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# BLESSINGS AND BLIGHTS OF SMALL SCALE IRRIGATION ON THE LIVELIHOOD OF SMALLHOLDER FARMERS IN THE CENTRAL RIFT VALLEY OF ETHIOPIA

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## ABSTRACT

The study aims to investigate the effects of small scale irrigation on households' livelihood in the Central Rift Valley of Ethiopia. Data was collected through household survey, focus group discussions and in-depth interview. Small scale irrigation enhances agricultural productivity, serve as a source of diversified options to access food, creates employment opportunity, creates a means to cope up with the effects of climate variability and increases household asset. The proliferation of new plant pests and diseases, degradation of natural resources and biodiversity change were some of its damaging effects. The sustainable development of irrigated agriculture has continued to be unsatisfactory due to lack of sustainability in using financial, natural resources and technical performance of schemes. To ensure sustainable development, much work has to be done in creating access to market linkage and transportation infrastructures, access to rural financial institutions, adopting water saving irrigation technologies and ensure equity in water use.

**Keywords:** Small Scale Irrigation, Livelihood, Farmers' View, Sustainability, Central Rift Valley, Ethiopia.

## INTRODUCTION

Looking at population growth projection, the Sub-Saharan Africa (SSA) region will account for about half of the global population growth between 2010 and 2050 (United Nations (UN), 2011). SSA might also face a serious challenge to feed more than 2 billion people by 2050 due to the adverse effect of climate change on rain-fed agriculture (Intergovernmental Panel on Climate Change (IPCC), 2007). Coupled to this climate change has threaten rain-fed agricultural production and increases the vulnerability of people dependent on it for their livelihood in SSA (Claessens et al., 2012; Lipper et al., 2014). The issue of climate change is global, long-term and it includes complex interaction between climatic, social, environmental, economic, technological, institutional, and political processes (Smit & Pilifosova, 2003). Thus, combating climate change is a key to attain the goal of sustainable development and achieving the goal of sustainable development is integral to lasting climate change mitigation and adaptation (Fischer et al., 2007). In this regard, the contribution of irrigation towards boosting agricultural production is enormous to avert the adverse effect of climate change on rain-fed agriculture and to produce food for rapidly growing global population. If irrigated area could be tripled by 2050, it would dramatically contribute to food supply in SSA (Rosegrant, Ringler, & Zhu, 2009). The demand for irrigation water is expected to continue in SSA (Mancosu, Kyriakakis, & Spano, 2015). However, at a global level 60% of the diverted water for agriculture does not contribute directly to food production due to inefficient irrigation systems (Food and Agricultural Organization (FAO), 2013). The same projection also showed that by 2025, 1,800 million people are expected to be living in regions with absolute water scarcity. Thus, water scarcity might be the future big challenge for expanding irrigation and to enhance sustainable agricultural production.

In Ethiopia, smallholder rain-fed dependent farmers have been facing climate related hazards due to rainfall variability and droughts (Kassie et al., 2013). In the Central Rift Valley (CRV) of Ethiopia rapid population growth, poverty and natural resource degradation are firmly intertwined (Pascual-Ferrer, Pérez-Foguet, Codony, Raventós, & Candel, 2014). Extreme rainfall variability has serious impact on food security in the area due to the dependency of the population on climate-sensitive subsistence farming (Muluneh, Bewket, Keesstra, & Stroosnijder, 2017; Yihun, 2015). Thus, the area is chronically food insecure and farmers have been under food aid. As a result, it is incontestable that irrigation has big role to increase rain-fed dependent farmers' resilience capacity against changing climate (Awulachew, Merrey, Van Koopen, & Kamara, 2010).

The central rift valley region of Ethiopia encompasses a chain of four lakes (Ziway, Langano, Abyata and Shala) and streams (Jansen et al., 2007). Large scale national and foreign horticulture and floriculture farms have been operating in the area taking the water resources endowment as an advantage (Hengsdijk & Jansen, 2006). In the area small scale irrigation schemes (SSIS) have been practiced on lakes, stream and river diversions, groundwater, dams and perennial springs. There is high competition for water resources among large and small scale irrigators, commercial farmers, fishery, industrial water use, domestic water use, nature and related eco-tourism (Jansen et al., 2007; Pascual-Ferrer et al., 2014). The result of this study can be used as an input for policy makers with regard to small scale irrigation (SSI) development in the era of climate variability and the mechanisms required for adoption.

Previous studies conducted on analogous matters had focused on the assessment of the positive effects of SSI on rural livelihood using mainly quantitative research techniques in Ethiopia and other countries (Gebrehiwot, Mesfin, & Nyssen, 2015; Smith, 2004; Van Halsema, Keddi Lencha, Assefa, Hengsdijk, & Wesseler, 2011; Zeweld, Huylenbroeck, Hidgot, Chandrakanth, & Speelman, 2015 and others). However, in this study a more holistic and livelihood-centered assessment of SSI agriculture was undertaken using both quantitative and qualitative data sources and deploying different analysis techniques. Thus, the objectives of the study were to (1) identify the contribution of SSI farming on rural livelihood improvement (2) investigate the damaging effects of SSI farming; (3) identify the constraints of SSI agricultural enhancement; (4) analyze the sustainability of irrigation based rural livelihoods in the Central Rift valley regions of Ethiopia based on the perspectives of sustainable development.

## ANALYTICAL FRAMEWORK OF THE STUDY

The analytical framework for the study was developed based on the framework developed by (Department for International Development (DFID), 2000) as presented in Figure 1. Adhering to conception by DFID (2000) "a livelihood comprises the capabilities, assets and activities required for a means of living." The livelihood of the rain-fed dependent farmers is extremely vulnerable due to climate change induced hazards like rainfall variability and occurrence of recurrent drought especially in arid and semi-arid areas (IPCC, 2007). Such situations together with rapid population growth have increased the level of vulnerability of smallholder farmers to be able to cope with livelihood strategies towards achieving enhanced living condition on sustainable basis, for example, prevalence of food insecurity and poverty cited as the major obstacles. These current global and local challenges of rain-fed agricultural system were the drivers for the introduction of SSI in the study sites. In the analytical framework, SSI development is considered as an agricultural intensification using improved seed varieties and other productivity enhancing inputs as strategies towards achieving livelihood objectives. On the other hand, SSI development is affected by different interrelated factors such as access to market and transportation services, which largely determines the farmers' economic gain from SSI (Amede, 2015). The type of available irrigation technology also determines the development of SSI because some technologies are friendly for smallholder farmers while others might not be conducive for the farming community in a specific area. Farmers' level of access to the five livelihood capitals (human, social, physical, natural and financial) has effect on the sustainability of development interventions in a given area, in this context SSI development (DFID, 2000). Government policies on agriculture, SSI and sustainable development also have detrimental effect on the enhancement irrigation based livelihoods (Ministry of Water Resources (MoWR), 2002).

This study analyzed the livelihood contribution of SSI from different dimensions. It also made investigation on the unintended damaging effects of SSI with respect to socio-economic and environmental resources aspects. Furthermore, the sustainability of irrigation based livelihood is the key concept in order to validate the significance of SSI for sustainable development in the study sites.

> *A livelihood is sustainable which can cope with and recover from stress and shocks, maintain or enhance its capabilities and assets, and provide sustainable livelihood opportunities for the next generation; and which contributes net benefits to other livelihoods at the local and global levels and in the short and long term* (Chambers & Conway, 1992).

