COLLEGE OF DEVELOPMENT STUDIES

CENTER FOR ENVIRONMENT AND DEVELOPMENT

NAFKOT GETINET ALEMAW

# EFFECTS OF WATER-SPREADING WEIRS ON HOUSEHOLDS' FOOD SECURITY AND THE ENVIRONMENT: THE CASE OF CHIFRA WOREDA, AFAR REGION

A THESIS SUBMITTED TO THE CENTER FOR ENVIRONMENT AND DEVELOPMENT OF COLLEGE OF DEVELOPMENT STUDIES IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF ARTS IN DEVELOPMENT STUDIES (ENVIRONMENT AND SUSTAINABLE DEVELOPMENT)

ADDIS ABABA

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ADVISOR: DR. BELAY SIMANE

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**ADDIS ABABA UNIVERSITY**

**SCHOOL OF GRADUATE STUDIES**

This is to certify that the thesis prepared by Nafkot Getinet Alemaw, entitled: *Effects of Water-Spreading Weirs on Households' Food Security and the Environment: The Case of Chifra Woreda, Afar Region*, and submitted in partial fulfillment of the requirements for the Degree of Master of Arts in Development Studies (Environment and Sustainable Development) complies with the regulations of the University and meets the accepted standards with respect to originality and quality.

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Examiner: ___________________ Signature: _______________ Date: _______________

Examiner: ___________________ Signature: _______________ Date: _______________

Advisor: ___________________ Signature: _______________ Date: _______________

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**ABSTRACT**

Effects of Water-Spreading Weirs on Households' Food Security and the Environment: The Case of Chifra Woreda, Afar Region

Nafkot Getinet Alemaw

Addis Ababa University, 2019

*Water stress is the most dominant challenge in drylands which lowers crop production and yield, and increases their susceptibility to land degradation and climate change. Due to this, effective techniques of water harvesting, and water development and conservation techniques are much needed. This study assessed the effects of water-spreading weirs, a water harvesting technique introduced in Chifra Woreda in 2015. Household survey and focus group discussions were used to collect data from 188 beneficiary and non-beneficiary households. The weirs increased water availability, and maize yield 3 times higher than sampled non-beneficiaries, almost double than that of the regional average, 1.5 times than the national average. Weirs also increased livestock ownership and reduced number of livestock deaths among beneficiaries as a result of increased water and feed availability. Weirs also rehabilitated previously severely eroded land which had 4-5 meters deep gullies. Their contribution toward food security was assessed using a HFIAS, a food insecurity indicator. It was found that the average beneficiary had a score of 2.58, while the average non-beneficiary had a score of 15.37 making beneficiaries much less food insecure. Therefore, water-spreading weirs have significantly improved food security and contributed to environmental rehabilitation in Chifra Woreda. Scaling up the project further along the flooding plain and in other woredas affected by flashfloods is recommended. Trainings on how to best maintain the weirs should also be given to the local community to ensure their sustainability in the woreda.*

**Key words**: Drylands, water stress, water-spreading weirs, environmental rehabilitation, food security.

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**ACRONYMS**

| | |
|---|---|
| AGDP | Agricultural Gross Domestic Product |
| AI | Aridity Index |
| CSA | Central Statistics Agency |
| $^{o}$C | Degree Centigrade |
| ELD | Economics of Land Degradation |
| ESIF SLM | Ethiopian Strategic Investment Framework for Sustainable Land Management |
| FAO | Food and Agriculture Organization (of the United Nations) |
| FGD | Focus Group Discussion |
| GDC | German Development Cooperation |
| GDP | Gross Domestic Product |
| GIZ | Deutsche Gesellschaft für Internationale Zusammenarbeit |
| HCE | Household Consumption – Expenditure |
| HFIAS | Household Food Insecurity and Access Scale |
| IISD | International Institute for Sustainable Development |
| IOM | International Organization for Migration |
| ISPPBE | Intergovernmental Science-Policy Platform on Biodiversity and Ecosystems |
| KfW | Kreditanstalt für Wiederaufbau - German Development Bank |
| MoA | Ministry of Agriculture |
| PPP USD | Purchasing Power Parity in United States Dollar |
| SLM | Sustainable Land Management |
| SPR | Soil Protection and Restoration |
| Sq. km.s | Square Kilometers |
| SWC | Soil and Water Conservation |
| UN | United Nations |
| UNCCD | United Nations Convention to Combat Desertification |
| UNDP | United Nations Development Program |
| UNEMG | United Nations Environment Management Group |
| UNEP | United Nations Environment Program |

| | |
|---|---|
| UNOCHA | United Nations Office for the Coordination of Humanitarian Affairs |
| USAID | United States Agency for International Development |

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# CHAPTER 1: INTRODUCTION

## 1.1. Background

Drylands cover 41.3% of the world, and are home to 40% of the world's population (2.7 billion people), 90% of whom are located in developing countries (Davies, 2017). Particularly, in Sub-Saharan Africa, drylands cover 43% of its land area, and are home to 50% of its population (425 million people) (Saghir, 2015; Raffaello & Morris, 2016).

In Ethiopia, drylands cover 75% of the land, and are inhibited by one third of its population (Kidane, 2015). They are mostly found within Ethiopia's lowlands located in the eastern, central Rift Valley areas, southern and southeastern parts of the country encompassing a wide range of agro-ecological environments. 52% of Ethiopia's pastoralists are found in Afar region (UNDP, 2014a). From the total number of 1.4 million people that live in the region, 80% of them are transhumant pastoralists, while the rest are agro-pastoralists (UNDP, 2014b).

The traditional practice that was held for generations in the past by pastoralists and agro-pastoralists in the region was sharing resources among themselves within each clan. They also divided their land into grazing reserves and open rangelands. All these were enforced by community leaders guided by community laws. Each clan also owned a grazing reserve it used as pasture during dry spells for emergency feeding. This was mainly done to provide grazing land for their livestock throughout the year. But in recent years, these laws have been broken as a result of more frequent and long lasting dry spells which led to violent conflicts among pastoralists which led to protracted shortage of resources. These challenges have further entrenched the vulnerability of pastoral communities in Afar Region. Moreover, the disappearance of local grass species and numerous livestock deaths have also been reported as a result of dry spells, worsened water and feed shortage (Afar National Regional State, 2010).

Common to all pastoralists and agro-pastoralists is water stress that is faced almost all year round. It is a major challenge for their livelihood (Koohafkan & Stewart, 2008; UNEMG, 2011; Davies, 2017). Shortage of water has also resulted in poor crop yields, perennial food shortages, widespread poverty, conflict and livestock deaths among them (De Trincheria, 2017).

Land degradation is another prevalent condition in drylands. The scarcity of water in these areas is shown by studies as leading to land degradation and worsening climate variability. All these factors put together increase the risk of natural disasters like drought and flood (Van Aalst, 2006; UNCCD, 2013; Davies, 2017; ISPPBE, 2018). A study conducted by United Nations Environment Program (UNEP) (2015) about land degradation in 42 African countries (among which was Ethiopia) states that land degradation causes a significant impediment to economic and social development, and poses serious environmental threats. Failing to act against it will also cost these countries dearly. In addition, it will increase food insecurity, exacerbate poverty and diminish national income.

Hence, water stress in drylands causes a ripple effect that leads to land degradation, climate variability and lowered crop production and yield. This makes water stress the most dominant challenge in drylands.

Due to this, effective methods of water harvesting, and water development and conservation technologies are of interest in drylands. It has led development agents and governments to partner together in order to forge various types of flood and rainwater management systems with the intention of alleviating the problem of water shortage. Examples of such flood and rainwater management systems are called micro- and macro-catchment systems, and in-situ systems. These are methods of capturing, storing and reusing locally available flood and/or rainwater. These technologies have been used as irrigation methods to increase the production and productivity crops, livestock production and improve food security especially in Sub-Saharan Africa (GIZ, 2012; De Trincheria, 2017).

In the study area, Chirfra Woreda, agro-pastoralists are faced with the same challenges of water stress. In addition, it is subject to flashfloods that come from the bordering highlands of the Amhara Region. This resulted in erosion, land degradation and livestock deaths.

