail.
o. Apart from supporting irrigation, in what other ways does the government support this Kebele?

13. Role of irrigation in food security outcomes

a. How did irrigation contribute to the income of the people in the Kebele?
b. How did irrigation affect the health of the people in this area?
c. How did irrigation affect the schooling and performance of children in the Kebele?

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d. How did irrigation contribute to the diversity of employment opportunities in this area?
e. How did irrigation contribute to the sustainable availability of food production?
f. What coping strategies did people in the area use when they don't have enough food and money to buy food? Give lists.

14. Factors influencing rural smallholders' food security outcomes.

l. What are the challenges that affect your crop production?
m. What are the challenges that affect the production of feeds/fodder for animals in this area?
n. What are the challenges that affect the sustainable availability of food in the area?
o. What barriers affect people's participation in irrigation water management and decision-making processes?
p. What are the challenges that affect irrigators' utilisation of agricultural inputs like improved seed, fertilizer, pesticide etc? Give detail.

15. What do you suggest benefitting more from irrigation and improve the food security outcomes in the area?

Thank you very much!!

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APPENDIX F: CONSENT FORM

CONSENT FORM

(Focus Group Discussion/Key Informant's Interview)

The role of Small-scale irrigation on rural smallholders' food security outcomes in Wolaita Zone of Southern Ethiopia.

CONSENT TO PARTICIPATE IN THIS STUDY

I, __________________, confirm that the person asking my consent to take part in this research has told me about the nature, procedure, potential benefits, and anticipated inconvenience of participation. I have read (or had explained to me) and understood the study as explained in the information sheet. I have had sufficient opportunity to ask questions and am prepared to participate in the study. I understand that my participation is voluntary and that I am free to withdraw *before the collected data has been started to be processed* without penalty. I am aware that the findings of this study will be processed into a research report, journal publications and/or conference proceedings, but that my participation will be kept confidential unless otherwise specified. I agree to the recording of the discussion/interview. I understand that the information that I provide will be stored electronically and will be used for research purposes now or at a later stage. I have received a signed copy of the informed consent agreement.

Participant Name & Surname……………… Signature…………. Date……………

Witness Name & Surname----------------------Signature ------------ Date --------------

Researcher : I have explained this study to the best of my ability. I invited questions and gave answers. I believe that the participant fully understands what is involved in being in the study, any potential risks of the study and that he or she has freely chosen to be in the study.

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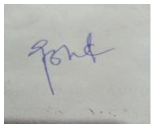
Researcher Name & Surname Mr **Biruk Seifu koisha**

signature  Date 06/04/2022

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CONSENT FORM

(Household Survey)

The role of Small-scale irrigation on rural smallholders' food security outcomes in Wolaita Zone of Southern Ethiopia.

CONSENT TO PARTICIPATE IN THIS STUDY

I, ___________________, confirm that the person asking my consent to take part in this research has told me about the nature, procedure, potential benefits, and anticipated inconvenience of participation. I have read (or had explained to me) and understood the study as explained in the information sheet. I have had sufficient opportunity to ask questions and am prepared to participate in the study. I understand that my participation is voluntary and that I am free to withdraw *before the collected data has been started to be processed* without penalty. I am aware that the findings of this study will be processed into a research report, journal publications and/or conference proceedings, but that my participation will be kept confidential unless otherwise specified. I understand that the information that I provide will be stored electronically and will be used for research purposes now or at a later stage. I have received a signed copy of the informed consent agreement.

Participant Name & Surname……………… Signature………… Date……………

Witness Name & Surname----------------------Signature ------------ Date --------------

Researcher : I have explained this study to the best of my ability. I invited questions and gave answers. I believe that the participant fully understands what is involved in being in the study, any potential risks of the study and that he or she has freely chosen to be in the study.

Researcher Name & Surname Mr Biruk Seifu koisha

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Researcher signature  Date 06/04/2022

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APPENDIX G: LANGUAGE EDITING CERTIFICATE

EDITING AND PROOFREADING CERTIFICATE

22 Osche Street

The Reeds

Centurion

0157

09 June 2024

TO WHOM IT MAY CONCERN

This certificate serves to confirm that I have edited Biruk Seifu Koisha's thesis titled, **"The role of small-scale irrigation on rural smallholders food security outcomes in Wolaita Zone of Southern Ethiopia**."

I found the work easy and intriguing to read. Much of my editing basically dealt with obstructionist technical aspects of language, which could have otherwise compromised smooth reading as well as the sense of the information being conveyed. I hope that the work will be found to be of an acceptable standard. I am a member of Professional Editors' Guild.

Hereunder are my contact details:

Jack Chokwe (PhD – University of Leicester (United Kingdom)

Contact numbers: 072 214 5489

jackchokwe@gmail.com

Professional EDITORS Guild

APPENDIX H: HOUSEHOLD SURVEY QUESTIONNAIRE

Questionnaire for Household Survey

GEOGRAPHIC PARTICULARITY						
RESPONDENT CODE						
COUNTRY NAME:	**ETHIOPIA**					
REGION NAME: SNNPR		**ZONE NAME**	**Wolaita**			
DISTRICT NAME	**1= Humbo**	**2= Abela Abaya**	**3=Damot Gale**	**4= Damot woyde**	**5= Boloso Sore**	
Kebele	**1= Ampo Koisha**	**2= Abela Mareqa**	**3= Buge**	**4= Adecha**	**5= Gurumo Koisha**	

PARTICULARS OF VISITS								
	Year	**Month**		**Day**		**Time code**	**Response code**	
First visit	2022							
Second visit	2022							
Third visit	2022							
						Final response code		