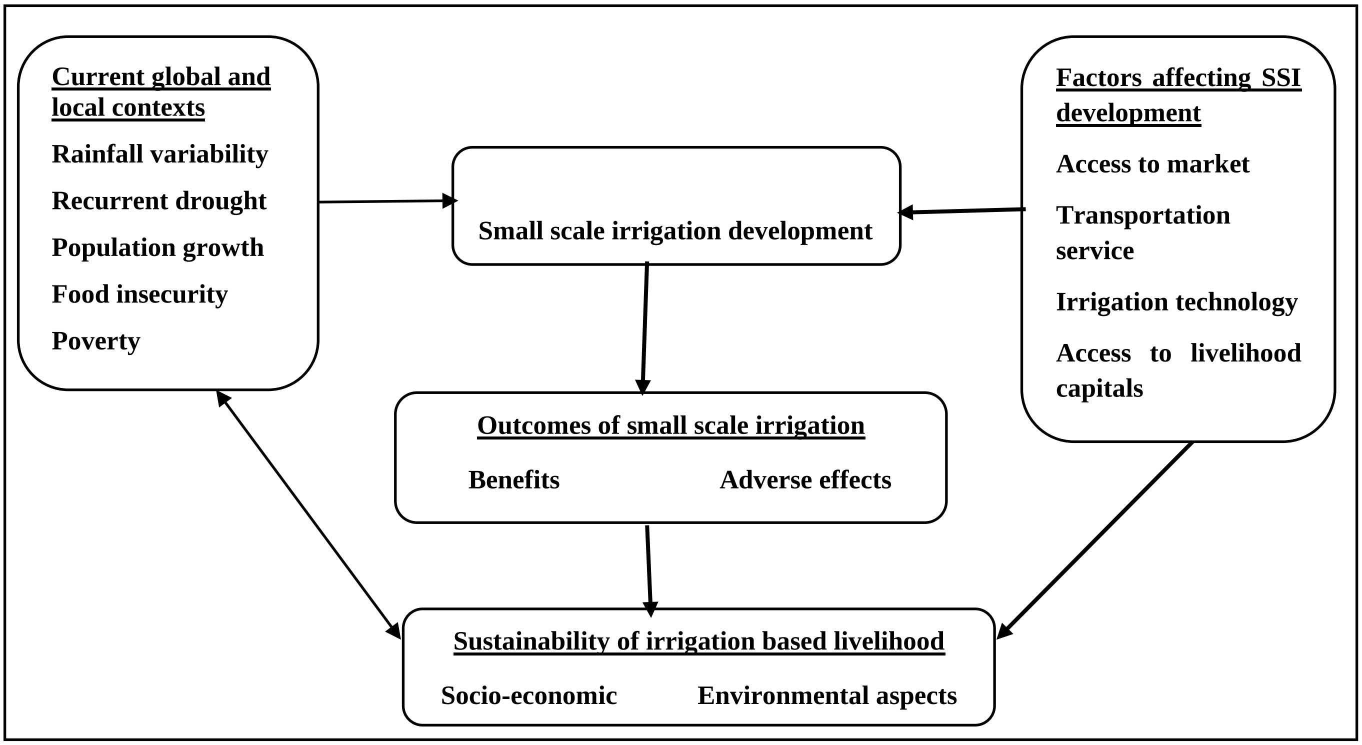


Figure 1. Analytical framework of the study (source: Authors own construction)

The sustainability issue of livelihoods fall into two groups such as environmental and socio-economic sustainability. Environmental sustainability focuses on the internal capacity of livelihoods to withstand outside pressures. Most conventional thinking equates sustainability with preservation or enhancement of the productive resource base, particularly for future generations. Livelihood activities can be regarded as environmentally unsustainable if they have a net negative effect on the claims and access needed by others. Claims and access can be diminished in several ways, including by law, by force or by bureaucratic barriers, for example, negative effects on claims and access to resources at the local level are their erosion or loss through appropriation and exclusion by the powerful. The livelihoods of the powerful gain, but there are net losses (Chambers & Conway, 1992). Socio-economic sustainability refers to whether a human unit (individual, household or family) cannot only gain but maintain an adequate and decent livelihood in terms of equity. The livelihoods and survival of human individuals, households, groups and communities are vulnerable to stresses and shocks. Stresses are pressures which are typically continuous and cumulative, predictable and distressing, such as seasonal shortages, rising population or declining resources. Shocks are impacts which are typically sudden, unpredictable, and traumatic, such as fires, floods (Chambers, 1987).

Any definition of livelihood sustainability has to include the ability to avoid, or more usually to withstand and recover from such stress and shocks. Examples of livelihood stress which build up gradually are declining labour work available; declining real wages; declining yields on soils which is degraded through salinization, acidity or erosion; declining common property resources, and having to go further and spend longer for less, for fuel, fodder, grazing or water; declining water tables; declining rainfall; population pressures on resources leading to declining farm size and declining returns to labour; ecological change leading to lower bio-economic productivity; indebtedness; physical disabilities like river blindness, the effects of which build up gradually affecting the whole household (Evans, 1989); and the domestic cycle with its periods of high rates of dependents to active adults. Seasonally occurring stresses are more significant in affecting the sustainability of livelihoods as they have physical, biological, and socio-economic dimensions which often interlock at bad times of the year (Chambers, 1987). Examples of shocks affecting the whole communities include wars, persecutions and civil violence, droughts, storms, floods, fires, famine, landslips, epidemics of crop pests or of animal or human illness, and the collapse of a market. As pointed out by the Commission for Sustainable Development (CSD) in 2002 as cited in UN (2018): "Poverty eradication, changing unsustainable patterns of production and consumption and protecting and managing the natural resource base of economic and social development are overarching objectives of, and essential requirements for, sustainable development" (UN, 2018). Sustainability of irrigation based livelihoods might be affected by multiple factors as shown in Figure 1.

## MATERIALS AND METHODS

### Description of the study Area

Central rift valley of Ethiopia (CRV) is located between, approximately $38^0$15'E to $39^0$25'E and $7^0$10'S to $8^0$ 30'S, at 150 km south of Addis Ababa covering an area of 10,000$Km^2$. The diversity of landscapes and ecosystems comprise unique biodiversity-rich wetlands. In 2007, 1.9 million people were living in the area. The population living in the rural area was 1,600,000 (Federal Democratic Republic of Ethiopia Population Census Commission, 2008). The projected population number of the people in the area estimated by 2035 ranges between 4.0 and 4.8 million. Among this population, between 3.1 and 3.7 million will be living in rural settings.

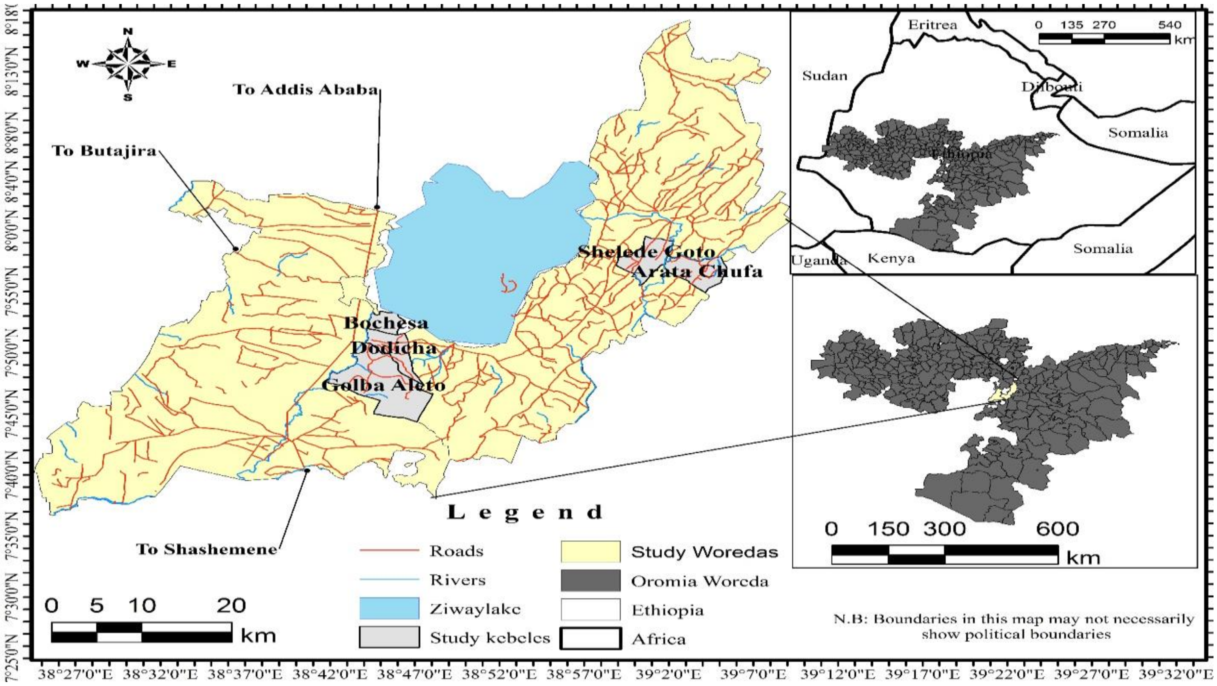


Figure 2. Map of the study area

The main rainy season ranges from June to September and the dry season is from October to March with variable and low average monthly precipitation. There is local variability of precipitation depending on altitudinal variation (Muzein, 2006). The area is characterized by relatively high temperature. February to April is the hottest months having the highest average maximum temperature nearly $30^0$C. The lowest average minimum temperature recorded in the months of October to December as shown in Figure 4.

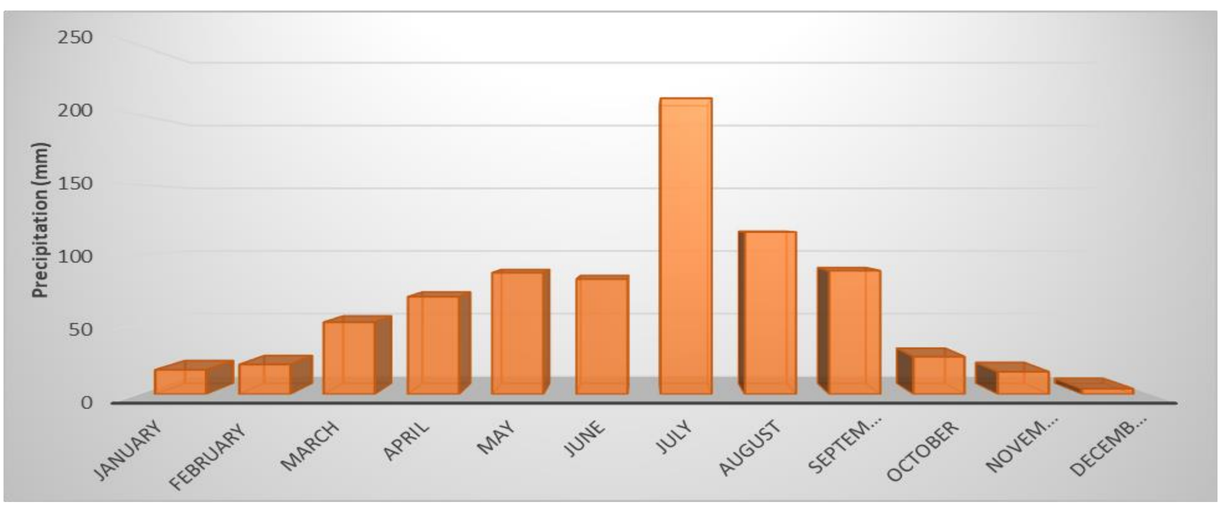


Figure 3. Monthly average of 15 years precipitation of Ziway station (Source: Ethiopian National Meteorology Agency, 2003-2017).