After a successful implementation in West Africa, a water harvesting technique called water-spreading weirs were built by Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) in Chifra Woreda in 2015 for the purpose of increasing water availability, production and productivity of crops, livestock production and improve food security. This study is part of an effort to assess and measure the effectiveness of the water harvesting technique.

In summary, the study is organized in such manner: the first chapter is the introduction chapter, followed by the second chapter which is literature review, third chapter which is methodology, fourth chapter which is results and discussion, and fifth chapter which is conclusions and recommendations.

### 1.2. Statement of the Problem

Water harvesting, and water development and conservation techniques used in drylands have been utilized as irrigation methods (GIZ, 2012; De Trincheria, 2017). There are various types of irrigation systems. The varying types are dependent upon crop and crop water requirements, water supply, soil characteristics, topography, size and shape of the field, and climate of the area. There are also numerous determining economic factors such as labor requirements, available capital, and resource costs. The most common ones are surface irrigation, drip irrigation, sprinkler irrigation, localized irrigation, center pivot irrigation, lateral move irrigation, sub-irrigation and manual irrigation (Evans, 2010; FAO, 2014; CDC, 2016).

Although these irrigation methods have resulted in increase the production and productivity crops, and improve food security not only in Africa but the rest of the world (GIZ, 2012; De Trincheria, 2017), they require the presence of water in the immediate vicinity of irrigated areas (FAO, 2014).

But this prerequisite cannot be fulfilled in semi-arid and arid dryland areas like Chifra Woreda, which is the study area. Chifra like all other drylands faces water shortage problems which has continued to threaten both pastoralists and agro-pastoralists as their livelihood is centered on water availability. Although Awash River is located in Afar Region, it is too far away to be considered for irrigation in Chifra Woreda. Mille River, a tributary to Awash River, is also located in the region, but is still not close enough for irrigation in Chifra.

In addition the woreda is also faced with flash floods that come from the bordering highlands in Amhara Region, which means that with the no/very low rainfall, water availability in Chifra is limited to the inundating floods that come a few times a year. This causes additional problems of severe erosion and land degradation. Studies show that erosion and land degradation causes a significant impediment to economic and social development, and poses serious environmental threats. Failing to act against it will also cost these countries dearly (UNEP, 2015).

The issue of flash floods in the region as a whole has also caused devastating challenges, In 2017, the United Nations Office for the Coordination of Humanitarian Affairs (UNOCHA) reported that Awash and Asabera rivers caused massive flooding in Afar Region causing the harm and displacement of over 4,500 people and destruction of over 500 hectares of agricultural land (UNOCHA, 2017). In reviewing the state of displaced people in Afar Region in 2019, the International Organization for Migration (IOM) stated that 50,092 individuals (9,227 households) in 58 displacement sites were displaced in the region with no access to food and affected by diseases like malaria (IOM, 2019).

About two decades ago, GIZ developed a water harvesting technique called water-spreading weirs that make irrigation based farming for agro-pastoralists in drylands that are affected by flash floods. Water-spreading Weirs are “artificial obstructions in any watercourse that result in increased water surface level upstream for some, if not all flow conditions” as shown in the figure below (Rickard, Day & Purseglove, 2003, p. 5). They are used for permanent or seasonal flows of water with a width ranging from 2 and 4 m high and 100 to 1,000 meters wide depending on the flooding area (GIZ, 2012). Unlike the other water harvesting and development techniques, water-spreading weirs do not require the availability of water sources being available in the immediate vicinity. The structures capture and spread flood water from wherever it comes and make irrigated farming possible for agro-pastoralists. These are techniques have been in use in West African drylands for close to two decades in countries like Niger, Chad and Burkina Faso.

After more than 12 years of implementation, studies in the West African countries have shown that water-spreading weirs have successfully resulted in increased water availability to agro-pastoralists and their livestock, production and productivity of crops, cultivable land size, and rehabilitated previously degraded flood plain areas (GIZ & KfW, 2011; GIZ, 2012; Bender, 2012; Schöning, van den Akker, Wegner & Ackermann, 2012; Ackermann et al, 2014).

It was after the success achieved in West Africa water-spreading weirs were also built by GIZ in Chifra Woreda in 2015. It has been three years since the introduction of water-spreading weirs in Chifra Woreda and the first in Ethiopia with 38 project beneficiaries (Tilahun, 2018).

But, the effect of the weirs has not been analyzed and assessed so far to the best of the researcher's knowledge. The extent of the effect they have had on alleviating water stress, improve food security, and rehabilitate degraded flood plain areas has also not been researched. In addition, the effect they have had on crop production and productivity in the study area in comparison to the regional and national average levels has not been investigated empirically as well. The extent of the effect they have had on preventing erosion has also not been studied. Therefore, this research will fill in this gap.

## 1.3. Objectives of the Study

The general objective of this research is to assess the effect of water-spreading weirs built in Chifra Woreda on the food security of agro-pastoral households, and the environment.

The specific objectives are:

- To analyze the effects of water-spreading weirs on crop and livestock production and gains on households' income,
- To analyze the effects on improving food security for agro-pastoral households living within the water-spreading weirs, and
- To assess the contribution made towards environmental rehabilitation (reduction of erosion and increase of water availability).

## 1.4. Significance of the Study

The success of GIZ's project in West Africa is indicative of the success that can be expected in Afar. Therefore, the result of this study is expected to be informative to governmental and non-governmental decision makers in exploring the possibility of scaling up the project to other degraded flood plain areas in Ethiopia. In addition, it is also meant to be informative to building the capacity of woreda leaders to sustain the gains achieved in the study area and collaborate further with other development partners.

### 1.5. Scope and Limitation of the Study

This research aims to study the effect of water-spreading weirs. Its limitation lays in the fact that it assess the effects of the weirs after only two years of implementation. Therefore, there is a need to further assess the full effect of the water-spreading weirs after a few more years to understand the full effect of the weirs. In addition, this study did not include the cost effectiveness and unintended effects of the weirs.

# CHAPTER 2: LITERATURE REVIEW

## 2.1. Definition of Terms

***Food Security***

FAO defines food security is being a situation whereby households "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, 1996 cited in FAO, 2006).

***Environmental Rehabilitation***

Environmental rehabilitation is an effort made to restore both the physical and biological surrounding human beings, other organisms and the biotic and abiotic factors that influence them. Influencing biotic factors include all forms of life like plants, animals, microorganisms. Influencing abiotic factors include soil, air, water, light, temperature etc (Mondal, 2019).

One of the most common environmental destructions the environment faces are gullies. Gullies are landforms that are caused by erosion of soil resulting from running water. They characteristically take the form of a valley or a large ditch (Worldatlas, 2019).

***Drylands***

The United Nations Convention to Combat Desertification (UNCCD) defines drylands as "areas where the potential amount of water that is transferred from the land to the atmosphere is at least 1.5 times greater than the mean precipitation" (UNCCD, 2000, p. 1). This is expressed through the Aridity Index (AI) whereby drylands are also defined as having an index value 0.03 to 0.65 (Food and Agriculture Organization (of the United Nations) [FAO], 2000; Davies, 2017).

AI is the ratio of precipitation and potential evapotranspiration (Zomer, Trabucco, Bossio & Verchot, 2008). It is also used to divide drylands into four zones as shown in Table 1 below.

Table 1: Dryland Zones

| **Dryland Zone** | **Aridity Index Range** | **Share of Total Dryland** | **Share of Global Area** |
|---|---|---|---|
| Hyper-arid (Desert) | 0.00 – 0.03 | 16% | 6.6% |
| Arid | 0.03 - 0.20 | 26% | 10.6% |
| Semi-arid | 0.20 - 0.50 | 37% | 15.2% |
| Dry sub-humid | 0.50 - 0.65 | 21% | 8.7% |
| **Total** | | **100%** | **41.3%** |

Source: UNEMG, 2011; Davies, 2017

Based on this classification, drylands cover 41.3% of the world, and are home to 2.7 billion people, 90% of whom are located in developing countries (Davies, 2017). They are located in all continents, but they are most widespread in Africa and Asia (UNEMG, 2011). Particularly, in Sub-Saharan Africa, drylands cover 43% of its land area (Saghir, 2015; Raffaello & Morris, 2016).