Time code	**Response code**	
1 = Morning till 12h00 2 = 12h01-15h00 3 = 15h01-18h00 4 = 18h01-21h00 5 = 21h01 and later	1 = Interview completed 2 = Interview partly completed 3 = Appointment made for interview 4 = Not a valid visiting point 5 = No one living here (unoccupied)	6 = No one at home 7 = No one at home for duration of the survey 8 = Refusal by household head 9 = No one eligible to complete questionnaire 10 = Incapacitated/Child-headed 11 = Other (specify)

Interviewer Name:	**Name:**				
	Interview Date:				
	H	**H**	**M**	**M**	
Interview starting time:	H	H	M	M	
Interview finishing time:	H	H	M	M	

FACILITATOR	NAME	
	DATE	
	NAME	

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PARTICULARS OF VISITS		
CO-ORDINATOR	DATE	

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GENERAL INSTRUCTION	RESPONDENT SHOULD BE HEAD OR ACTING HEAD OF HOUSEHOLD AND BE 18 YEARS OLD OR OLDER. READ THE ANSWER OPTIONS AND CIRCLE THE CODE TO THE APPROPRIATE ANSWER. ACCORDING TO THE QUESTION THE RESPONSE OR ANSWERS COULD BE MORE THAN ONE.

FIELD WORKER: READ AND CIRCLE THE APPROPRIATE RESPONSE(S) FROM THE OPTIONS OR CATEGORIES.

MODULE 1: - DEMOGRAPHICS AND SOCIOECONOMIC

A household is a group of persons related or not, living under the same roof, under the responsibility of a head whose authority is acknowledged by all the members. The ordinary household is composed of a head of household, his spouse (s), his unmarried children, and possibly his relatives or other persons to whom he is unrelated.

1.1. Respondent	1.2. What is your current living arrangement?	1.3. Respondent sex	1.4. Age category of the respondent	1.5. Respondent Ethnic	1.6. Which one of the following languages do you speak the most at home?
1= Small-scale irrigation user	1= Living with husband/wife	1= Male	1= 18 – 24	1= Wolaita	1= Wolaitigna
2= Small-scale irrigation non-user	2= Living with others not related	2= Female	2= 25- 34	2= Hadiya	2= Hadigna
	3= Living together with partner		3= 35- 44	3= Kembata Timbaro	3= Kembatigna
	4= Living with children and husband/wife		4= 45 -54	4= Gamo	4= Gamogna

	5= Living with children only (no husband/wife/life partner)		5= 55- 64	5= Gedio	5= Gediyogna
	6= Living alone		6= 65+	6**=** Others (specify)	6= Others (specify)
	7= Living with my mother and brothers/sisters				

1.7. **What is your marital status?**	1.8. **Do you have a disability?**	1.9. **If yes, what is your disability?**	1.10. Do you have rural land certification?	**1.11. If yes for Q. 1.10., what is your total farmland size owned in hectares**	**1.12. If No for Q.1.10., Please estimate your total farmland from the given category.--------**
1= Married	1= Yes	1= Physical (spinal injury, loss of a limb etc.)	1= Yes		1= < 0.25 ha
2= Widow/Widower	2= No	2= Sight	2= No		2= 0.26 to 0.5 ha
3= Divorced/ Separated		3= Hearing			3= 0.51 to 0.75 ha
4= Never Married		4= Speech			4= 0.76 to 1.00 ha

		5= Mental Illness/ psychiatric reasons			5= 1.01 to 1.50 ha
		6= Intellectual Disability			6= 1.51 to 2.00 ha
		7= Other (specify)			7= 2.01 to 5ha
		8= Not Applicable			8= 5ha plus
					9= Not Applicable

1.13. How many children do you have, living with you? Write 0 the if the respondent doesn't have any children.

1.14. HOW MANY PEOPLE, INCLUDING ADULTS AND CHILDREN, MAKE-UP YOUR HOUSEHOLD? THAT IS THOSE WHO LIVE WITH YOU ON A REGULAR BASIS.

Module 2. The role of irrigation in Food Production

2.1. For how long you experienced farming (includes both crop production and animal raising)?	**2.2. For how long you used modern agricultural technologies and extension services (e.g., use of fertilizer, improved seed, pesticides, technical advice etc)?**	**2.3. How do you rate the fertility status of your farmland?**	**2.4. Did you irrigate all your farmland that are accessible to irrigation water?**	**2.5. From your total farmland size, how much is irrigated (have access to irrigation), please e[illegible] in ti[illegible]**
1= < 1 year	1= < 1 year	1= Highly fertile	1= Yes	1= < 0.25 ha

2= 1.1 to 2 years	2= 1.1 to 2 years	2= Fertile	2= No	2= 0.26 to 0.5 ha
2= 2.1 to 3 years	2= 2.1 to 3 years	3= Moderately fertile	3= Not Applicable	3= 0.51 to 0.75 ha
4= 3.1 to 4 years	4= 3.1 to 4 years	4= Poorly fertile		4= 0.76 to 1.00 ha
5= 4.1 to 5 years	5= 4.1 to 5 years			5= 1.01 to 1.50 ha
6= > 5 year	6= > 5 year			6= 1.51 to 2.00 ha
				7= 2.01 to 5ha
				8= 5ha plus
				9= Not Applicable

2.6. What is the reason (s) for the response you gave to question 2.4.?	**2.7. Did you plough additional farmland than you did in last production year?**	**2.8. If yes for Q.2.7, how did you get the additional farmland?**	**2.9. If yes for Q. 2.7. how much land size have you use in addition? Please estimate in timad**	**2.10. Do you have home garden?**
1= The benefit from the irrigation is encouraging	1= Yes	1= Rental	1= < 0.25 ha	1= Yes
2= The benefit from rain-fed agriculture is not significant	2= No	2= Purchase	2= 0.26 to 0.5 ha	2= No

3= The land is not accessible for irrigation		3= Gifted from family	3= 0.51 to 0.75 ha	
4= The water is not sufficient		4= Owned due to land distribution from government	4= 0.76 to 1.00 ha	
5= Do not have enough labour		5= legal share distributed after family death	5= 1.01 to 1.50 ha	
6= Do not have enough finance and farm implements		6= Others (specify)	6= 1.51 to 2.00 ha	
7= Not Applicable			7= 2.01 to 5ha	
			8= 5ha plus	