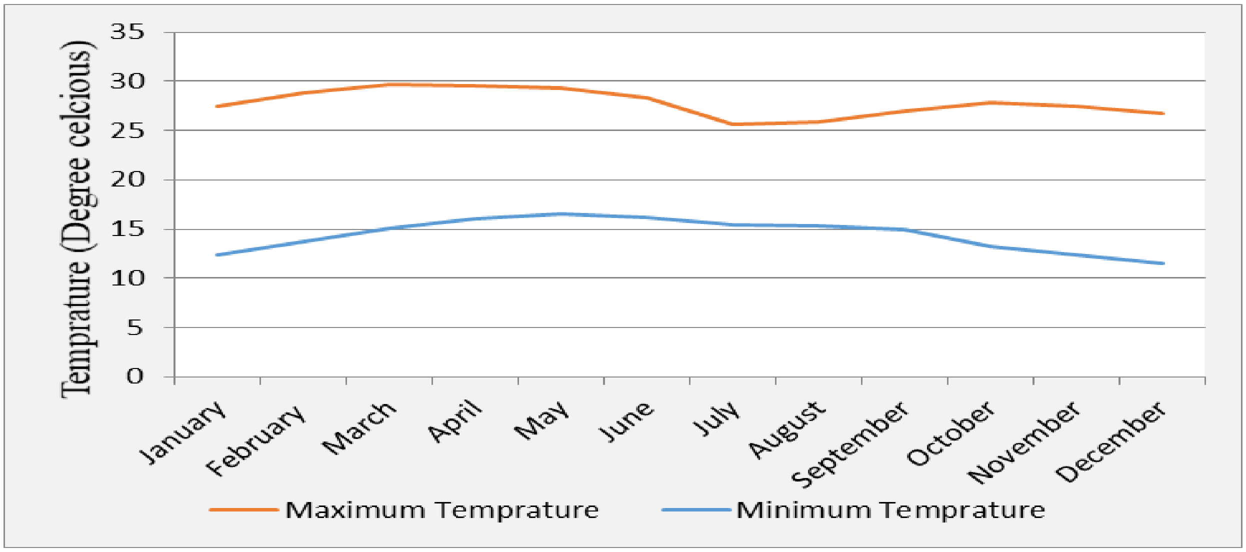


Figure 4. Monthly average of 15 years minimum and maximum temperature of Ziway station (Source: Ethiopian National Meteorology Agency, 2003-2017).

**Sample size and sampling techniques**

Purposive sampling was used to select the two study districts (*Woredas*) (Adami Tulu Jido Kombulcha (ATJK) and Zeway Dugda) among 11 districts in the zone. These districts were characterized with the occurrence of chronic drought, extreme rainfall variability, food and nutrition insecurity, safety net dependency and longtime SSI practices. In 2016/17, there were 13,6329 and 58,000 people who received relief assistance food aid in ATJK and Zeway Dugda districts respectively (ATJK and Zeway Dugda districts' Disaster Risk Management Office (DRMO), 2017). *Kebeles*[1] that have both irrigation user and non-user were identified with the support of agricultural extension workers. Then, using simple random sampling technique Bochessa, Dodicha and Gulba Aluto *Kebeles* were selected as representative *Kebeles* from ATJK. Sheld Gutu and Arata Chufa *Kebeles* were selected from Ziway Dugda. The list of non-irrigators and irrigators were collected from the district agriculture and irrigation offices respectively in order to select the sample population. The sample households (HHs) were selected using stratified systematic proportional sampling technique stratifying the HHs based on their sex, irrigation users and non-users and type of irrigation water source used by the irrigators.

The sample size determination formula proposed by Kothari (2004) was used to determine the sample size of the study, at 95% confidence level with standard variate $(z)$ value of 1.96, sample proportion (p) value of 0.5 and a 5% of level of precision($e$) are assumed.

$$n = \frac{z^2.p.q.N}{e^2(N-1)+z^2.p.q}$$

[1] Smallest administrative unit

$n$ is sample population

$N$ is total population

$p$ is sample proportion and $q$= 1- $p$

$e$ is level of precision (acceptable sampling error)

$z^2$ is the value of the standard variant with the given confidence level.

Based on the formula, the calculated sample size was 384. 15% of this sample size was added to the sample size as a contingency to accommodate incomplete questionnaires. Hence, data was collected from 442 Household heads (HHHs). Finally, 11 incomplete questionnaires were found, which were not included in the analysis. Hence, 431 respondents with complete questionnaires were included in the final analysis. Among these 259 are irrigation users and 172 are non-irrigation users.

Purposive sampling technique was used to select participants for Focus Group Discussion (FGD) and In-depth Interviews (IDIs) based on judgmental basis until a saturation point is reached. 10 FGDs were conducted (5 FGDs with irrigation users separately and 5 FGDs with mixed groups of irrigation users and non-users). The number of FGD participant members ranges from 8 to 10 including the composition of male headed households (MHHH), female headed households (FHHH), elderly and younger farmers. In-depth interviews were conducted with 15 irrigation user farmers (young, elderly, men and women).

The FGD guide with irrigators include how irrigation affects their livelihood, the negative effects of SSI in the area, the challenges farmers have been facing and on the ways how to improve the productivity of SSI farming. In the FGDs conducted with mixed groups participants were asked to discuss whether the adoption of SSI farming brought livelihood improvement compared to the non-irrigators based on community wealth indicators. The FGDs were conducted by principal investigators using Afan Oromo[2] language translators. IDIs were used to get deeper understanding about conflict on water use right, farmers' access to market, extension services and on the benefits and costs of irrigation. IDIs were conducted in Afan Oromo and Amharic[3] language

**Data and methods of data collection**

Primary data was collected using household survey questionnaire. Semi-structured questionnaire was prepared based on review of literature and preliminary field visit and discussion with experts. Data on HHs' wealth status was collected from

[2] The dominant language spoken in the study site

[3] Ethiopian official working language

irrigators and non-irrigators using community based wealth indicators, which were determined based on literature (Duguma, 2015). The questionnaire has questions only for irrigation users regarding the views of irrigators on the effects of SSI agriculture and the hindering factors of SSI development. The HH survey was conducted during May to June, 2017. The data was collected in Afan Oromo and Amharic language based on household heads' language skills.

### Methods of data analysis

The survey data were analyzed using descriptive statistics. The qualitative data were organized and reduced into themes, interpreted and presented concurrently with the quantitative data. The data was analyzed using with and without irrigation and before and after irrigation techniques to investigate the livelihood effects of SSI agriculture, the constraints in the development SSI and sustainability of irrigation based livelihoods.

## RESULTS AND DISCUSSION

### Features of selected irrigation schemes

Farmers reported that using pressurized irrigation system provides better source of water than gravity. Based on FGDs held with farmers at Arata Chufa and Shelad the use of pond for night time water storage reduce the problem of scarcity of irrigation water to some extent. SSIS that are found in ATJK district have better access to market and irrigation water compared to Zeway Dugda based on the discussion held with farmers.

Table 1: Summary of selected SSIS

| **District** | **Name of SSIS** | **Number of beneficiary HHs** | | **Irrigated area (ha)** | **Year of establish ment** | **Source of water** | **Type of irrigation** |
|---|---|---|---|---|---|---|---|
| | | MHHHs | FHHHs | | | | |
| Zeway Dugda | Arata Chufa | 279 | 45 | 100 | 1995 | Chufa River, Pond | Gravity |
| | Sheld | 223 | 54 | 75 | 1977 | Katar River, Pond | Gravity |
| ATJK | Dodicha | 235 | 45 | 147 | 1997 | Bulbula River | Pressurized |
| | Bochessa | 209 | 113 | 116 | 2005 | Bulbula River and Groundwater | Pressurized |
| | Gulba Aluto | 185 | 93 | 102 | 2007 | Bulbula River | Pressurized |

Source: Zeway Dugda and ATJK districts Irrigation Office, 2017.