### 2.2. Characteristics of Drylands

Drylands are characterized by low/limited water supply, ever-present water scarcity, erratic precipitation, repeated drought, extreme climatic variability, strong winds, natural fires, high susceptibility to land degradation, high loss rates for natural resources (including biodiversity), high infant mortality rates, low levels of human well-being, including the lowest per capita Gross Domestic Product (GDP), high costs of delivering services such as electricity or piped water, limited investment in infrastructure (Millennium Ecosystem Assessment, 2005; Koohafkan & Stewart, 2008; International Institute for Sustainable Development [IISD], 2003; Davies, 2017).

Of all the factors that characterize drylands, water stress is the most defining characteristics (Davies et al, 2016). Moreover, their susceptibility to land degradation and climate change is also noteworthy which raises environmental concerns in these areas (Davies, 2017). In light of these, it is critical to have an adept understanding of these for the sustainable development of drylands as will be done in the following sub-sections (Li et al, 2017).

### 2.2.1. Water Stress and Livelihoods in Drylands

The two livelihood strategies in drylands are crop cultivation and livestock rearing (Koohafkan & Stewart, 2008). Pastoralists rear a number of livestock like cattle, goats, sheep, camels and donkeys. In addition to these, agro-pastoralists grow three main staple crops (Linstädter et al, 2016; Raffaello & Morris, 2016). The staples are maize, millet and sorghum, planted mostly owing to their tolerance to drought and heat. Agro-pastoralists sow these with other crops arranging them according to their different growth cycles and maturity dates. This is mainly done as a method of protection against risk (Raffaello & Morris, 2016). But through their various mechanisms of adapting to aridity, some staple crops have thrived, and have made it possible for the practice of crop cultivation even though there are fewer of such species as aridity increases (Creswell & Martin, 1998).

With water stress being the most prevailing phenomenon in drylands, it has been known to be a major challenge for the livelihood of pastoralists and agro-pastoralists (Koohafkan & Stewart, 2008; UNEMG, 2011; Davies, 2017). Shortage of water has also resulted in poor crop yields, perennial food shortages, widespread poverty, conflict and livestock deaths (De Trincheria, 2017).

As a result, water harvesting, and water development and conservation technologies have been suggested as a way of enhancing land and crop productivity and utilizing existing water resources in drylands (Seleshi et al, 2007; Vohland & Barry, 2009; Nagaraj, 2013). It has been argued that these technologies can also increase the production and yield of crops, increase livestock production and tackle food insecurity especially in Sub-Saharan Africa. Water stress can also be addressed in a cost effective manner in arid and semi-arid areas in Sub-Saharan Africa for off-season small-scale irrigation by "capturing, storing and reusing as much as locally-available" flood and rain water when and where it flows and falls (De Trincheria, 2017, p.10).

### 2.2.2. Land Degradation and Climate Change in Drylands

In addition to water stress, land degradation is another prevalent condition in drylands. It has been recognized as one of the most urgent issues of environmental concerns in these areas. Studies show that water unavailability in drylands makes them "inherently susceptible to degradation" (Davies, 2017, p. 12). It can be defined as land that is not able to support its original economic and ecological function owing to natural processes or human activity (Koohafkan & Stewart, 2008). Desertification is land degradation in drylands (UNEP, 2015).

Land degradation is also a worldwide challenge. A study in 2014 analyzed long-term trends of vegetation coverage to detect land degradation using remote sensing, and revealed that 29% of the world is a degradation focal point (Bao Le et al., 2014). Moreover, UNCCD in 2013 estimated global cost of desertification to be 1-10% of Agricultural Gross Domestic Product (AGDP) annually (UNCCD, 2013). The Millennium Ecosystem Assessment (2005, p. 13) reported with "medium certainty" (with 65–85% probability) that 10–20% of the land within dryland regions are degraded causing harm to local inhabitants and the world at large.

According to Linger et al. (2011), 67% of Africa's total land area is degraded. This area has lost 25% of its productivity in croplands, and 6.6% of its productivity in pasture lands. Additionally, 4 - 7% of it is severely degraded, and is located in Sub-Saharan Africa which is the highest regional proportion in the world.

A study conducted by UNEP (2015) about land degradation in 42 African countries (among which was Ethiopia) states that land degradation causes a significant impediment to economic and social development, and poses serious environmental threats. Failing to act against it will also cost these countries dearly.

With regards to increasing food insecurity, exacerbating poverty and diminishing national income, land degradation caused by human induced soil erosion in Africa costs an additional 280 million tons of cereal crops that could be produced every year. Soil erosion induced nutrient depletion is estimated to cost about 4.6 trillion PPP USD in the coming 15 years, which is equal to about 286 billion PPP USD (= 127 billion USD) per year, or about 12% of the average GDP of all 42 countries from 2010–2012. Failing to act against land degradation caused by poverty will also cost a hefty amount in the coming 15 years, which is about 665 billion PPP USD in present value, which is equivalent to 27.6 billion PPP USD (=11.3 billion USD) per year (ibid).

Linger et al. (2011) also states that joint effort to tackle land degradation in Africa should utilize sustainable land management (SLM) that focuses on increasing water availability, soil fertility and organic matter content, and biodiversity. This will boost the productivity of land and increase resilience against environmental perils.

### 2.2.3. Drylands and Land Degradation in Ethiopia

According to Kidane (2015), drylands cover 75% of Ethiopia's land, and are inhibited by one third of its population. They include three dryland zones: arid, semi-arid and dry sub-humid. They are mostly found within Ethiopia's lowlands located in the eastern, central Rift Valley areas, southern and southeastern parts of the country encompassing a wide range of agro-ecological environments. Their climate, temperature, rainfall and soil types differ significantly with altitude.

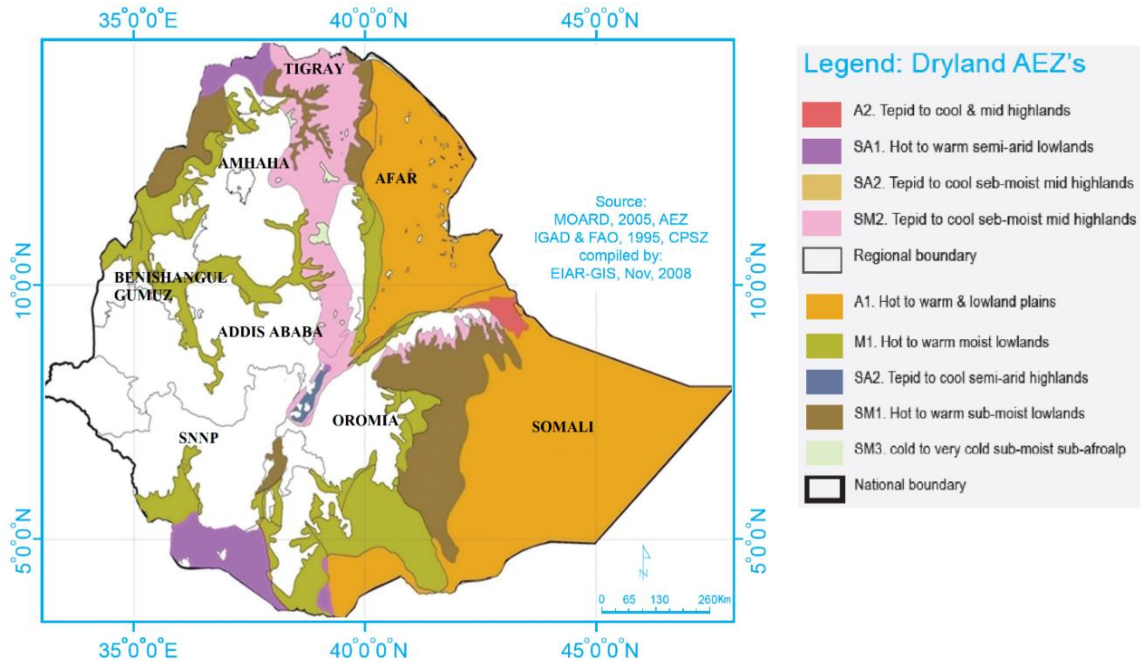
The livelihood of inhabitant of these regions is mostly pastoralism. The area covered by these pastoralists is about 625,000 $km^2$. This is 57% of the whole of Ethiopia. Of this, 52% is found in Afar region (UNDP, 2014a). From the total number of 1.4 million people that live in the region, 80% of them are transhumant pastoralists, while the rest are agro-pastoralists (UNDP, 2014b).