2.11. Who is responsible for cultivating the home garden of the household?	**2.12. Do you irrigate your home garden?**	**2.13. How do you evaluate the fertility status of your irrigated and/or non-irrigated farmland?**	**2.14. Did you have a habit to fallow part or all your farmland?**	**2.15. For your response to Q. 2.14., Please describe the reason.**

1= Husband	1= Yes	1= Similar	1= Yes	1= Do not have enough land to fallow.
2= Wife	2= No	2= Different	2= No	2= To enhance the fertility status of the land
3= Children		3= I don't know		3= To reduce the incidence of disease or pest
4= Both (Husband and wife)				4= To increase crop production
5= All family members				5= Do not have knowledge about the benefit of fallowing
				Other (specify)

2.16. What are the perennial crop types available in your farmland?	**2.17. What are the annual crop types cultivated in "Belg+ Meher+**	**2.18. How much land did you allocate for each crop type in 2021 for "Belg+**	**2.19. How much did you harvest from each crop at the end of "Belg+ Meher+**	**2.20. What are the annual crop types cultivated in "Home**

	Irrigation'' season of 2021.	**Meher+ Irrigation'' season? (1 timad =0.25ha) please insert 0 if it is not allocated.**	**Irrigation'' season in 2021(in quintal)? please insert 0 if there is no harvest or not cultivated.**	**Garden'' season of 2021.**
1= False Banana ("Enset")	1= Maize	2.18.1. Maize	2.219.1. Maize	1= Maize
2= Cassava	2= Wheat	2.18.2. Wheat	2.19.2. Wheat	2= Wheat
3= Mango	3= Barley	2.18.3. Barley	2.19.3. Barley	3= Barley
4= Avocado	4= Sorghum	2.18.4. Sorghu	2.19.4. Sorghu	4= Sorghum
5= Papaya	5= Teff	2.18.5. Teff	2.18.5. Teff	5= Teff
6= Guava	6= Haricot bean	2.18.6. H/bear	2.19.6. H/Bear	6= Haricot bean
7= Coffee	7= Pea	2.18.7. Pea	2.19.7. Pea	7= Pea
8=Others (specify)	8= Bean	2.18.8 Bean	2.19.8. Bean	8= Bean
	9= Chickpea	2.18.9. Chickpe	2.19.9. Chickp	9= Chickpea
	10=Tomato	2.18.10. Tomato	2.19.10. Tomat	10= Tomato
	11= Paper	2.18.11. Paper	2.19.11. Pape	11= Paper
	12= Local cabbage	2.18.12. L/ cabba	2.19.12. L/cabba	12= Local cabbage
	13= Cabbage	2.18.13. Cabba	2.19.13. Cabba	13= Cabbage
	14= Onion	2.18.14 Onior	2.19.14 Onior	14= Onion

	15= Beet Root	2.18.15. Beet Ro	2.19.15. Beet Ro	15= Beet Root
	16= Potato	2.18.16. Potat	2.19.16. Potat	16= Potato
	17= Sweet Potato	2.18.17. S/ Pota	2.19.17. S/ Pota	17= Sweet Potato
	18= Garlic	2.18.18. Garli	2.19.18. Garlic	18= Garlic
	19= Taro	2.18.19. Tar	2.19.19. Taro	19= Taro
	20=Other (specify	2.18.20. Oth (specify)	2.19.20. Oth (specify)	20=Other (specify)
2.21. Is there any productivity difference between irrigated and rainfed crops?	**2.22. Did you practice rotation or shifting cultivation activity?**	**2.23. Did you use agricultural inputs such as improved seed, fertilizer etc during last production year i.e., 2021?**	**2.24. How much agricultural inputs did you use during Belg + Meher+ irrigation season, in last production year (2021) Kg or litre?**	**2.25. Did you get any training on crop production during last years (2021)?**
1= Yes	1= yes	1= Yes	2.24.1. DAP in kg ------	1= Yes
2= No	2= No	2= No	2.24.2. UREA in kg ---	2= No

			2.24.3. Pesticide/ Herbicide/ Insecticides in kg or litre ------	
			2.24.4. Improved Seed in kg ------ (specify each)	
			2.24.5. Others (specify)	
2.26. If you take training on crop production, who gave the training?	**2.27. If you take training, does it have an impact on your crop production?**	**2.28. Did you get enough harvest to fulfil your family consumption demand, for the entire family needs?**	**2.29. Are you interested with the introduction of small-scale irrigation technologies?**	**2.30. How did you rate the contribution of irrigation to your food production? (Users only)**
1= Government organisation	1= Yes	1= Yes	1= Yes	1= Greatly Increasing
2= NGO	2= No	2= No	2= In between	2= Increasing
3= Others (specify)			3= No	3= Fluctuating

			4= Not Applicable	4= Remain the same
				5= Reducing
				6= Greatly Reducing
				7= Not Applicable
2.31. Did the availability of irrigation scheme nearby contribute to your production (for non-users)?				
1= Yes				
2= No				
3= Not Applicable				