**Effects of small scale agriculture on livelihood: Irrigators' view**

The views of irrigation user farmers on the effects of SSI on livelihood was analyzed and presented in Figure 5. The survey result showed that some farmers viewed only positive effects, some only negative effects and others both types of effects. Relatively larger number of respondents in Zeway Dugda viewed negative effects of SSI agriculture compared to ATJK. This is due to farmers' limited access to market and water scarcity problems in Zeway Dugda district. Irrigation users in FGDs at Arata Chufa confirmed the frequent problem of crop failure due to water scarcity during dry season in particular. On the other hand, in the good cropping seasons when farmers get better production they gain low income from selling their irrigated products because they sell their produce with low price in the farm gates. Smith (2004) and Brabben, Angood, Skutsch, & Smith (2004) argued that negative effects of irrigation outweighs its positive livelihood effects due to its disproportionate role in increasing the wealth of the already wealthy group. Irrigation has both benefits and negative effects with respect to societal equity, environment and health (Namara et al., 2010). Van Den Berg and Ruben (2006) argued that irrigation played positive role in the development of Ethiopia.

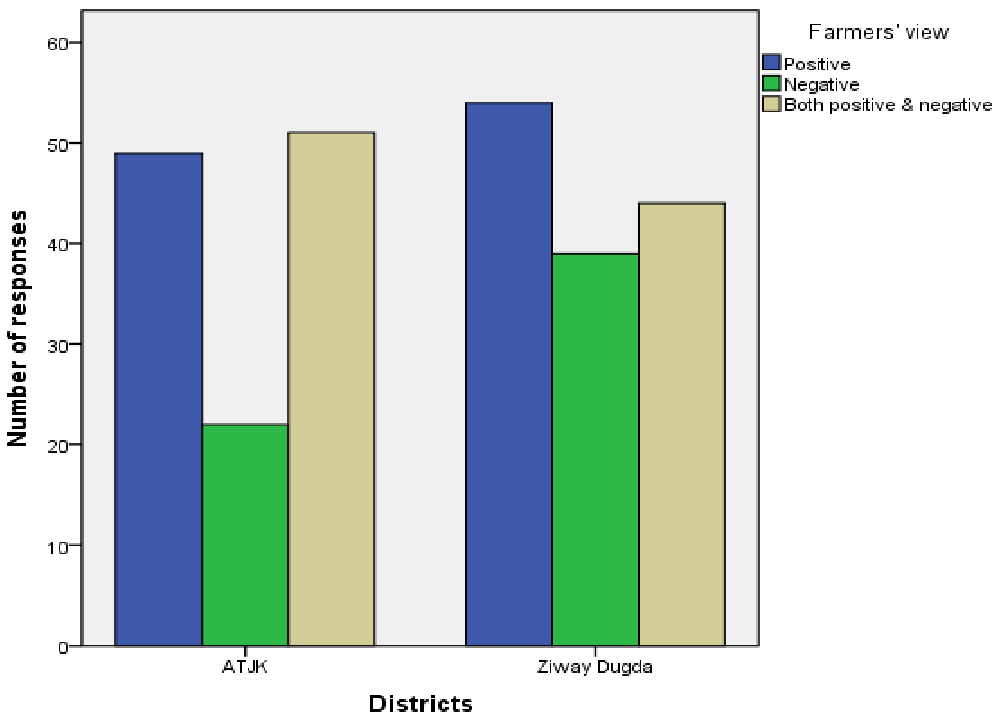


Figure 5. Irrigators' view on the effects of SSI on livelihood

**Livelihood contribution of SSI agriculture**

The major positive outcomes of SSI were presented and discussed in this section (Table 2).

Asset creation and household economy

In the view of the majority of the farmers (75%), SSI helped farmers to build their HH assets. Compared to Zeway Dugda district relatively larger percentage of respondents in ATJK district noticed that households were able to purchase different household goods(television, sofa, motor cycle and the like) since they have begun SSI (Table 2). Furthermore, 62.2% of the respondents indicated that SSI contributes towards increasing household income. "Those farmers who have no livestock bought cattle and goats. There are farmers who bought motorcycle from income generated by irrigation" (FGD, Irrigation users, Bochessa *Kebele)*. The interviewed farmers in the IDIs also confirmed the economic benefit of SSI as noted in the following quote:

> *My income is increasing because of irrigation and hence I have changed my house from grass roofed into corrugated iron sheet, bought new oxen and household furniture. The income obtained from irrigation helped me to cope up in times of shocks (*IDI, 46 years old, MHHH, Gulba Aluto *Kebele*).

Table 2: Contribution of SSI agriculture towards improving rural livelihood: Irrigators' view

| Livelihood contribution of SSI | ATJK | | Zeway Dugda | | Total | |
|---|---|---|---|---|---|---|
| | Freq. | % | Freq. | % | Freq. | % |
| Better food availability during dry spells for HH consumption | 89 | 73 | 72 | 59 | 161 | 62.2 |
| Improvement in agricultural production | 101 | 82.8 | 114 | 83.2 | 215 | 83 |
| Increase HH income | 86 | 70.5 | 75 | 54.8 | 161 | 62.2 |
| Contribute to livelihood diversification | 45 | 36.9 | 56 | 45.9 | 101 | 39 |
| Resist/coping drought situation | 99 | 81.2 | 108 | 78.8 | 207 | 79.9 |
| Purchase livestock (Oxen, cows, goats and others) | 50 | 41 | 59 | 43.1 | 109 | 42.1 |
| Purchase household assets (Sofa, Television, motor cycle) | 105 | 86.1 | 89 | 65 | 194 | 75 |
| Build houses in urban areas | 78 | 63.9 | 58 | 42.3 | 136 | 52.5 |
| Construct houses with corrugated iron sheet roofs | 111 | 91 | 116 | 84.7 | 227 | 87.6 |
| Use credit and pay back credit | 35 | 28.7 | 24 | 17.5 | 59 | 22.8 |
| Enable saving money at saving institutions | 74 | 60.7 | 31 | 22.6 | 105 | 40.5 |
| Cover educational costs of children properly | 89 | 73 | 62 | 45.3 | 151 | 58.3 |
| Create employment opportunity | 108 | 88.5 | 95 | 69.3 | 203 | 78.4 |
| Increase agricultural labour wage | 95 | 77.9 | 80 | 58.4 | 175 | 67.6 |

Source: Survey data, 2017

Tandem with the views' of the research participants, a number of authors had long age noted that irrigation helps farmers to generate regular income (Tadesse, Berhane, & Bheemalingeswara, 2008). Moyo, Van Rooyen, Moyo, Chivenge, & Bjornlund (2017) reported that SSI negatively affects farm income. The level of access to natural capital is one of the key factor determine welfare gains from irrigation (Tekana and Oladede, 2011).

As can be seen from Table 2, in the view of relatively small proportion of respondents (22.8% and 40.5%) irrigation user farmers have been practicing credit service and saving money respectively. In the FGDs farmers mentioned the inaccessibility of banks and micro-finances for the limited practice of saving. Farmers noted that they have less practice to use credit because they fear on how to pay back their credit as they have no guarantee of getting good production from irrigation farming due to the irregular nature of agricultural income. Thus, farmers' demand for financial services are unmet and consequently affects their potential to invest in SSI. The demand for financial services were unmet among farmers in Africa (Alliance for a Green Revolution in Africa (AGRA), 2017). Lefore, Giordano, Ringler, & Barron (2019) reported that rural financial institutions are unreachable for the rural people as they concentrate in regional and district towns. Saving has critical role for financial sustainability as agricultural income has irregularity (AGRA, 2017). This implies that agricultural development plans and policies has to give strong emphasis in building irrigators' financial capacity in a sustainable way.

Improvement in agricultural production

The study indicated that in the view of the majority of the farmers (83%) SSI played a role in enhancing agricultural production. The FGD participants indicated that rain-fed farming doesn't even support them to produce adequate amount of production for their HHs food consumption due to rainfall variability. In the view of irrigators, SSI allows to produce better amount of production per plot of farm land compared to rain-fed farming. SSI also helped farmers to produce high value market oriented agricultural products. In our field visit, we have observed the practice of intercropping in irrigated plots at Shelad (Figure 6) and Arata Chufa; farmers intercrop Banana, Cabbage, Papaya, Coffee, seedling development and the like. Intercropping is advantageous as it ensures optimum use of the soil, serves as insurance against crop damage in areas which were vulnerable to extreme weather fluctuation and brings greater financial return.

Figure 6. Irrigated farm land at Shelad SSIS with intercropping practice (Source: own picture 2017).

The knowledge in the works of analogous literature also backs up similar views that irrigation increases agricultural production efficiencies (Jara-Rojas, Bravo-Ureta, & Díaz, 2012). Irrigation support farmers to cultivate highly valued crops (Tadesse et al., 2008). Moyo et al. (2017) indicated different finding, SSI results in low yields due to poor soil fertility, limited agricultural knowledge and other factors. Although SSI has big role towards improving agricultural productivity in the study sites, appropriate soil and water conservation practices should be implemented to optimize its benefit.