As shown in Figure 1, drylands are found in north, east, central, south and southeastern parts of Ethiopia and in all of its regions except in Gambella. They also encompass highlands, mid-altitude and lowland areas. Of these, the lowland drylands comprise about 61% of Ethiopia with an altitude that ranges from 124 meters below sea level to 1,500 meters above sea level. Their average annual rainfall ranges from 200 to 700 mm with an average growing period of 90 to 180 days (ibid).

As in drylands in other parts of the worlds, drylands in Ethiopia are also generally characterized by their low and erratic rainfall with variable distribution leading to water stress, sparse vegetation, land degradation, eroded soils with low organic matter content, high temperatures, strong winds, high evapotranspiration and water scarcity (Kidane, 2010).

As with water stress, land degradation is also a rampant problem in Ethiopia (Temesgen et al, 2017). If undealt with, it could cost Ethiopia a 5% decrease in crop production in the coming 30 years (Hurni et al, 2015). Land degradation is also a challenge in Ethiopia's drylands advancing at a shocking rate (Kidane, 2010; Temesgen et al, 2017). Major reasons for this are increasing human and livestock population and the subsequent increase in demand for basic resources such land, water, vegetation and other natural resources (Kidane, 2015). Additionally, there is also a drop in soil fertility in these areas due to salinity and alkalinity which continues to hamper agricultural productivity especially in Afar (Kidane, 2010).

Figure 1: Ethiopian Drylands




Source: Kidane, 2010

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Studies have indicated that land degradation is a major challenge in Ethiopia that needs to be addressed especially in drylands. They have assertively reiterated that there is a greater need for SLM in these areas, and that the "business as usual" route cannot be pursued hereafter (UNDP, 2008; Kidane, 2010; Hurni et al, 2015, p. 6; Sircely, 2016).

### 2.2.4. Climate Change in Drylands and Development

Land degradation is a "major contributor" to climate change which in turn increases the risk for natural disasters like drought and flood (Van Aalst, 2006; IPBES, 2018, p. 1). As a result, climate change poses a challenge against pastoralists and agro-pastoralists by increasing the frequency of occurrence of extreme heat events, worsening aridity, rainfall variability and deteriorating water stress (Serdeczny et al, 2017). Increasing temperature also has serious repercussions in terms of food security and poverty because climate change and development are highly intertwined (Keller, 2009; Ringler, Zhu, Cai, Koo, & Wang, 2010).

Studies show that about 90% of dryland dwellers are located in developing countries (Davies, 2017), and 47% of them exhibit one of the highest levels of poverty and infant mortality in the world (Darkoh, 2003; Vohland & Barry, 2009; FAO et al, 2011). Climate change is likely to undermine gains made in the past; and, poses a threat to sustainable development because of poor people's weak adaptive capacity (Castells-Quintana, Lopez-Uribe, McDermott, 2018). As put by Center for Global Development (2018, p.1), "climate change will be awful for everyone, but catastrophic for the poor".

Davies (2017) showed that there are two ways in particular climate change affects (agro-) pastoralist. They are by worsening land degradation and by lowering crop productivity. Both these factors in turn induce drought, aggravate rainfall variability, increase the occurrence of extreme weather events, deteriorate food security, diminish availability of pasture for livestock, worsened water stress and reduced households' income. Among these, worsened water stress is known to lead to loss of livestock which is of a particular interest to (agro-) pastoralists (Mekuyiea, Jordaan & Melka, 2018). Additionally, the resulting acute shortage of resource and environmental degradation could trigger violent conflict among (agro-) pastoral communities (Davies, 2017).

### 2.3. Flood and Rain Water Management Systems

As discussed in earlier sub-sections (2.2.1, 2.2.2 and 2.2.4), water stress in drylands cause a ripple effect that leads to land degradation, climate variability and lowered crop production and yield. In addition, the utilization of water development and conservation technologies and SLM methods have also been put forward as efficient solutions to increase water availability, soil fertility and organic matter content, biodiversity and crop productivity. These technologies and methods are meant to make use of existing water resources.

Consequently, the following sub-sections discuss flood and rain water based irrigation systems used in various parts of Sub-Saharan Africa as methods of increasing water availability, production and yield of crops, livestock production and improve food security. De Trincheria (2017) presents these systems dividing them into three as discussed below.

#### 2.3.1. Macro-catchment Systems

These are techniques that have been used in arid and semi-arid areas to collect surface runoff from relatively large catchment areas including roads, roofs, naturally inclined areas, etc. Tanks, ponds and earth dams have also been used in Sub-Saharan Africa as part of these techniques. They have been found to be beneficial particularly in Ethiopia and Rwanda as gravity-fed irrigation techniques for off-season irrigation, spate irrigation, and/or livestock watering.

Table 2: Potential of Macro-catchment Systems in Sub-Saharan Africa

| **Flood and Rain Water Management Technology** | **Potential*** |
|---|---|
| On-farm ponds | + + + |
| Rooftop catchments + on-farm ponds | + + + |
| Road catchments + on-farm ponds | + + + |
| Shallow groundwater recharge | + + + |
| Small earth dams | + + |
| Groundwater dams: subsurface dams and sand storage dams | + + |
| Rock outcrops + earth dams | + + |
| Surface dams and perennial riverbeds | + |

Note: * Potential: High (+ + +), Medium (+ +), Low (+).

Source: De Trincheria et al (2016)

### 2.3.2. Micro-catchment Systems

These are techniques that have been used in arid and semi-arid areas to collect surface runoff from small catchment areas within farm boundaries including pitting, contouring, terracing and micro-basins. They have been found to be beneficial particularly in Ethiopia, Kenya, Zimbabwe and Mozambique.

Table 3: Micro-catchment Technologies in Ethiopia, Kenya, Mozambique and Zimbabwe

| **Micro-catchment Technologies** | **Potential*** | | | |
|---|---|---|---|---|
| | **Ethiopia** | **Kenya** | **Mozambique** | **Zimbabwe** |
| Pitting: Different types of planting pits and trenches | + + + | + + + | + | + + + |
| Contouring: Stone and soil bunds, hedge rows and vegetation barriers | + + + | + + + | + | + |
| Terracing: Fanya juu, semi-circular and hillside terraces | + + + | + + + | + | + + |
| Micro-basins: Different shapes of basins surrounded by low earth bunds | + + + | + + + | + | + |

Note: * Potential: High (+ + +), Medium (+ +), Low (+).

Source: De Trincheria, 2017

### 2.3.3. In-situ Systems

As indicated by its name, these are techniques that focus on maximize infiltration, decrease surface runoff and soil evaporation by capturing and holding rain and/or flood where it falls and/or flows. These techniques also improve soil fertility and water availability. Examples of in-situ techniques used in Sub-Saharan African are ridging, mulching, various types of furrowing and hoeing, and conservation tillage (Biazin, Sterk, Temesgen, Abdulkedir & Stroosnijder, 2012).

Table 4: In-situ Systems in Ethiopia, Kenya, Mozambique and Zimbabwe

| **In-situ Systems** | **Potential*** | | | |
|---|---|---|---|---|
| | **Ethiopia** | **Kenya** | **Mozambique** | **Zimbabwe** |
| Furrowing | + + + | + + + | + | + |
| Ridging | + + + | + + + | + + | + + + |
| Mulching | + + | + + | + | + |
| Conservation tillage | + + + | + + + | + + | + + + |

Note: * Potential: High (+ + +), Medium (+ +), Low (+).

Source: Biazin et al. (2012) and and De Trincheria et al. (2016).

All three flood and rainwater management systems are used for the purpose of irrigating agricultural lands. There are various types of irrigation systems used to increase agricultural production and yield, and alleviate water shortage problems. The varying types are dependent upon crop and crop water requirements, water supply, soil characteristics, topography, size and shape of the field, and climate of the area. There are also numerous determining economic factors such as labor requirements, available capital, and resource costs (Evans, 2010; FAO, 2014; CDC, 2016). The most common ones are shown in the table below.