Module 3. THE ROLE OF IRRIGATION IN FOOD DIVERSIFICATION

3.1. Which of the following food group did you produce at your home during last year?	**3.2. Which of the following food group did you purchase from**	**3.3. Which of the following food group did you consume during last 4 weeks?**	**3.4. which of the following food items you consumed during**

	market during last 4 weeks?		**the last month? Vitamin rich**
1= Cereals	1= Cereals	1= Cereals	1= Carrot
2= Vegetables	2= Vegetables	2= Vegetables	2= Sunflower seed
2= Fruits	2= Fruits	2= Fruits	3= Leafy green
4= Meat, poultry	4= Meat, poultry	4= Meat, poultry	4= Soya beans
5= Eggs	5= Eggs	5= Eggs	5= Pumpkin
6= Root and tubers	6= Root and tubers	6= Root and tubers	6= Grain
7= Fish and seafood	7= Fish and seafood	7= Fish and seafood	7= Beans
8= Milk and milk products	8= Milk and milk products	8= Milk and milk products	8= Peas
9= Oil/fats	9= Oil/fats	9= Oil/fats	9= Avocado
10= Sugar/honey	10= Sugar/honey	10= Sugar/honey	10= Potato
11= Pulses/legumes/nuts	11= Pulses/legumes/nuts	11= Pulses/legumes/nuts	11= Sweet potato
			12= Pepper
			13= Citrus fruits
			14= Others (specify)
			15= None of them
3.5. which of the following food items you consumed	**3.6. Have you been involved in cattle, goat, sheep, chicken,**	**3.7. If yes for Q3.6. which animals?**	**3.8. Please describe the number of livestock you selected for Q.3.7**

during last month? Micronutrient rich	**beekeeping or any other livestock operations?**		
1= Chickpea	1= Yes	1= Heifer/s	3.8.1. Heifer/s in No------
2= Pineapple	2= No	2= Bull/s	3.8.2. Bull/s in No --------
3= Banana		3= Cow	3.8.3. Cow in No --------
4= Onion		4= Oxen	3.8.4. Oxen in No ---------
5= Garlic		5= Sheep	3.8.5. Sheep in No -------
6= Beans		6= Goat	3.8.6. Goat in No -----------
7= Others (specify)		7= Chicken	3.8.7. Chicken in No --------
8= None of them		8= Bees	3.8.9. Bees in hives No -------
		9= calves	3.8.10. calves in No ______
		10= Other (specify)	3.8.10 Other (specify)
3.9. Please describe the age range of livestock you selected for Q.3.7	**3.10. The average livestock age from Q.3.7**	**3.11. From where you get fodder or food for your livestock production?**	**3.12. From where you got knowledge about nutritional foods?**
3.9.1. Heifer/s from------to ---------	3.10.1. Heifer/s ------	1= From own rain-fed crop post-harvest products	1= Radio
3.9.2. Bull/s from -----to------	3.10.2. Bull/s --------	2= From own irrigated crops post harvested products	2= Other mass media (television, newspaper, posters)

3.9.3. Cow from ------to------	3.10.3. Cow --------	3= From market	3= Peers (neighbours, friends, relatives)
3.9.4. Oxen from ------to------	3.10.4. Oxen ---------	4= From own grazing land	4= Community based farming group (Farmers Training centre)
3.9.5. Sheep from-----to-------	3.10.5. Sheep -------	5= Other (specify)	5= Home visit by community Extension Agent
3.9.6. Goat from ----- to------	3.10.6. Goat -----------		6= Agricultural and nutrition activity-based, funding organisation or NGO
3.9.7. Chicken from -----to----	3.10.7. Chicken --------		7= Others (specify)
3.9.9. Bees in hives from -----to------	3.10.9. Bees in hives -------		
3.9.10. calves from -------- to --------	3.10.10. calves ------------		

3.13. How did you rate the contribution of irrigation to your food consumption diversity?	
1= Greatly Increasing	
2= Increasing	

3= Fluctuating	
4= Remain the same	
5= Reducing	
6= Greatly Reducing	
7= Not Applicable	

MODULE 4. ROLE OF IRRIGATION IN FOOD SECURITY OUTCOMES

THREE STANDARD FOOD SECURITY OUTCOMES INDICATORS

4.1. QUESTIONNAIRE FOR HOUSEHOLD DIETARY DIVERSITY SCALE

Now I would like to ask you about the types of foods that you or anyone else in your household ate **yesterday during the day and at night**, whether **at home or outside the home (it should be produced at home in both cases)**, start with the first food or drink of the morning. Write down all foods and drinks mentioned. When composite dishes are mentioned, ask for the list of ingredients. When the respondent has finished, probe for meals and snacks not mentioned (It is possible to attach additional table if required).

Breakfast	Snack	Lunch	Snack	Dinner	Snack

CIRCLE A *ONE* IN THE BOX IF ANYONE IN THE HOUSEHOLD ATE THE FOOD IN QUESTION AND PLACE A *ZERO* IN THE BOX IF NO ONE IN THE HOUSEHOLD ATE THE FOOD.

4.1.1 Was yesterday a celebration or feast day where you ate special foods or where you ate more or less than usual?	**4.1.2. Were there any cereals (maize, rice, wheat, sorghum, or any other grains or foods made from these (e.g., bread, porridge, biscuits, or other grain products) e.g. Porridge or paste?**	**4.1.3. Was there any roots and tuber (e.g., potatoes, yams, cassava, or any other foods made from roots or tubers)?**	**4.1.4. Was there any Vitamin A-rich vegetables and tubers (e.g., pumpkin, carrot, sweet potato, orange-red sweet pepper)?**
1= Yes	1= Yes	1= Yes	1= Yes
0= No	0= No	0= No	0=No
4.1.5. Were there Dark green leafy vegetables (e.g., cassava leaves, spinach dark green leafy vegetables, including wild forms	**4.1.6. Were there other vegetables (e.g., tomato, onion, eggplant, local vegetables)**	**4.1.7. Were there any vitamin A-rich fruits (e.g., ripe mango, ripe papaya)**	**4.1.8. Was there any other fruit (e.g., other fruits, including wild fruits)?**
1= Yes	1=Yes	1= Yes	1= Yes
0= No	0= No	0= No	0=No