Livelihood diversification

In this study, in the view of relatively large proportion of respondents in Zeway Dugda (45.9%) compared to ATJK (36.9%), SSI has played the role on livelihood diversification (Table 2). Based on discussions made with FGDs participants, farmers explained two different types of scenarios in this aspect. In one aspect, SSI creates financial potential, for example, farmers either purchase or construct houses in urban areas. In such a way, farmers get additional income by renting houses in the urban areas, open shops or get income from available employment opportunities in the urban areas. On the other hand, SSI also creates the opportunity for farmers in the rural areas itself to diversify their livelihood system to trading activities like animal fattening to sell the livestock in time of financial need, planting and selling seedlings of onion, cabbage and like for other irrigators. The interviewed farmers emphasized that farmers can practice livelihood diversification system if they are able to get better income from SSI during good market prices for some consecutive cropping seasons. Otherwise the life of the irrigators remain to be hand-to-mouth. In the second scenario, the study participants discussed that irrigation user farmers forced to diversify their livelihood systems like livestock fattening, trading activities, working as employees in different organizations in nearby urban areas and the like when they lack the hope to get sustainable benefit from irrigation farming due to water scarcity, limited market access and financial inability to invest in SSI. In such circumstances, some farmers choose to work in trading activities while other farmers lease out their irrigable farmland and work being hired commonly as guard in nearby offices in their locality or work as daily labourer. Moreover, some farmers who have good access to Lake Zeway engaged in fishery in ATJK; some farmers practice fish farming in artificial pond near to their irrigated plot while they are working on irrigation at the same time in Zeway Dugda as shown in Figure 7. Ellis (2000) noted that policies should facilitate the adoption of multiple livelihood strategies because diversified livelihoods are less vulnerable than undiversified (Ellis, 2000). Therefore, farmers have to be encouraged by providing appropriate trainings on viable alternative livelihood strategies in addition to SSI to cope up with the effect of climate variability on agriculture and to ensure sustainable development in the face of climate change.

Figure 7. Artificial pond for fish farming near to a farmer's irrigated farm land (Source: Own picture, 2017)

Food availability for household consumption and coping with drought

In this study, based on the view of 80% of the respondents SSI enables farmers to create a capacity to cope up with the risks of recurrent drought. Furthermore, in the view of 62.2% of the farmers SSI plays a role in helping farmers to produce food for their HH consumption including diversities of cereals, vegetables and fruits (Table 2). For example, cabbage was mentioned by farmers as food for themselves and feed for their livestock during dry spells due to its short growing season. "It is the irrigation farming that helps to sustain our life with the help of God in the severe drought situation last year[4]" (Irrigators FGD, Shelad SSIS). Farmers also noted that SSI being a coping mechanism against climate variability while the fate of rain-fed dependent farmers is either to work as a daily labouer or destocking their livestock. The FGD participants pointed out that irrigators used to sell their irrigated vegetables and buy stable food items like maize and *Teff* when there is crop failure in rain-fed agriculture. Irrigation is useful for risk reduction, food security and poverty reduction (Jara-Rojas et al., 2012). In Ethiopia, irrigation reduces the number of people dependent on food-for-work programs (Van Den Berg and Ruben, 2006). Smallholder irrigation improves HHs feeding habit and food security (Domenech, 2013; Tadesse et al., 2008). Yet, Moyo et al., (2017) reported that SSI resulted in food insecurity in Zimbabwe. In Bangladesh SSI farming increased food production, however, HHs lack balanced diet due to rice mono-cropping (Brabben et al., 2004)).

Employment opportunities and wage improvement

The study revealed that in the view 78.4% and 76.6% of the participants SSI farming has contributed in creating new employment opportunities and increasing agricultural labour wage respectively (Table 2). In the FGDs farmers pointed out that the non-irrigators, women, poor farmers and the landless are the beneficiaries from the employment opportunities. The daily wage rate has increased as the demand for agricultural labour increases. SSI also increased the migration of people into the area from other parts of the country such as Amhara, Tigray and the like either to invest in irrigation or in search of job. The IDI conducted with a 38 years old male farmer at Shelad *Kebele* confirmed the labour migration into the irrigated fields.

> *I came to Shelad area some 15 years back from Wollo[5] to work as a daily labourer as I heard about the available employment opportunities in irrigation farming from my friends. I was working as a daily labourer for about 7 years in irrigation farming. Once I saved money to invest in irrigation agriculture, I began to work on it by renting irrigable land from other farmers. I find irrigation agriculture being profitable for me.*

However, SSI has certain undesired outcomes from the attraction of employment in the locality such as population pressure, expansion of settlements and pressure on the natural resources. Hence, managing this undesired outcomes is valuable in order to enhance the sustainability of irrigation based livelihoods. Irrigated areas are more labour intensive than rain-fed areas, which increases labour demand having positive effect on the wage of agricultural labourers (Brabben et al., 2004; Domenech, 2013). This implies the spillover and indirect benefits of SSI.

Improvement in children's education

In the view of irrigators SSI helped farmers to cover their children's educational expenses (Table 2). Farmers noted that although irrigators most of the time use family labour for agricultural activities including their children, the improvement of their income from SSI helped them to use hired labour. Hence, they are able to send all their children into school even into

[4] It refers to the year 2015/2016 when there was severe drought in the area

[5] It is found in the northern part of Ethiopia, which is more than 600km from Shelad area.

urban schools. "My income and livelihood is changing since I have started working in irrigation agriculture. I am teaching my children from the income generated from irrigation agriculture" (IDI, 36 years old, FHHH, Arata Chufa). Chazovachii (2012) reported that income generated from SSI supported farmers to send their children into school. The introduction of irrigation has increased students' enrollment, girls' school attendance and women education (Brabben et al., 2004).

**SSI Agriculture and Wealth Creation: Comparing Irrigation Users and Non-users**

Based on community's wealth indicators, farmers are considered as wealthy if they have houses made of corrugated iron sheet, build houses in urban areas, educate their children in urban areas, use hired labour for farming, saving money at banks and micro finance, able to feed his/her family throughout the year and having large number of livestock. These indicators were used to compare the wealth status of irrigation user and non-users (Table 3).

Table 3: Role of irrigation on HHs' wealth creation based on community's wealth indicators

| Variable Definition | | | Irrigation user | | Irrigation non-user | | Total | | Chi-square value |
|---|---|---|---|---|---|---|---|---|---|
| | | | Freq. | % | Freq. | % | Freq. | % | |
| Housing condition | Corrugated iron sheet | | 77 | 29 | 24 | 14 | 101 | 23.4 | 72.31*** |
| | Grass roofed | | 79 | 31 | 124 | 72 | 203 | 47.1 | |
| | Both types | | 103 | 40 | 24 | 14 | 127 | 29.5 | |
| | Total | | 259 | 100 | 172 | 100 | 431 | 100 | |
| Housing location | Rural | | 138 | 53.3 | 152 | 88.4 | 290 | 67.3 | 60.24*** |
| | Urban | | 24 | 9.5 | 0 | 0 | 24 | 5.6 | |
| | Both rural & urban | | 97 | 37.5 | 20 | 11.6 | 117 | 27.2 | |
| | Total | | 259 | 100 | 172 | 100 | 431 | 100 | |
| Location of children education | Rural | | 83 | 39 | 68 | 59 | 151 | 46 | 13.85** |
| | Urban | | 49 | 23 | 12 | 10 | 61 | 18.5 | |
| | Both rural & urban | | 81 | 38 | 36 | 31 | 117 | 35.5 | |
| | Total | | 213 | 100 | 116 | 100 | 329 | 100 | |
| Hire labour | Always | | 79 | 30.5 | 12 | 7 | 91 | 21.1 | 54.57*** |
| | Sometimes | | 51 | 19.7 | 15 | 8.7 | 66 | 15.3 | |
| | Rarely | | 30 | 11.6 | 33 | 19.2 | 63 | 14.6 | |
| | Never | | 99 | 38.2 | 112 | 65.1 | 211 | 49 | |
| | Total | | 259 | 100 | 172 | 100 | 431 | 100 | |
| Food provision for HHs throughout the year | Always | | 68 | 26.3 | 11 | 6.4 | 79 | 18.3 | 60.91*** |
| | Sometimes | | 61 | 23.6 | 15 | 8.7 | 76 | 17.6 | |
| | Rarely | | 52 | 20.1 | 38 | 22.1 | 90 | 20.9 | |
| | Never | | 78 | 30.1 | 108 | 63 | 186 | 43.2 | |
| | Total | | 259 | 100 | 172 | 100 | 431 | 100 | |
| | Always | | 31 | 12 | 4 | 2.3 | 35 | 8.1 | |
| | Sometimes | | 36 | 14 | 14 | 8.1 | 50 | 11.6 | |
| Saving money | Rarely | | 73 | 28.2 | 39 | 22.7 | 112 | 26 | 24.33** |
| | Never | | 119 | 46 | 115 | 67 | 234 | 54.3 | |
| | Total | | 259 | 100 | 172 | 100 | 431 | 100 | |
| *** and ** significance at P-values 0.01 and 0.05 respectively | | | | | | | | | |

Source: Survey data, 2017

In this study irrigation user HHs found to have better wealth status than non-users in all community wealth indicators. The difference is statistically significant at $P< 0.01$ for all indicators except saving money at banks $P<0.05$. Compared to non-irrigators, irrigators were able to construct better housing condition made from cemented wall, cemented floor, corrugated iron sheet roof and own houses in urban areas. Moreover, the use of hired labour force is significantly higher for irrigation users (Table 4). Yet, this is not always true because some poor farmers even lease out their irrigable land for others and work as a daily labourer. This implies that irrigation is not pro-poor in the study sites. If there is inequality in the access to livelihood assets, irrigation may result in increasing relative poverty (Smith, 2004).