Table 5: Types of Irrigation Systems

| **Type of Irrigation System** | **Definition** |
|---|---|
| Surface Irrigation | Water is distributed over and across land by gravity, no mechanical pump involved. |
| Drip Irrigation | A type of localized irrigation in which drops of water are delivered at or near the root of plants. In this type of irrigation, evapotranspiration and runoff are minimized. |
| Sprinkler Irrigation | Water is distributed by overhead high-pressure sprinklers or guns from a central location in the field or from sprinklers on moving platforms. |
| Localized Irrigation | Water is distributed under low pressure, through a piped network and applied to each plant. |

| | |
|---|---|
| Center Pivot Irrigation | Water is distributed by a system of sprinklers that move on wheeled towers in a circular pattern. This system is common in flat areas. |
| Lateral Move Irrigation | Water is distributed through a series of pipes, each with a wheel and a set of sprinklers, which are rotated either by hand or with a purpose-built mechanism. The sprinklers move a certain distance across the field and then need to have the water hose reconnected for the next distance. This system tends to be less expensive but requires more labor than others. |
| Sub-irrigation | Water is distributed across land by raising the water table, through a system of pumping stations, canals, gates, and ditches. This type of irrigation is most effective in areas with high water tables. |
| Manual Irrigation | Water is distributed across land through manual labor and watering cans. This system is very labor intensive. |

Source: CDC, 2016

Although these irrigation methods have resulted in increase the production and productivity crops, livestock production and improve food security not only in Africa but the rest of the world (GIZ, 2012; De Trincheria, 2017), they require the presence of water in the immediate vicinity of irrigated areas (FAO, 2014). But this prerequisite cannot be fulfilled in semi-arid and arid drylands since water shortage problem is a persistent problem in these areas. But this prerequisite cannot be fulfilled in semi-arid and arid dryland areas like Chifra Woreda, which is the study area. Chifra like all other drylands faces water shortage problems which has continued to threaten both pastoralists and agro-pastoralists as their livelihood is centered on water availability. Although Awash River is located in Afar Region, it is too far away to be considered for irrigation in Chifra Woreda. Mille River, a tributary to Awash River, is also located in the region, but is still not close enough for irrigation in Chifra.

Subsequently, GIZ developed a water harvesting technique called water-spreading weirs that make irrigation based farming for agro-pastoralists in drylands that are affected by flash floods. These are techniques that have been in use in West African drylands for close to two decades in countries that have been severely degraded due to flash floods.

### 2.4. Flash Floods in Afar Region

Flood is one of the shocks caused by climate variability that occurs in various parts Ethiopia (Adane, Ayalew & Bekele, 2006). It has been known to have displaced and claimed the lives of hundreds of people, and destroyed physical, natural and economic assets especially in the lowlands, including in Afar Region. The major contributing factor for this is Ethiopia's topography which is mountainous where 60% of the land has slopes greater than 16%, and highly deforested. When heavy and torrential rain falls, rivers and water bodies overflow leading to increased runoff with very little infiltration and vegetation cover (Gutu, 2019).

In 2017, the United Nations Office for the Coordination of Humanitarian Affairs (UNOCHA) reported that Awash and Asabera rivers caused massive flooding in Afar Region causing the harm and displacement of over 4,500 people and destruction of over 500 hectares of agricultural land (UNOCHA, 2017).

In reviewing the state of displaced people in Afar Region in 2019, the International Organization for Migration (IOM) stated that 50,092 individuals (9,227 households) in 58 displacement sites were displaced in the region with no access to food and affected by diseases like malaria (IOM, 2019).

Consequently, Afar Region is one of four regions identified by the Ethiopian government to resettle pastoralists and agro-pastoralists living in those regions in order to improve their livelihood resilience and reduce poverty since they are severely affected by drought and flashfloods and seasonal floods (MoA, 2013).

Furthermore, the high temperature and low rainfall in the woreda is reported to lead to a higher evapotranspiration that exceeds precipitation which in turn leads to be barely sufficient for vegetation growth without supplementary water supply (Afar National Regional State, 2016).

## 2.5. Water harvesting Techniques for Chifra Woreda

Due to the high evapotranspiration that exceeds precipitation in the woreda which hinders vegetation growth, the need for water harvesting techniques has been emphasized by the regional government. It has identified water harvesting techniques such as Micro- and Macro-Catchment Runoff Water Harvesting, Stream Bed Floodwater Harvesting and Floodwater Diversion (ibid).

***Micro Catchment Runoff Water Harvesting (MIRWH)***

Micro Catchment Runoff Water Harvesting (MIRWH) system is a "method of collecting surface runoff from small catchment areas storing it in the root zone of an adjacent infiltration area/basin" (ibid: p. 53). These methods are cheaper, simpler to replicate and adopt, have higher runoff efficiency than medium or large scale water harvesting systems, have no conveyance losses, reduces erosion, and can be constructed on almost any slope.

***Macro Catchment Runoff Water Harvesting (MARWH)***

Macro Catchment Runoff Water Harvesting (MARWH) system is method of collecting and storing surface runoff from large catchment areas ranging from 1,000 $m^2$ - 200 ha of land. It is relatively more difficult to install as it requires expertise for designing the system and calculating its Catchment to Pasture Ration (CPR).

***Stream Bed Floodwater Harvesting (SBFWH)***

Stream Bed Floodwater Harvesting (SBFWH) is a method of building structures such as loose stone and check dams in order to dam the water flow of seasonal steams that flood valley bottom of a flood plain. It is also relatively more difficult since it requires expertise for evaluating site suitability and to design the system.

***Floodwater Diversion (FWD)***

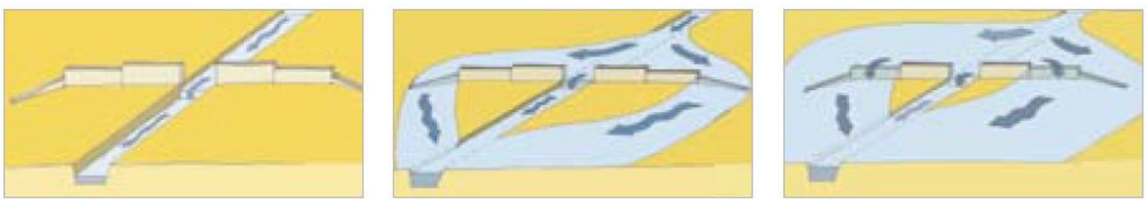
Floodwater Diversion (FWD) is a method of forcing rivers to leave their natural course in order to irrigate farm lands and pasture lands. Although this offers a wide catchment area, is also needs more complex structures of dams and distribution networks and a higher technical input than the other three water harvesting methods.

### 2.6. Water-spreading Weirs

Water-spreading weirs are a relatively new SWC and SPR techniques implemented by the German development cooperation (GDC) about 19 years ago in West Africa's drylands. The GDC has used this techniques in the Niger, Burkina Faso and Chad to alleviate water shortage, improve food security, and combat land degradation and drought (GIZ & KfW, 2011).

Water-spreading Weirs are "artificial obstructions in any watercourse that result in increased water surface level upstream for some, if not all flow conditions" as shown in the figure below (Rickard, Day & Purseglove, 2003, p. 5). They are used for permanent or seasonal flows of water with a width ranging from 2 and 4 m high and 100 to 1,000 meters wide depending on the flooding area (GIZ, 2012).

Figure 2: How Water-spreading Weirs Work



Source: Bender, 2012

These robust dam-like barriers that can endure hydraulic forces were built on small-scale by the GDC as a rehabilitation technique in drylands that often suffer from flash floods from nearby highlands. They are also built from stone and cement at varied distances from each other along a flat flooding area in order to "break the speed and strength" of run-off, capture it and spread it out (Ackermann et al, 2014, p. 17).

Figure 3: Water-spreading Weirs in the Sahel

Source: GIZ & KfW, 2011

Much of the construction of the weirs is carried out by trained members of the local community. A single weir costs from 500 to 2,600 USD per hectare depending on its width and height (Bender, 2012; Schöning et al, 2012).