4.1.9. Was there any organ meat (e.g., liver, kidney, heart or other organ meats or blood-based foods)?	**4.1.10. Were there any flesh meats (e.g., beef, pork, lamb, goat, chicken, duck, other birds, insects)?**	**4.1.11. Was there any egg (e.g., eggs from chicken, duck, or any other egg)?**	**4.1.12. Was there any fresh or dried fish or seafood (e.g., fresh, or dried fish)?**
1= Yes	1=Yes	1= Yes	1= Yes
0= No	0=No	0=No	0=No
4.1.13. Were there any foods made from beans, peas, lentils, or nuts (dried beans, dried peas, lentils, nuts, seeds, or foods made from these (e.g., peanut butter)?	**4.1.14. Were there any cheese, yoghurt, milk, or other milk products?**	**4.1.15. Was there any food/s made with oil, fat, or butter (added to food or used for cooking)?**	**4.1.16. Was there any sugar or honey (sweetened soda or sweetened juice drinks, sugary foods such as candies, cookies, and cakes?**
1=Yes	1=Yes	1= Yes	1= Yes
0=No	0= No	0= No	0=No
4.1.17. Were there any other food/s, such as condiments, coffee, tea, spices, beverages?	**4.1.18. Did you feed any special foods to children or lactating/pregnant women?**	**4.1.19. Sum of all values from Q 4.1.2. to Q 4.1.18., __________**	
1= Yes	1=Yes		

0=No	0=No	

4.2. HHS Questionnaire

Occurrence questions: - In the past [4 weeks/30 days], ………. Circle 0 for "No", 1 for "yes" answers in the box.

For frequency questions: - How often did this happen? Circle 1 being " rarely" i.e once or twice within 30 days, 2 being " sometimes,"i.e 3 to 10 times within 30 days and 3 being "often i.e more than 10 day in 30 days.

Occurrence question	**Occurrence question**	**Occurrence question**	**Occurrence question**
4.2.1. was there ever no food to eat of any kind in your house because of lack of resources to get food?	**4.2.2. did you or any household member go to sleep at night hungry because there was not enough food?**	**4.2.3. did you or any household member go a whole day and night without eating anything at all because there was not enough food?**	**4.2.4. Sum of occurrence question responses -------------**
0= No	0= No	0= No	
1= Yes	1= Yes	1= Yes	
Frequency question	**Frequency question**	**Frequency question**	**Frequency question**
4.2.5. How often did this happen for Q 4.2.1	**4.2.6. How often did this happen for Q 4.2.2**	**4.2.7. How often did this happen? For Q 4.2.3**	**4.2.8. Sum of frequency questions responses----------**
1= rarely	1= rarely	1= rarely	
2= sometimes	2= sometimes	2= sometimes	
3= often	3= often	3= often	
4= NA	4= NA	4= NA	

4.3. **Household Coping Strategy Index Questionnaire**

Write numbers from 0 to 7 to answer the frequency and NA if that coping strategy behaviour does not used at the household, and finally probe the household if they used other coping strategy behaviours than the listed and specify by adding rows at the end.

Behaviours	**Frequency**
In the past 7 days, if there have been times when you did not have enough food or money to buy food, how many days has your household had to:	**Number of days out of the past seven: (Use numbers 0 – 7 to answer number of days; Use NA for not applicable)**
4.3.1. Rely on less preferred and less expensive foods?	
4.3.2. Borrow food, or rely on help from a friend or relative?	
4.3.3. Purchase food on credit?	
4.3.4. Gather wild food, hunt, or harvest immature crops?	
4.3.5. Consume seed stock held for next season?	
4.3.6. Send household members to eat elsewhere?	
4.3.7. Send household members to beg?	
4.3.8. Limit portion size at mealtimes?	
4.3.9. Restrict consumption by adults for small children to eat?	
4.3.10 Feed working members of HH at the expense of non-working members?	
4.3.11 Reduce number of meals eaten in a day?	

4.3.12. Skip entire days without eating?	
4.3.13. Others (specify)	

Module 5 Other Food Security Outcomes indicators

5.1. Under which employment type does your household members engaged?	**5.2. Did you get income from-------**	**1=Yes**	**2=No**
1= Farming	5.2.1. Salaries/wages	1	2
2= Local trading	5.2.2. any business	1	2
3= Government employment	5.2.3. Remittances (money received from people living elsewhere)	1	2
4= Private companies (sectors)	5.2.4. Pensions (exclude old age state grant)	1	2
5= Others (specify)	5.2.5. Sales of farming products and services	1	2
	5.2.6. Other income sources e.g., rental income, interest	1	2
	5.2.7. No income	1	2

5.3. Did you sell any crop type you harvested	**5.4. If yes for Q5.3 how much did you earn for**	**5.5. If yes for Q5.3 how much**	**5.6. Did you sell any animals, animal sources,**	**5.7. If yes for Q5.6 how much did you**	**5.8. If yes for Q5.6 how much did you earn for**

from your farm during last 4 weeks and/or last year (2021)?	the last 4 weeks?	did you earn for the last year?	farm, non-farm assets during last 4 weeks and/or last year (2021)?	earn for the last 4 weeks?	the last year (2021)?
1= Yes	1=No income	1=No income	1= Yes	1=No income	1=No income
2= No	2=B1 - B500	2=B1 - B500	2= No	2=B1 - B500	2=B1 - B500
	3=B501 - B1,000	3=B501 - B1,000		3=B501 - B1,000	3=B501 - B1,000
	4=B1,001 - B1,500	4=B1,001 - B1,500		4=B1,001 - B1,500	4=B1,001 - B1,500
	5=B1,501 - B2,000	5=B1,501 - B2,000		5=B1,501 - B2,000	5=B1,501 - B2,000
	6=B2,001 - B2,500	6=B2,001 - B2,500		6=B2,001 - B2,500	6=B2,001 - B2,500
	7=B2,501 - B3,000	7=B2,501 - B3,000		7=B2,501 - B3,000	7=B2,501 - B3,000
	8=B3,001 - B3,500	8=B3,001 - B3,500		8=B3,001 - B3,500	8=B3,001 - B3,500
	9=B3,501 - B4,500	9=B3,501 - B4,500		9=B3,501 - B4,500	9=B3,501 - B4,500
	10=B4,501 - B5,500	10=B4,501 - B5,500		10=B4,501 - B5,500	10=B4,501 - B5,500