Although investing in SSI helped irrigators to provide food for their HH members throughout the year in some chronic drought years, both irrigators and non-irrigators were under food aid support, for example, during the 2015/16 severe and prolonged drought in the area. Irrigation users were asked why they were under food aid like the non-irrigators during that drought year. Small irrigable land holding, water scarcity (rivers dried during drought season) and poor market linkage were mentioned by irrigation users as factors that hinder their potential to provide adequate food for their HH members. For example, the poor market linkage hindered irrigators not to sell their irrigated vegetables with good price and to purchase stable food items. In addition, SSI helps irrigators to have more livestock. The farmers participated in the FGDs noted that livestock have better resistant to immediate climate variability than crop production. SSI found to be beneficial towards improving the livelihood of the farming community, however, it is not pro-poor and is not a lasting solution during extended drought situation. Therefore, policies and strategies have to be designed in the provision of agricultural inputs in affordable prices for farmers, rural financial institutions have to be reachable for the farming community, drought tolerant crops have to be introduced and much work has to be done by development agents in helping farmers to diversify their livelihood strategies.

**Negative effects of small scale irrigation**

Prevalence of plant disease, pests and new weeds

The study revealed that in the view of 95.4% and 86.5% of the respondents there are the prevalence of plant disease and pests and growth of new weeds respectively due to SSI (Table 4). For example Tomato, Cabbage, Potato, and Onion are commonly infected with diseases. The FGD participants also stressed that some of the vegetable diseases are resistant to pesticides. “The disease of tomato is very dangerous. We bought a pesticide with 3000[6] Birr, but it doesn’t kill the worms. In the past we didn’t know any vegetable disease and we have been getting a good harvest” (Irrigators FGD, Arata Chufa). The interviewed farmers in Bochessa reported the growth of two previously unknown weeds in the irrigated land. The farmers reflected that the high financial demand of SSI farming for controllng pests and weeds discourages them to continue investing in irrigation. This implies that appropriate pest and weed management are among the priotirized aspects to sustain the benefit of SSI. Thus, integrated pest management should be taken as an intervention to resolve the problem. Ayele, Nicholson, Collick, Tilahun, & Steenhuis (2013) and Asayehegn (2012) have similar findings.

[6] Expensive price for a farmer in the Ethiopian context.

Table 4: Negative effects of SSI based on irrigation users' view

| Negative effects of SSI | ATJK | | Zeway Dugda | | Total | |
|---|---|---|---|---|---|---|
| | Fre. | % | Fre. | % | Fre. | % |
| Growth of new weeds | 109 | 89.3 | 115 | 83.9 | 224 | 86.5 |
| Prevalence of crop disease and pests | 118 | 96.7 | 129 | 94.2 | 247 | 95.4 |
| Prevalence of animal disease | 32 | 26.2 | 41 | 30 | 73 | 28.2 |
| Prevalence of human disease and harms to human | 14 | 11.5 | 21 | 17.2 | 51 | 19.7 |
| Land fertility declines | 97 | 79.5 | 79 | 57.7 | 230 | 88.8 |
| Degradation of water resources | 104 | 85.3 | 113 | 82.5 | 217 | 83.8 |
| Water logging due to seepage | 23 | 18.9 | 84 | 61.3 | 107 | 41.3 |
| Increased soil salinity | 46 | 37.7 | 54 | 39.4 | 100 | 38.6 |
| Introduction of exotic species of plant | 34 | 28 | 45 | 33 | 79 | 30.5 |
| Drive out indigenous species of plant | 82 | 32 | 63 | 46 | 145 | 56 |
| Reduction of the local biodiversity | 30 | 24.6 | 38 | 27.7 | 68 | 26.3 |

Sources: Survey data, 2017

Degradation of land and water resources

Compared to the land productivity before expansion of SSI in the area, its productivity has been declining due to expansion of intensive irrigation farming based on the view 88.8% of the respondents as shown in Table 4. The coming of urbanites to invest in irrigation agriculture renting land from poor farmers was mentioned as factor for deterioration of farmland by farmers in the FGDs. Farmers noted that the application of high amount of fertilizer and pesticide by urbanites are factors that aggravate the deterioration of farm land, for example in Bochessa and Gulba Aluto *Kebele*s there are many urbanities who rent irrigable land and invest in irrigation agriculture. In addition, salinity development on farm land was among the serious problems that constrain the growth of vegetables as shown in Figure 8. Farmers reported that many farm plots become no more productive due to the effect of salinity particularly in Bochessa groundwater irrigated plots. On the other hand, water logging is a serious problem that make some hectare of land out of production in Shelad SSIS. Consequently, some farmers have the intention to stop working on SSI and change their livelihood into livestock husbandry and other non-farm activities. Etissa, Dechassa, Alamirew, Alemayehu, & Desalegne (2014), supports our result. The poor performance of irrigation institutions restrict the resource-poor farmers' access to natural resources and it might lead to serious environmental degradation (Lafore et al., 2019).

The study also revealed that in the view of 83.8% of the respondents SSI causes the reduction of both volume and quality of water resources (Table 4). "It is because of the expansion of irrigation agriculture that the river now becomes empty of water

(IDI, 37 years old, MHHH, Arata Chufa).” Fertilizer and pesticide use causes the deterioration of Lake Ziway[7] (Teklu, Hailu, Wiegant, Scholten, & Van den Brink, 2018).

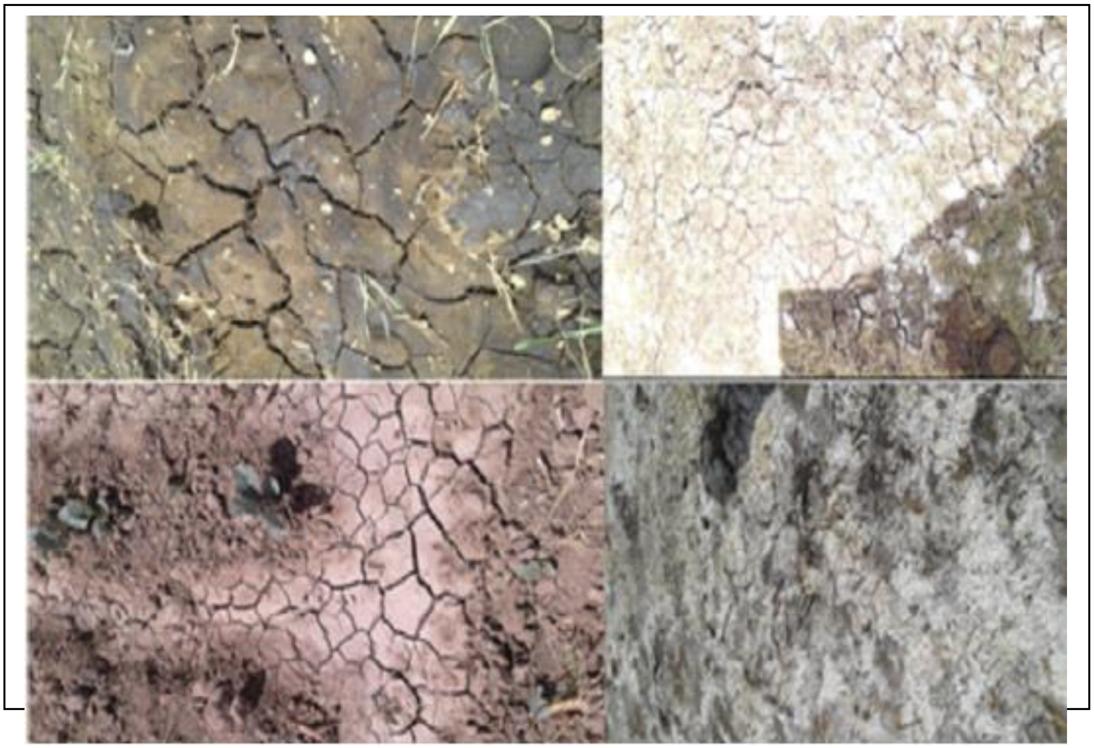

Figure 8. Farm lands affected with salinity due to irrigation at Bochessa (left) and Shelad (right)
(Source: own picture 2017)

According to Getnet, Hengsdijk, & van Ittersum (2014), increased evapotranspiration consumed 207 $Mm^3\ yr^{-1}$ more water (1990-2007) of lakes and land surfaces in CRV. These authors also reported the trend of increasing irrigation water abstraction from ±20 to 285 $Mm^3\ yr^{-1}$. The dominant field water application system is furrow irrigation (Figure 9), which is less efficient compared to sprinkler and drip irrigation. The irrigation water applied in farm fields didn’t much to crop water needs and poor irrigation water management results in misuse of water (Derib, Descheemaeker, Haileslassie, & Amede, 2011; Etissa et al., 2014). On the other hand, efficient agricultural water management at the farm level is a key for future sustainability of agricultural water both globally and locally (Jara-Rojas et al., 2012).