Table 6: Cost of Water-spreading Weirs

| **Factor** | **Cost** |
|---|---|
| Labor | 25 people for 2 to 3 months (depending on the size of the structure) |
| Lorries to transport stones | 150 to 200 lorryloads (skip loader – 4.5 $m^3$ per load), and 10 to 15 lorryloads a day |
| Stonework | 50 USD/$m^3$ |
| Basin | 27 USD/$m^3$ |
| Cost of construction | 1 medium-sized weir 50 meters long and 1 meter high with 200 m long wingwalls plus basin: 2,600 USD<br>1 weir 100 meters long and 1 meter high with basin: 5,200 to 5,500 USD |

Source: GIZ, 2012

In spreading out flood water, the weirs enable it to infiltrate the soil and recharge the groundwater table. The environmental benefit of this is the betterment of local ecology and rehabilitation by way of reduced soil erosion and enhanced soil fertility. Weirs also increase the availability of water to people and livestock. Socially, they develop the organizational capacity of communities in order to encourage sustainable use of natural resources, and avert conflict. They also strengthen the livelihood of pastoralists, and enhance their resilience against extreme weather events and other external factors (GIZ, 2012).

Moreover, the weirs also increase cultivable area. They enable pastoralists to grow a variety of crops over a much larger area for a longer period of time, thereby alleviating household's food insecurity, increasing and diversifying production, boosting income (Ackerman et al, 2014).

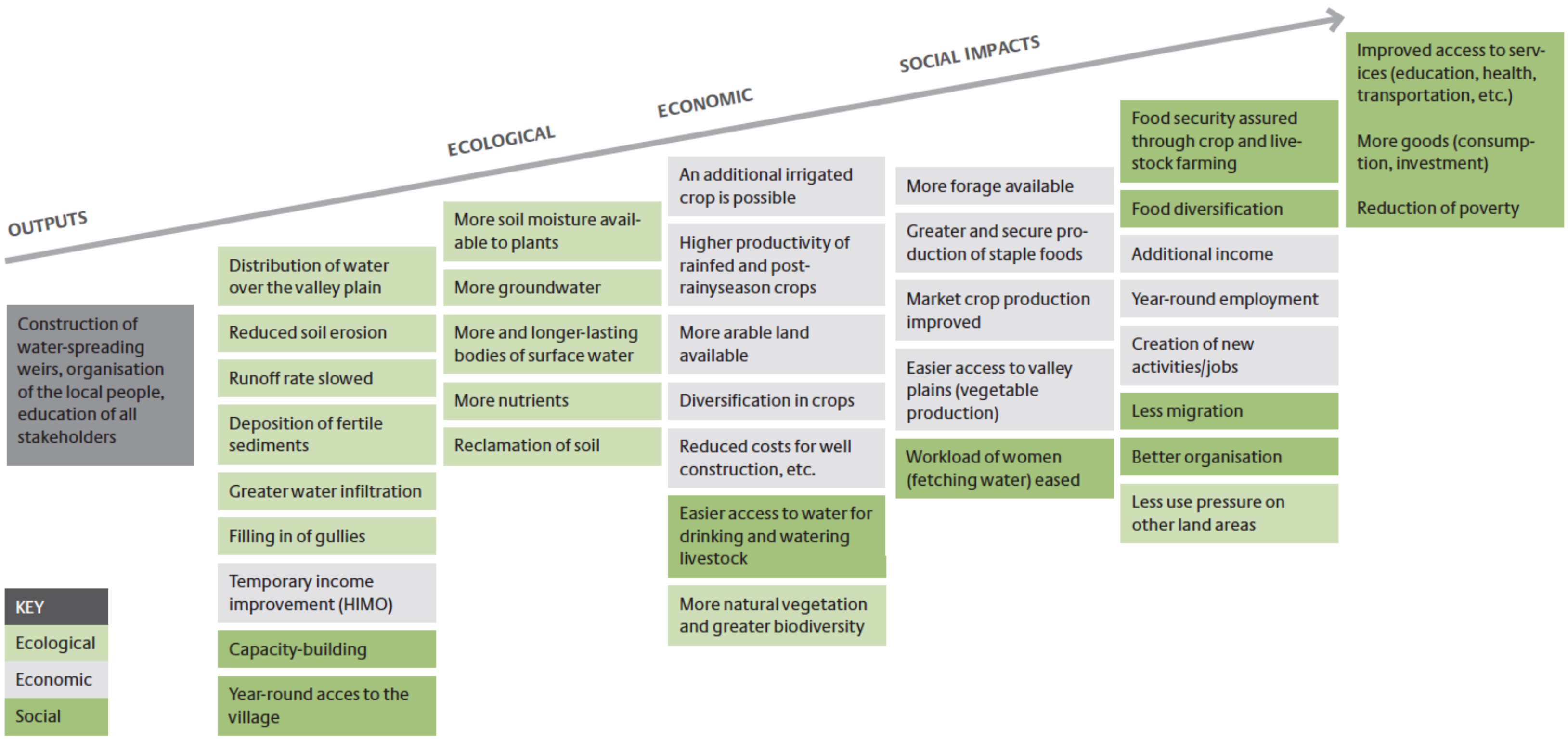
### 2.7. Related Empirical Studies

Since water-spreading weirs are relatively new, studies conducted on it are also relatively sparse. Some of the few that are available are published in French (Bender, 2011; Kambou, 2011; Lütjen, 2011; Bureau Consult International, 2011). Therefore, this section will heavily relay on GIZ and KfW (2012), Schöning et al (2012), and Bender (2012), which are studies that assess the impact of water-spreading weirs in Niger, Chad and Burkina Faso, and are published in English.

GIZ and KfW (2012) present impact of water-spreading weirs in Burkina Faso, Niger and Chad. The results presented demonstrate that water-spreading weirs bring about significant ecological, economic and social change within a few years in rehabilitated communities. The report summarized the results from all three countries pictorially as shown in the figure below. It can be seen that ecological impacts of the weirs entail increased surface and ground water availability, reduced erosion, deposits of fertile sediments, increased water infiltration, increased biodiversity, less pressure on other land areas, etc. Economic impacts include increased income and employment opportunities, increase production and productivity, increased cultivable land size, diversity of crops, increased availability of feed and water, etc. Social impacts entail capacity building, reduced poverty, year-round access to villages, easier access to water, workload decreased for women who fetch water, less migration, better organization, food diversification, ensured food security, etc.

According to the report, the impact was revealed in the first rainy season after the structures were constructed. They are constructed in dry season so that construction would not coincide with agricultural activities, and so that trained members of the local community would benefit from employment in the construction and by developing their professional skills. Since areas where weirs are constructed are often hit by flood, communities used to remain isolated in rainy seasons. But now, floods are used to their advantage and not as a disaster that causes environmental and social hazards. Rather, these communities are now connected to the outside world year-round (ibid).

Figure 4: Impact of Water-spreading Weirs in Burkina Faso, Niger and Chad




Source: GIZ & KfW, 2012

Environmental benefits also manifest early on. Erosion was reduced; runoff was slowed down; infiltration was increased; gullies were filled; soil moisture and nutrients were increased; and surface water and groundwater were also increased. Furthermore, because of the environmental rehabilitation and increased water availability, vegetation coverage was also increased, and there was less pressure on the rest of the land. Additionally, economic benefits were also obtained in terms of increased household income along with social benefits of different kinds (ibid).

**Increase in Groundwater and Surface Water**

Evidence in Niger shows that the average depth of the groundwater table of rehabilitated regions rose by 8.5 meters from the previous 12.5 meters. The average depth from the surface to the groundwater also became 3.5 meters. In Burkina Faso, the average depth of the groundwater table of rehabilitated regions rose from the previous level which was on average more than 8 meters below the surface before the construction of the weirs to 2-5 meters below the surface. These regions were reported to have their surface water disappear 1-2 months after the arrival of dry seasons. But presently, surface water in waterholes and ponds is available for a longer time.  In Chad, the study told stories of respondent who stated that they used to travel long distances (up to 6 kilometers) to fetch water. But since the construction of the weirs, they have water available all year round in their village.

**Increase in Cultivable Land Size**

In Niger, while the size of cultivable land around rehabilitated regions is 90% of during rainy seasons, it drops to <10% in dry seasons. But after the construction of water-spreading weirs, these regions showed that up to 50% of the land can be cultivated in dry seasons. Usable land has also increased approximately from 710 hectares to 2,320 hectares. In Burkina Faso, four dry regions where weirs were constructed were also able to have their usable land area increased from two-fold to eight-fold. Additionally, arable land area in Chad has been reported to have increased.