	11=B5,501 - B6,500	11=B5,501 - B6,500		11=B5,501 - B6,500	11=B5,501 - B6,500
	12=B6,501 - B7,500	12=B6,501 - B7,500		12=B6,501 - B7,500	12=B6,501 - B7,500
	13=B7,501 - B8,500	13=B7,501 - B8,500		13=B7,501 - B8,500	13=B7,501 - B8,500
	14=B8,501 - B9,500	14=B8,501 - B9,500		14=B8,501 - B9,500	14=B8,501 - B9,500
	15=B9,501 - B10,500	15=B9,501 - B10,500		15=B9,501 - B10,500	15=B9,501 - B10,500
	16=B10,501 - B11,500	16=B10,501 - B11,500		16=B10,501 - B11,500	16=B10,501 - B11,500
	17=B11,501 - B12,500	17=B11,501 - B12,500		17=B11,501 - B12,500	17=B11,501 - B12,500
	18=B12,501 - B13,500	18=B12,501 - B13,500		18=B12,501 - B13,500	18=B12,501 - B13,500
	19=B13,501 - B15,000	19=B13,501 - B15,000		19=B13,501 - B15,000	19=B13,501 - B15,000
	20=B15,001 - B20,000	20=B15,001 - B20,000		20=B15,001 - B20,000	20=B15,001 - B20,000
	21=B20,001 - B30,000	21=B20,001 - B30,000		21=B20,001 - B30,000	21=B20,001 - B30,000
	22=> B30,001	22= > B30,001		22= > B30,001	22=> B30,001

	23=Refuse to answer	23=Refuse to answer		23=Refuse to answer	23=Refuse to answer
	24=Not sure	24=Not sure		24=Not sure	24=Not sure
5.9. Did you go to any nearby local market to sell or observe or hear the prices of crop, livestock, and livestock products?	**5.10. If yes for Q. 5.9., what is the price of crops in birr/quintal this week in nearby local market?**	**5.11. If yes for Q. 5.9., what is the price of livestock in birr/ individual this week in nearby local market (indicate the average value)?**	**5.12. If yes for Q. 5.9., what is the price of livestock products in birr/ individual this week in nearby local market?**	**5.13.** Have you experienced any food or income shortage or loss in the last 10 years?	**5.14. If yes, for Q. 5.13., in which season did you mostly experience?**
1= Yes	5.10.1= Maize per qt, birr ----------	5.11.1= Heifer/s in no, birr------	5.12.1= Meat in Kg, Birr ----	1= Yes	1= During absence or shortage of rainfall
2= No	5.10.2= Wheat per qt, birr ---------	5.11.2= Bull/s in no birr ------	5.12.2= Egg in No, Birr------	2= No	2= During food crises period
	5.10.3= Barley per qt, birr -----------	5.11.3= Cow in birr, -------	5.12.3= Fish in kg B-----		3= Other (specify)

	5.10.4= Sorghum per qt, birr ------	5.11.4= Oxen in birr, ------	5.12.4= Cheese in kg B---		
	5.10.5= Teff per qt birr -----	5.11.5= Sheep in birr, ----	5.12.5= Yoghurt in lit B-----		
	5.10.6= H/bean per qt, birr-----	5.11.6= Goat in birr, -----	5.12.6= Fresh milk in lit B--		
	5.10.7= Pea per qt birr------	5.11.7= Female Meat hen in birr- -	5.12.7= Other (specify): -		
	5.10.8= Bean per qt birr-----	5.11.8= Rooster in birr----			
	5.10.9= Chickpea per qt birr----	5.11.9= Egg laying hen in birr------			
	5.10.10= Garlic per qt birr-------	5.11.10= Honey in kg, birr----			
	5.10.11= Tomato per kg, birr------	5.11.11= Other (specify): -			
	5.10.12= Paper per kg, birr ------				
	5.10.13= Local cabbage, birr				

	5.10.14= Cabbage per kg, birr---				
	5.10.15= Onion per kg, onion -----				
	5.10.16= Beet Root per kg, birr----				
	5.10.17= Potato per kg, birr---				
	5.10.18= Sweet Potato per qt, birr-----				
	5.10.19= Taro per qt, birr-----				
	5.10.20= False Banana (“Enset”)				
	5.10.21= Cassava per qt, birr---				
	5.10.22= Mango per kg, birr----				

	5.10.23= Avocado per kg, birr----				
	5.10.24= Papaya per kg, birr-----				
	5.10.25= Guava per kg, birr---				
	5.10.26= Others (specify)				

Dwelling of the household

INSTRUCTION TO INTERVIEWER: Circle the materials used of the MAIN dwelling*: Multiple responses allowed.*

5.15. What are the materials of the walls of the House (dwelling)?	5.16. What is the material of roofs of the House (dwelling)?	5.17. What are the materials of the FLOORS of the dwelling?
1= Bricks	1= Bricks	1= Tile/ceramic
2= Cement block	2= Cement block	2= Concrete
3= Corrugated iron	3= Wood+ Corrugated iron	3= Plastic/Cloth
4= Wood, Grass, and Mud	4= Timber + corrugated iron	4= Mud/clay
5= Plastic/Cloth	5= Plastic/Cloth	5= Wood/Timber
6= Cardboard	6= Cardboard	6= Other (specify)
7= Wood, Mud, Grass, and cement mix	7= Mud and cement mix	
8= Mud/Clay	8= Mud/Clay	
9= Grass	9= wood + Grass	
10= Asbestos	10= Timber + Asbestos	
11= Other (specify)	11= Other (specify)	