Based on our field visit and discussion with farmers, loss of irrigation water due to leakage of earthen canal, ponds filled with sediments, broken Polyvinyl chloride (PVC), growth of plants along earthen canals and canals filled with soil and other materials are common problems in the areas as shown in Figure 10. The types of irrigation scheme, crop choice and the irrigation methods have significant effect on water use efficiency (Speelman, D’Haese, Buysse, & D’Haese, 2008). According to Sakaki and Koga (2013), sustainability of irrigation schemes can be achieved with the fulfillment of water utilization system, operation and maintenance system and succession system.

[7] Main water source for irrigators at ATJK, the rivers originate from this lake

Figure 9. Furrow irrigation field water application system (Source: own picture 2017)

Figure 10. Irrigation water conveyance systems damaged canals (left) broken PVC (middle) and pond filled with sediments (right) (Source: own picture 2017)

Accordingly to Derib, Descheemaeker, Haileslassie, & Amede (2011), the use of costly pumped irrigation to use deficient irrigation and Comas, Connor, Isselmou, Mateos, & Gómez-Macpherson (2012) suggested the use of crops that need less water and empowering farmers to maintain canals and use proper irrigation schedules. This implies that adoption of water saving irrigation technologies is a pressing issue to sustain irrigation based livelihoods. Thus, to ensure sustainable irrigated agriculture efforts are important towards optimizing the productive potential of the sustainable management of two important natural resources-land and water. Non-sustainable irrigation systems are the constraints that compromise the benefits of smallholder farmers from SSI. According to some previous researchers (Amede, 2015), many schemes do not operate at full capacity due to design failures, excessive siltation, poor agronomic and water management practices, and weak local institutions.

### Livestock and human diseases

Small scale irrigation expansion results in the prevalence of livestock and human diseases based on the view 28.2% and 19.7% respondents respectively (Table 4). The respondents reported that sometimes livestock get sick while they eat weeds from irrigated fields and drink irrigation water. FGD participants in Arata Chufa reported the death of three people entering into the irrigation water pond as it has no fence. Moreover, fever, typhoid, typhus, common cold and aching were some of the perceived human health problems due to expansion of SSIS. The respondents noted that giardia is the frequently occurring human health problem because people simply drink the irrigation water. The use of unregulated pesticide use and unsafe handling practices are aggravating human poisoning by pesticides in developing countries (Domenech, 2013). Asayehegn (2012) indicated that 25% of adult and child diseases are caused from malaria due to swampy areas around irrigation dams. The author also pointed out the prevalence of fungal, bacterial and viral diseases due to expansion of SSI.

The concentration of some physicochemical parameters in Lake Ziway are above the maximum permissible limit of the standard for drinking water in Ethiopia (Teklu et al., 2018).This has big implication on the adverse effects on human health particularly on the rural people, who are still drinking the Lake water. Yet, the residents of Ziway town are not using the Lake water for drinking purpose currently. According to Domenech (2013), irrigation might affect human health both positively (improved nutrition and hygiene) and negatively (production of contaminated crops due to pesticides and increasing water-borne diseases). Farm HHs with poor health might not use productivity enhancing and resource conserving technologies that have effect on sustainability of agriculture (Ersado, 2005). Health impacts with expansion of irrigation schemes in CRV might be the future big challenge, however, it needs further clinical research. Generally, precautions measures are important to avoid health problems while planning irrigation schemes. Moreover, irrigation water quality monitoring has to be done.

### Modification of the local biodiversity

The benefits from irrigation are offset by environmental costs on wetlands and aquatic animals (Lemly et al., 2000). The survey data revealed that in the view of 56% of the respondents the expansion of SSI farming results in driving out indigenous species of plant. Based on the view of 30.5% and 26.3% the respondents SSI agriculture causes the coming of exotic species of plant and reduction of the local biodiversity respectively (Table 4). For instance, farmers in Arata Chufa noted that they were planting orange, guava and coffee in the past but now they don’t plant these plants. In Shelad site also the interviewed farmers stated that they were plating orange, lemon and mango in the past, currently these fruits don’t grow in the area. Irrigators in Shelad relate the current disappearance of many wild animals from the area with expansion of agriculture in general including SSI. Farmers in Dodicha *Kebele* relate the disappearance of bees from their area with coming and expansion of irrigation. Moreover, the reduction in the quality and quantity of fish stock at Lake Ziway was indicated by the interviewed farmers in Bochessa *Kebele* with expansion of large and SSI. Biodiversity is so complex and its modification might be affected by many observable and unobservable factors including climate change and other factors. Thus, further researches are recommended on the effect of SSI on biodiversity based on species level of analysis, investigating the historical aspects of species in the area and how it affects the livelihood of the community due to the interaction between SSI and biodiversity. Generally, unless these negative effects of SSI are addressed, it is difficult to get the benefits of SSI as it is planned. Therefore, tackling these undesired effects of SSI should be prioritized in the SSI development plans and strategies.

**Challenges of small scale irrigation**

Market Saturation

Agricultural engineers assumed that economic development is granted once farmers are provided with irrigation equipment. However, this can be practical when irrigation potential positively articulates with market demands (Van Der Zaag (2010). In this study according to the view 80.7% of the respondents sometimes the local market gets saturated with homogeneous and perishable vegetables like tomato, onion and cabbage. In such situations farmers just leave their vegetables in their farm plot for livestock feed if they consider that the market price even does not cover transportation fees. Van Der Zaag (2010) noted that highly volatile and unpredictable market situation in his words “merciless market gluts” have been disappointing innovative farmers in Africa. Limited market access for irrigated crop results in price slumps due to lack of marketing facility (Amede, 2015; Ayele et al., 2013). To overcome the problem, planting dates and diversification of commodities and market linkages should be considered. Mobile technologies are important for better dissemination of market information to get profit from irrigated production (Moyo et al., 2017).

Table 5: Challenges hindering SSI enhancement

| Challenges of SSI agriculture | ATJK | | Zeway Dugda | | Total | |
|---|---|---|---|---|---|---|
| | Fre. | % | Fre. | % | Fre. | % |
| Market saturation | 118 | 96.7 | 91 | 66.4 | 209 | 80.7 |
| Irregular financial returns | 107 | 87.7 | 116 | 84.7 | 223 | 86.1 |
| Conflicts on water use rights | 65 | 53.3 | 102 | 74.5 | 167 | 64.5 |

Sources: Survey data, 2017

Irregular financial returns from small scale irrigation

In the view of the highest percentage of the respondents (86.1%) irregular financial returns from SSI farming is the other challenge of irrigators (Table 5). The market price of the vegetables is highly fluctuating from one cropping season to the other. The respondents also noted that agricultural input prices have been increasing in the area. Irrespective of this irrigated vegetables found to be unprofitable particularly when there is no good market price. According to the view of irrigators, the benefits of irrigation can be optimized if agricultural markets are managed by farmers' cooperatives without middlemen intervention. Farmers' limited access for output markets, selling outputs in the farm gates without price information in urban centers and poor institutional setup makes irrigation unprofitable (Mwamakamba et al., 2017). Farmers have limited access to input markets and markets are uncoordinated (Moyo et al., 2017). To manage this, Amede (2015) suggested the involvement of agribusinesses and processes that could facilitate the value chain and reduce farm losses.

Water use right related conflicts

In the current study, larger proportion of irrigators perceived conflict over irrigation water use right as shown in Table 5. Conflict on irrigation water found to be a serious problem in Zeway Dugda compared to ATJK because ATJK has access to lake and groundwater. FGD participants in Arata Chufa *Kebele* reported the existence of fighting among upstream and downstream farmers almost on daily basis due to competition for irrigation water; some farmers even fight among each other with Konchera[8]. Water scarcity and inappropriate utilization is a major challenge of irrigators in Tigray, Ethiopia (Tadesse et al., 2008). IDIs also confirm the survey data.

> *I have been waiting for watering my onion as per the schedule. One farmer in the upper of my plot divert my water. I warn him not to divert it. He ignores my warning and used to water his plot. Then, I fought with him seriously* (IDI, 32 years old, MHHH, Arata Chufa).

The study also revealed that malfunctioning water distribution systems resulted in inequitable water use and conflicts. The interviewed farmers confirmed the situation; "let's talk in the name of God, there is no equality between women and men in participating at SSI and the *Kebele* didn't follow up our irrigation schemes properly" (IDI, 45 years old, FHHH, Arata Chufa). Moreover, the interview with a 63 years old MHHH irrigator in Shelad SSIS can be also a good account.

> *Old men like me cannot water their field competing with young people. The young can compete and water their farm land. We old men simply abandon and go without watering our land in fear of the harsh conflict over irrigation water.*

Unfair distribution of water is a big constraint for irrigators (Ulsido and Alemu, 2014). In Africa elderly, women and poor farmers are not beneficiaries from SSI (Lefore et al., 2019). When people start to irrigate, they have adverse impact on other users in the watershed. Thus, some form of coordination and rules governing water use can help to prevent conflicts and give users some assurance that their investments in irrigation will be sustainable and to attain the goal of sustainable development (Meinzen-Dick, 2014).