**Increase in Yield and Production**

The study also showed that because of the weirs, rehabilitated regions in all three countries saw an increase crop yield (Table 4). This was because the weirs increase the supply of water in the area from the incoming flood which carries with it soil from nearby elevations.

Due to this, fine soil is deposited within the area where the weirs were built and organic matter of soils also increases. In Burkina Faso, grain yields rose by 2.5-fold. In Niger, the increase was 1.9-fold and 1.3-fold in millet and sorghum yields, respectively. In Chad, the increase in yield was on average 1.8-fold higher in normal years, and 3.1-fold higher in dry years.

Table 7: Increased Yield of Rice, Millet and Sorghum

| **Country** | **Crop** | **Yield** | |
|---|---|---|---|
| | | **Without Water-spreading Weirs** | **With Water-spreading Weirs** |
| Burkina Faso | Rice | 800 kg/ha | 2,000 kg/ha |
| Niger*1 | Millet | 333 kg/ha | 675 kg/ha |
| | Sorghum | 362 kg/ha | 481 kg/ha |
| Chad*2 | Millet | 158 kg/ha | 653 kg/ha |

*1 Mean yield of three years in eight valleys and of one year in three valleys before and after weir construction
*2 Mean yield from three valleys in a drought year
Source: GIZ & KfW, 2012

Evidence from 11 rehabilitated regions in Niger also shows that production of crops had increased due to the construction of weirs (Table 5) (Schöning et al, 2012).

Table 8: Increase in Production in Niger

| **Element** | **Situation before Water-spreading Weirs** | **Situation afterwards** | **Difference** | **Growth factor** |
|---|---|---|---|---|
| Area under cultivation (ha) | 2,847 ha | 8,132 ha | 5,285 ha | 2.9 |
| Yield (kg/ha) | 333 kg/ha | 675 kg/ha | 342 kg/ha | 2.0 |
| Production (t) | 948 t | 5,489 t | 4,143 t | 5.8 |

*1 Mean yield of the three years prior to weir construction
*2 Mean yield of the years 2007–2009
Source: Schöning et al, 2012

A study in Eastern Chad (Bender, 2012) showed that water-spreading weirs were successful in drylands hit by floods and where rainfall is unpredictable in growing seasons (50-1,200mm/year). It presented the impact of water-spreading weirs in terms of production and socio-economic benefits, socio-cultural benefits, ecological benefits, off-site benefits and their contribution towards human well-being/livelihoods (shown in Figure 5 below).

Figure 5: Impact of Water-spreading weirs in Chad

| Production and socio-economic benefits | | Production and socio-economic disadvantages |
|---|---|---|
| +++ | increased crop yield | |
| +++ | increased fodder production | |
| +++ | increased fodder quality | |
| +++ | increased animal production | |
| +++ | reduced risk of production failure | |
| +++ | increased farm income | |
| +++ | increased production area | |
| +++ | decreased workload | |
| ++ | Temporary income was generated for the local workers during the weir construction. | |
| + | increased product diversification | |

| Socio-cultural benefits | | Socio-cultural disadvantages |
|---|---|---|
| +++ | community institution strengthening | |
| +++ | improved situation of disadvantaged groups | |
| +++ | improved food security / self sufficiency | |
| ++ | conflict mitigation | |
| ++ | improved conservation / erosion knowledge | |
| ++ | improved health | |
| ++ | diversification and creation of activities | |
| ++ | improved planning skills | |
| ++ | poverty reduction | |
| + | training for weir construction | |

| Off-site benefits | | Off-site disadvantages |
|---|---|---|
| +++ | increased water availability | |
| +++ | reduced downstream flooding | |
| +++ | reduced downstream siltation | |
| +++ | improved buffering / filtering capacity | |

Source: Bender, 2012

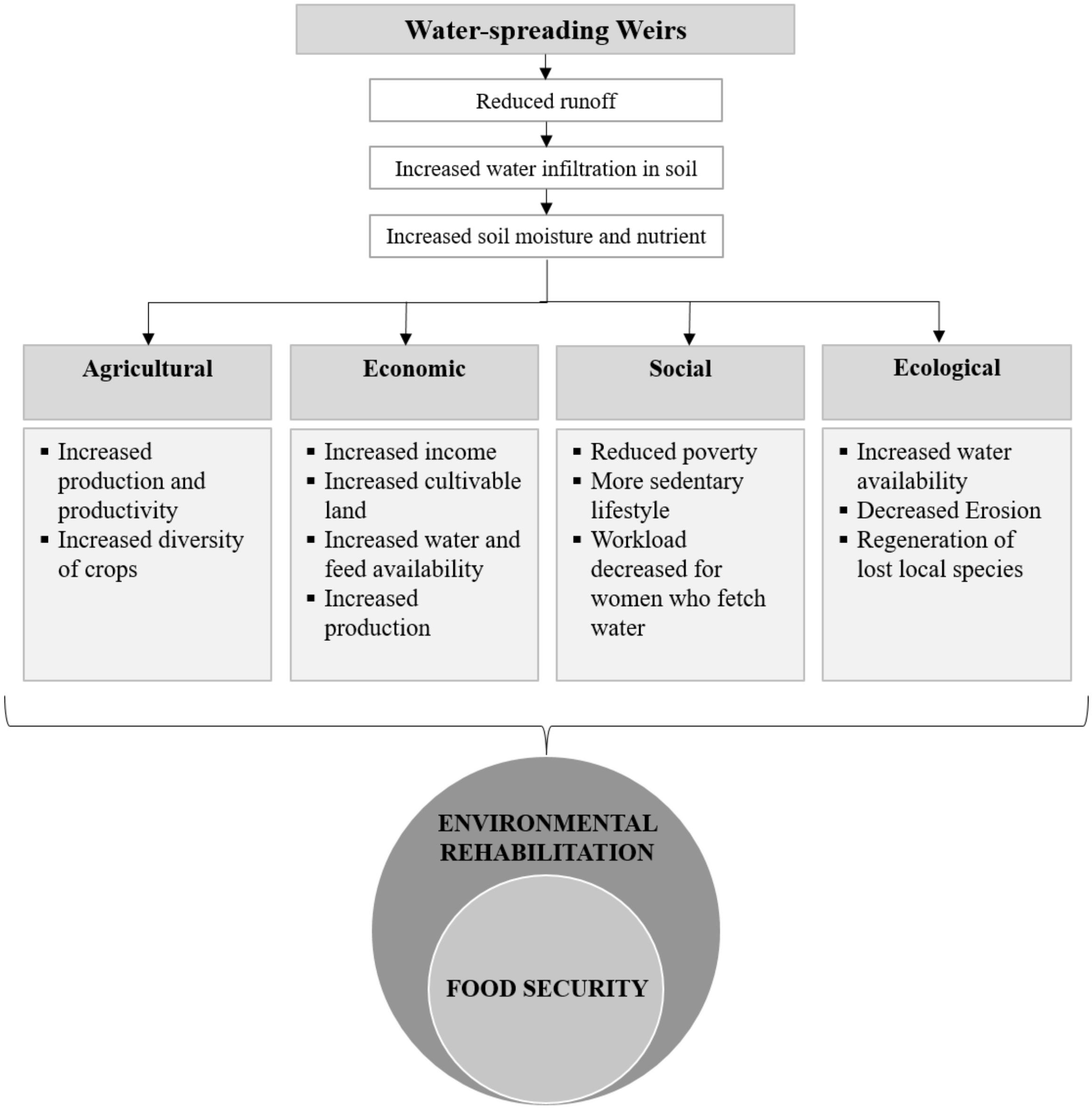
It can be seen from the figure that the production and socio-economic benefits include increased crop production and productivity, and feed production and quality which has led to increased animal production and farm income. In addition, weirs have also increased the production area and decreased the risk of production failures. Furthermore, work load for women who used to travel for hours to fetch water had also decreased as a result of the increased water availability made possible by the weirs. Due to the need for hired labor workers during the time of the construction of the weirs, work opportunity and temporary income had also increased during that time.Various socio-cultural benefits were also observed. The most impact was observed in the area of community institution strengthening, improved situation of disadvantaged groups and improved food security. Furthermore, significant off-site advantages were also derived from the constructed weirs. These are decreased downstream flooding and siltation, and improved buffering. Increased water availability has also been observed which has proven to lead to the increase in production and socio-economic benefits. It is also important to note that there were no disadvantages observed by the study for all three types of impacts observed due to the construction of the water-spreading weirs.