The educational situation of the household

5.18. What is the HIGHEST level of education?	5.19. If the response for Q. 5.18 is no	5.20. If the response for Q. 5.18 is no schooling, did you	5.21. Do you have children or other family member	5.22. If yes for Q.5.21., do you have children not enrolled in any

	schooling, did you participate in any adult literacy courses during last year?	participate in non-formal education programmes during last year?	greater than seven (7) years old?	educational level, but should be?
1= No Schooling	1= Yes	1= Yes	1= Yes	1= Yes
2= Grade 1	2= No	2= No	2= No	2= No
3= Grade 2				
4= Grade 3				
5= Grade 4				
6= Grade 5				
7= Grade 6				
8= Grade 7				
9= Grade 8				
10= Grade 9				
11= Grade 10				
12= Grade 11				
13= Grade 12				
14= certificate				
15= Diploma				
16= Bachelor's degree				

17= Other (specify)				
5.23. If yes for Q. 5.21. do you have any other family members who are not enrolled in any educational level, but should be?	**5.24. Is there any family member enrolled in any educational level above the age indicated on the country education policy for each grade?**	**5.25. Did you have children, or any other member of your household drop out attending school during last year 2020/21?**	**5.26. Did you have a habit of following children annual school academic performance?**	**5.27. If yes for Q. 5.26., how is the academic performance your children?**
1= Yes	1= Yes	1= Yes	1= Yes	1= Increasing
2= No	2= No	2= No	2= No	2= Decreasing
				3= Fluctuating
				4= Remain similar
				5= Not Applicable
5.28. Did your children or other family members get enough food	**5.29. If no for Q. 5.28., which one is not provided regularly on time?**	**5.30. Do you fulfil school aids, for your children?**	**5.31. Do you send any household members to better government or private schools?**	**5.32. Did you cost additional for different school aids which are outside of government subsidy?**

always when they went to and from school on time?				
1= Yes	1= Breakfast	1= Yes	1= Yes	1= Yes
2= No	2= Lunch	2= No	2= No	2= No
	3= Diner			
	4= Not Applicable			
5.33. If your response for Q 5.32., is yes, for what purpose did you cost during last year?	**5.34. Did you send any member of the household to government and private institutions, college, and university after completion of high school?**	**5.35. If the response for question 5.34., is yes, to get which education level.**	**5.36. Do you pay school fee for your children or other family members?**	**5.37. How much did you totally expend to educate your family members during the last academic year (2020/21)?**
1= School uniform	1= Yes	1= Certificate	1= Yes	1= Nothing

2= Exercise book, pen, and pencils	2= No	2= Diploma	2= No	2= B1 – B1,000
3= Class book		3= Degree		3= B1,001 - B2,000
4= Additional reference books		4= Greater than degree a (explain)		4= B2,001 - B8,000
5= School fee				5= B8,001 – B14,000
6= Residential and transportation cost				6= B14,001 – B20,000
7= Food and clothing cost				7= B20,001 – B26,000
8= Other (specify				8= B26,001 – B32,000
				9= B42,001 - B54,000
				10= B54,001 – And more
				11= Refuse to answer
				12= Not sure
5.38. How did you rate the contribution of				

irrigation to fulfilling your children's school expenditures?
1= Greatly Increasing
2= Increasing
3= Fluctuating
4= Remain the same
5= Reducing
6= Greatly Reducing
7= Not Applicable

Nutrition and Health status of the household

5.39. Do you have under 5, pregnant or lactating mother in your	**5.40. If yes for Q 5.39., do they have different**	**5.41. Did your children get breastfeed and supplementary**	**5.42. Are there any cultural or religious beliefs that hinder**	**5.43. If yes, for Q 5.42., which food group?**

household last year (2021)?	**consumption pattern?**	**feed regularly until the recommend age group?**	**you from consuming any food products?**	
1= Yes	1= Yes	1= Yes	1= Yes	1= Cereals
2= No	2= No	2= No	2= No	2= Vegetables
				3= Fruits
				4= Meat, poultry
				5= Eggs
				6= Root and tubers
				7= Fish and seafood
				8= Milk and milk products
				9= Oil/fats
				10= Sugar/honey
				11= Pulses/legumes/ nuts
				12= Other (explain)
5.44. Did any one of your household members sick or injured in the last	**5.45. Did you and your household**	**5.46. If yes for Q 5.45., did you cost additional**	**5.47. Did you and your household members enrol in the**	**5.48. Do you know about the importance of**

4 weeks or last year (2021)?	**members use any curative, preventive health care services from any health facilities when sick and injured during the last 4 weeks or last year (2021)?**	**money other than government subsidy to prevent and cure the sick or injured one?**	**National Health insurance scheme?**	**childcare practices?**
1= Yes	1= Yes	1= Yes	1= Yes	1= Yes
2= No	2= No	2= No	2= No	2= No
5.49. Did you face any death in your household due to a shortage of food or a loss of resources to get health services during last year?	**5.50. If yes, for Q 5.49., did that family member get health service before death?**	**5.51. Does irrigation help to improve your family's nutritional food consumption habits?**	**5.52. Does irrigation help to improve your family's health status?**	**5.53. Does the income generated due to irrigation support you to access health services**

1= Yes	1= Yes	1= Yes	1= Yes	1= Yes
2= No	2= No	2= No	2= No	2=No
5.54. Which of the listed main (Top) diseases affected you and your family members during the last 4 weeks or year?	**5.55. How much did you expend to get health services during the last 4 weeks?**	**5.56. How much did you expend to get health services last year (2021).**	**5.57. How did you rate the contribution of irrigation to fulfilling your children's food demands?**	
1= Malaria	1= Nothing	1= Nothing	1= Greatly Increasing	
2= HIV/AIDs	2= B1 - B500	2= B1 - B6,000	2= Increasing	
3= Tuberculosis	3= B501 - B1,000	3= B6,001 - B12,000	3= Fluctuating	
4= Meiselas	4= B1,001 - B1,500	4= B12,001 - B18,000	4= Remain the same	
5= Polio	5= B1,501 - B2,000	5= B18,001 - B24,000	5= Reducing	
6= Yellow Fever	6= B2,001 - B2,500	6= B24,001 - B30,000	6= Greatly Reducing	
7= Mental Health	7= B2,501 - B3,000	7= B30,001 - B36,000	7= Not Applicable	