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[8] Amharic term refers to sharp knife type of agricultural equipment

**Sustainability of irrigation based livelihoods: Synthesis of the finding**

The sustainability of irrigation based livelihoods in ATJK and Zeway Dugda districts appearance gloomy based on the data at hand in the perspective of sustainable development. Land and water resources being the crucial natural resources in irrigation have been under stressful situation, which consequently compromised farmers' economic gain from SSI on sustainable basis. Thus, conserving land and water resources should be prioritized by introducing organic fertilizer, water saving irrigation technologies (drip and sprinkler through government subsidies) and irrigation water payment system to attain the goal of sustainable development in agricultural based livelihood systems. Inefficient irrigation water utilization and degradation of water resources has been threating the sustainability of livelihoods dependent on water based agricultural development. The Ethiopian government should ensure equitable surface water access and, in situations when it is necessary, expand sources of surface water during irrigation seasons by employing appropriate planning and basin-wide management (Awulachew 2019). The same author also indicated that to ensure sustainable development addressing the critical challenge of land degradation is the priority, therefore, watershed and environmental management must be integrated into all irrigation development projects with particular attention in low land areas that are prone to salinization and poor soil quality. According to Sakaki and Koga (2013), sustainability of irrigation schemes can be achieved with the fulfillment of water utilization system, operation and maintenance system and succession system. As indicated in Figure 11 the interrelated aspects of socio-economic and environmental interfaces, whenever one system is not well functioning, the others will be also disturbed, which consequently undermines sustainable development of the area.

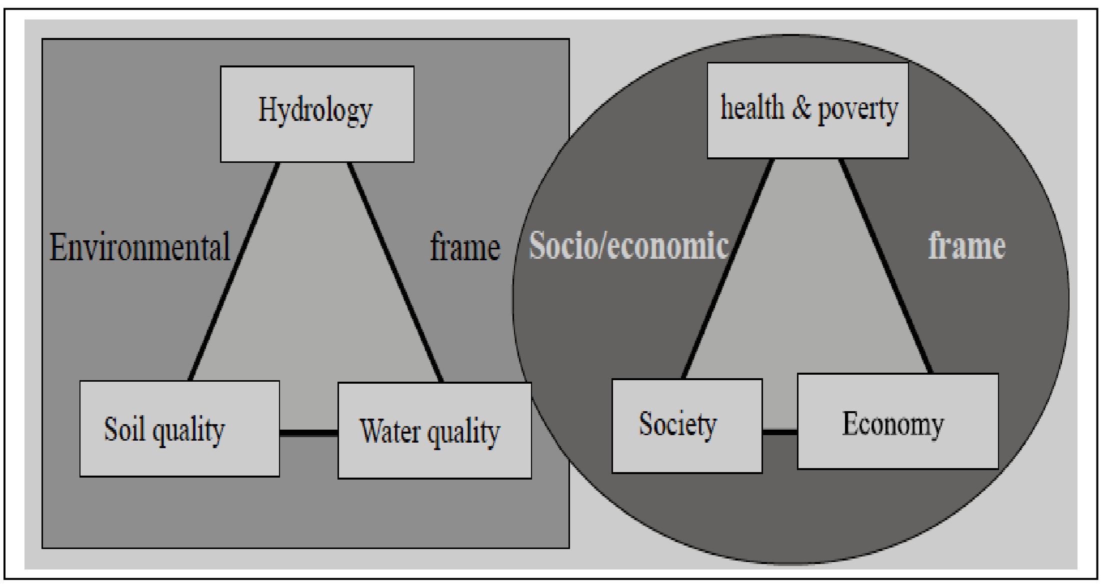


Figure 11. Environmental and socio-economic interaction (Awulachew, 2010)

The present study also revealed that farmers lack sustainable and secured financial capital that adversely affect their economic potential to invest in SSI. As a result, the sustainable development of SSI is hindered and irrigators even relied on hand-mouth type of economy especially poor farmers and sometimes depend on food aid during chronic drought season. Thus, farmers should be financially well-off to enable them to invest in SSI and to improve the performance of rain-fed agriculture at the same time through the adoption of drought tolerant crops in the study sites. Awulachew (2019) noted that the relatively high cost of irrigation farming creates a large investment risk for many smallholder farmers in Ethiopia, which hinders farmers continued investment in irrigation. SSI development should progress to low-input, effective and sustainable irrigation development (Sakaki & Koga, 2013). The poor, elderly and women found to be less benefited from the SSI. Yet, if a livelihood system is sustainable, it has to be coined with the principle of inclusive and equitable benefit for all groups of the community. Irrigation stimulates agricultural productivity and economic growth, but this may come at the cost of growing inequality (Van Den Berg & Ruben, 2006). Therefore, the Ethiopian government should work on designing projects or programs on building the financial capacity of the farmers on sustainable, equity and inclusive basis.

Furthermore, the current study indicated the problem of technical sustainability of SSIS such as broken canals, PVC and motor pumps, blockage of canals with grass and soil, and ponds being full of sediments. These technical problems are responsible for the wastage of available water for the farmers as it is wasted before it reaches into farm fields. Aberra (2004) pointed out the major causes of technical unsustainability include poor project planning, lack of appropriate engineering studies, poor designing, lack of farmers participation at all levels of project planning and implementation in his study at Tigray, Ethiopia. You (2008) concluded that it is only lower-cost irrigation technologies and approaches are viable in SSA. Programs that advocate and planned to introduce water saving irrigation systems should be holistic and have the role to address farmers' day-to-day problems (Burnham, Ma, & Zhu, 2015). The Ethiopian government should give emphasis to the introduction of appropriate irrigation technologies, which are farmer friendly such as simple, quick, cheap and safe to ensure the technical sustainability of SSIS.

On the other hand, climate variability found to be the cruel enemy that undermine the sustainability of irrigation based rural livelihoods as the change is unpredictable with its devastating effects. The adoption of strong watershed based development approach and environmental management activities can bring a solution to enhance sustainable development in the study sites. To mitigate the effect of rainfall variability in the area, crop water productivity should be enhanced by increasing yields per unit of land, by adopting good agricultural practice, enhancing soil fertility and pest control keeping into consideration the adverse environmental impacts to the minimal if possible preventing the adverse impacts. Furthermore, even for individual wells and rainwater harvesting, as more and more people start to irrigate, they impact other users in the watershed, and some form of coordination and rules governing water use can help prevent conflicts and give users some assurance that their investments in irrigation will be sustainable (Meinzen-Dick, 2014).

**Conclusion**

SSI agriculture plays a vital role for improving the economic status, human capital development, availability of food for households, improving the housing condition and a means to cope up with the adverse effects of climate variability. Thus, SSI appears fitting to drought prone areas to averse the unexpected or seasonal crop failure than those farmers who relied on rain-fed agriculture. However, the profitability of farmers' investment in SSI farming is constrained by its negative effects such as the prevalence of new pests, diseases, degradation of natural resources and other socio-ecological threats. Therefore, strong government intervention is necessary in the provision of the right type of pesticide with affordable price to enable farmers to protect crop loss. Farmers should be also assisted with better performing agricultural extension services with appropriate training packages on how to apply pesticide safely and the dose of the pesticide. The most important factor that hinder the enhancement of SSI is the volatile market price of the vegetables. The gain from irrigation can be optimized if agricultural input and output markets are managed by farmers' union without the involvement of middlemen.

Competition for water among multiple users results in water scarcity, which consequently brought conflict between upstream and downstream users. Women and elderly people have limited access to irrigation water. Moreover, water abstraction by large scale irrigation farms weakens the SSI farmers, which is related to the tragedy of the commons concept. However, equitable access to natural resources by the community is the key in the sustainable livelihood framework. Hence, applicable institutional interventions and legal laws are crucial to address the current dispute and inequitable water use among multiple users. Furthermore, the rural health extension program has to work and advocate fertility decline by making contraceptives accessible for the farming community to reduce the burden on the natural resources. The expansion of large scale irrigation farms should be also controlled to ensure the sustainability of natural resources in the area.

The sustainable development of irrigated agriculture is compromised in the study sites due to the effect of multiple factors related to natural resources, economic, technical, social and climate variability induced livelihood challenges. Addressing these multiple challenges at the grass-root level is the key to enhance sustainable development. Therefore, building sustainable irrigation based rural livelihood should be given priority in agricultural policy in Ethiopia rather than mere advocacy of SSI expansion. If the irrigation based rural livelihood ensures sustainable agricultural development, it enables the potential to address the current pressing livelihood challenges in the study sites including rainfall variability, recurrent drought, food insecurity, poverty and natural resources degradation. This implies that in a sustainable irrigation based livelihood the benefits of SSI outweighs its adverse effects in many ways. Furthermore, policy makers and implementers in the agricultural sector should focus towards building a healthy socio-economic and environmental interface in order to ensure sustainable development.

Future researches are recommended on the effects of SSI farming on human health and biodiversity change with regress analysis. In addition, future researches are recommended to investigate the balance of irrigation water supply and demand in the CRV of Ethiopia. The effects of SSI expansion on non-irrigators is one of the future research topic that needs rigorous investigation.

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