7= respiratory diseases (Like Pneumonia, or Bronchitis)	8= B3,001 - B3,500	8= B36,001 - B42,000
8= COVID 19	9= B3,501 – B 4,500	9= B42,001 – B 54,000
9= Hepatitis	10= B4,501 – B 5,500	10= B54,001 – B 66,000
10= Diarrhoea	11= B5,501 - B6,500	11= B66,001 - B78,000
11= Trachoma	12= B6,501 - B7,500	12= B78,001 - B90,000
12= Blindness	13= B7,501 - B8,500	13= B90,001 - B102,000
13= Other (specify)	14= B8,501 - B9,500	14= B102,001 - B114,000
	15= > B9,501	15= > B114,001
	16= Refuse to answer	16= Refuse to answer

Community participation and Social Interaction

5.58. How is your family members' participation in resource allocation and decision-making processes at the household level?	**5.59. How would you rate your social networks and community participation in your area?**	**5.60. Are you involved in any?** **1 = Yes 2= No**		
1= They don't participate in any resource allocation and decision-making process	1= Very Good	5.60.1. kebele cabinets committee member	1	2
2= Sometimes I let them participate including children	2= Good	5.60.2. Community (kebele) Representatives (elected)	1	2
3= I participate only my wife	3= Average	5.60.3. Water users Association	1	2
	4= Poor	5.60.4. Church committee	1	2
	5= Very Poor	5.60.5. Community-Based Organisations	1	2
		5.60.6. Any Civic Organisation	1	2
		5.60.7. Other (specify)	1	2
5.61. Is there any right or legal claiming ground to public provisions in your area?	**5.62. Do you exercise these rights or use legal claiming institutions to improve your**	**5.63. Does irrigation help to enhance your participation in the**		

	participation in decision-making processes?	decision-making process in the community?
1= Yes	1= Yes	1= Yes
2= No	2= No	2= No

Drinking water access

5.64. What is the household's MAIN source of drinking water?	**5.65. How far is the water source from the dwelling or yard.**	**5.66. How safe is the water from the main source of drinking water? 1= Yes 2= No**		
1= Piped tap water in dwelling	1= Water source is in dwelling	5.66.1. Safe to drink	1	2
2= Piped tap water on site/yard	2= Less than 200 metres	5.66.2. Clear (has no colour / free of mud)	1	2
3= Public/communal tap	3= 201 - 500 metres	5.66.3. Good in taste	1	2
4= Water carrier/ tanker	4= 501 metres - 1 kilometre	5.66.4. Free from bad smells	1	2
5= Water carrier/tank on site	5= More than 1 kilometre			
6= Borehole on site	6= Don't Know			
7= Borehole outside yard				
8= Rainwater tank on site				
9= Other (Specify)				
5.67. Do household members treat the water used for drinking?	**5.68. If yes, for Q 5.67., what method do you use to treat the water you drink?**	**5.69. Is your main source of drinking water supplied by the government?**	**5.70. Does the household pay for local government or water users association to get water?**	**5.71. If yes for Q., 5.70., how much?**

1= Yes, always	1= Boiling	1= Yes	1= Yes	5.71.1. Five litre water B- --------
2= Yes, sometimes	2= Natural Filtering	2= No	2= No	5.71.2. Ten litre water B- ------
3= No, never	3= Chemical (e.g., chlorine)			5.71.3. Twenty litre water B---
	4= Other (Specify)			5.71.3. yearly in b
5.72. If no, for Q 5.70., what is the main reason or why the household does not pay for water?	**5.73. Has your government water supply been interrupted at any time during the last 12 months?**	**5.74. If yes, for Q 5.73., from where do you get pure drinking water?**	**5.75. Did the income generated due to irrigation supported you and your family to get clean drinking water?**	
1= Use own source of water	1= Yes	1= Use alternative water source from the government	1= Yes	
2= Use a free water source	2= No	2= Use a free water source	2= No	

3= Pay directly to local government as part of rent		3= Buy pure water from nearby available source	3= NA
4= Payment included in levy		4= others	
5= Permission from municipality not to pay			
6= Do not have water meter			
7= Water meter not working/broken			
8= Do not receive water bill			
9= Community decision not to pay			
10= Cannot afford to pay			

SANITATION

5.76. What kind of toilet facility does your household use?	**5.77. Do you have a bathroom/shower?**	**5.78. If No for Q 5.81., where do you clean your body and cloths**	**5.79. Does the income generated from irrigation support your family access sanitation facilities?**

1= Flush toilet connected to a municipal sewage system	1= Yes	1= at the river	1= Yes
2= Flush toilet connected to a septic tank	2= No	2= at home by fetching water from the river	2= No
3= Pit latrine with ventilation pipe (long drop)		3= at home by fetching water from the tape	3= NA
4= Pit latrine without ventilation pipe (long drop)		4= at home by fetching water from the borehole	
5= Other (specify)		5= Other (specify)	

Further support the irrigation scheme

5.80. Did you or your family member get support from any organisation or NGO last year?	**5.81. If yes, for Q 5.80., in what area did they support you?**
1= Yes	1= Animal production activity
2= No	2= Nutritious food production techniques and their benefit
	3= School feeding
	4= Other Income generation activities like small business

	5= Children school support like fulfilling school materials
	6= Free Health facility services
	7= Agricultural input support
	8= Direct money (cash) support
	9= Other (specify)

Thank you very much!!