All in all, previous studies have shown that drylands are too valuable to ignore, and that land degradation in drylands is an urgent issue. Pastoralists and agro-pastoralists living in the area are also faced with numerous environmental, social and economic challenges that erode their resilience and engrain their vulnerability. Therefore, it is most fitting that SLM techniques that suite each region is introduced because these techniques have ripple effect that addresses all the above-mentioned problems. Opportunities to introduce best practices to degraded regions should be explored. Scaling up of best practices should also be considered in rehabilitated regions to further reap the benefits of SLM techniques.

### 2.8. Conceptual Framework

Figure 6 below presents the conceptual framework followed in this research. As discussed in previous sections, water-spreading weirs are soil and water conservation, and environmental rehabilitation techniques that capture and spread flood water over a flooding plain for the purpose of soil infiltration. They are methods of addressing food insecurity and environmental unsustainability.

Figure 6: Conceptual Framework




Source: Own compilation

The weirs built in Chifra Woreda, Afar Region following a few decades' implementation in West Africa primarily result in three outcomes: reduced runoff, increased soil infiltration and increased soil moisture and nutrient content. These in turn lead to four major results which are agricultural, economic, social and ecological effects. The agricultural effect entails increased production and productivity of crops, and diversity of crops cultivated.

The effect on economic gains entails increased income, increased cultivable land size, increased water and feed availability for livestock production and increased crop production. The social effect entails reduced poverty, more sedentary lifestyle of agro-pastoralists and the decreased workload for women who used to travel for several kilometers to fetch water. Ecological effect entails increased water availability, reduction of erosion which considerably reduces land degradation and the regeneration of previously lost local species. It is also important to note that increased production and productivity, and water availability is beneficial not only for agro-pastoralists and but also their livestock which are an integral part of their livelihood.

These lead to food security mainly as a result of the increased crop production and productivity, availability of water for agro-pastoralists, and availability of feed and water for their livestock. All these further enhance environmental rehabilitation of the area.

## CHAPTER 3: METHODOLOGY

### 3.1.Description of the Study Area

#### *Afar Region*

Afar is one of Ethiopia's nine regional states located in the northeastern part of the country. It is divided into five administrative zones plus a special woreda. It covers a total area of 270,000 square kilometers (sq. kms). It is also located within the Rift Valley with an altitude that ranges from 116 meters below sea level to 1,600 meters above sea level. Its temperature ranges from 25$^{o}$C to 48$^{o}$C (Afar National Regional State, 2010; Government of Ethiopia, 2018).

Figure 7: Afar Regional State

Source: USAID, 2014

According to the Central Statistics Agency's (CSA's) Household Consumption – Expenditure (HCE) Survey in 2015/16, Afar's total population was about 1.67 million (CSA, 2016). Majority of the population living in the area is engaged in pastoralism and agro-pastoralism. They are known to rear camels, cattle, goats, sheep and donkeys, and practice agriculture (Afar National Regional State, 2010; UNDP, 2014a).

Agro-pastoralists in Afar practice mixed farming. Most of the land in the region is shrub and range land which is largely degraded. Of the total land mass only little is cultivated and in 2017 it accounted only 2.5 %. (Michael & Seleshi, 2007).

Table 9: Cattle Population in Afar

| Geographic Area | Cattle | Camel | Sheep | Goat | Donkey |
|---|---|---|---|---|---|
| Ethiopia | 59,486,667 | 1,209,321 | 30,697,942 | 30,200,226 | 8,439,220 |
| Afar | 1,315,917 | 474,146 | 1,729,159 | 3,461,260 | 101,656 |
| Percentage | **2.2%** | **39.2%** | **5.6%** | **11.5%** | **1.2%** |

Source: CSA, 2016/17

Afar is also known for its high vulnerability to weather related natural disasters like drought and flood as the region is a flat land, and is one of the most arid drylands in Ethiopia (Afar National Regional State, 2010).

***Chifra***

Chifra is one of the Woredas located within Afar's first administrative zone called Awsi Rasuof and has 18 kebeles. According to the regional government, an estimated 95,456 people live in the woreda, of which 1,677 were found to be agro-pastoralists (Afar National Regional State, 20016). It has an elevation of 825 meters above sea level. Its temperature ranges from 24ºC to 40ºC (Afar National Regional State, 2010).

Figure 8: Chifra Map


Source: Ethio Demography and Health

Chifra has an arid climate. There is very little rainfall all year round with an annual average precipitation of about 312 mm. Annual rainfall reaches its highest in August with an average of 73.4 mm, and the driest month is December (Afar National Regional State, 2016). During this study period, it was reported by respondents that it had not rained in the woreda for the last two years.

Of the total population, 10% of the population is engaged in agro-pastoralism and 87% is engaged in pastoralism. In addition, Chifra's location near the base of the eastern escarpment of the Ethiopian highlands make it vulnerable to flood from the highlands of Amhara region (Tilahun, 2018).

According to Afar National Regional State (2016), there are nine types of soil in Chifra which is a "rough estimate" based on a participatory assessment of the woreda due to the lack of systematic soil survey in the woreda. Brown Soil (Eda-Bula-a) and black soil (Data Clayto) have the highest coverage with 100,565 ha and 23,361 ha of land, respectively. Based on the classification used by pastoralists and agro-pastoralists living in the region which relays on primarily color, texture and plants species, the most dominant soil types in the region are red soil (Assa Soil) and black soil (Beta Soil).

Moreover, there are two agro climatic zones in the woreda: arid and semi-arid. The arid zone covers 80% of the woreda, which is found in the central, eastern, western and northern parts. The semi-arid zone covers 20% of the woreda, which is found in the northwestern part bordering the Amhara Region. The two climatic zones along with the high temperature and low rainfall (which is 312 mm) leads a much higher evapotranspiration (1481 mm) that exceeds precipitation. This is known to be barely sufficient for the land in the woreda to support vegetation growth without supplementary water supply (ibid).

## 3.2. Description of the Intervention

In January 2015, a project called *Rebuilding Livelihoods of (Agro) Pastoral Communities in Afar Region through Diversifying and Integrating Drought Resistant Food and Feed Crops* was launched in Chifra, Afar by GIZ. It was implemented alongside another project it run called *Capacity Development to Strengthen Drought Resilience of the (Agro) Pastoral Population in Ethiopian Lowlands.* The main aim of the projects was to increase the capacity of agro-pastoralists to resist climatic shocks by rehabilitating the productivity of their landscapes.

With this intent, GIZ built structures called water-spreading weirs in Chifra that serve as a SWC and SPR technique. They were built along the flat flood plain where flood flows from the Ethiopian highlands in Tigray and Amhara regions. These structures are one-meter high dam like barriers that “break the speed and strength” of run-off, capture it and spread out floodwater on to the wider plains in order to rehabilitate degraded flood plain areas and use it for planting various kinds of crops (Ackermann et al, 2014, p. 17). GIZ built six of these structures with 400 meters distance from each other in Chifra Woreda.

GIZ also funded the provision of various drought-resistant, high yielding crops and fodder varieties on the rehabilitated land to the agro-pastoralists in the local community during both the belg and meher seasons covering about 44 hectares of land.

During the belg season, floods from the highlands has less in volume and frequency. Thus, crops planted are limited to areas only where the water reaches instead of covering the whole flood plain. Early maturing, drought resistant crops namely, chickpea, cowpea, mung bean and pigeon pea are planted on the fields by the local community. During the meher season, crops like maize, cowpea, sorghum, mung bean and pigeon pea are planted. Forage crops like lablab and elephant grass are also sown on both seasons.

Figure 9: Water-spreading Weirs in Chifra

## 3.3. Research Design

This research used quasi-experimental research design. It was used retrospectively since it was carried out after an intervention (the construction of the water-spreading weirs) has taken place. It also employed a mixed research approach and carried out a comparative analysis between households who are part of GIZ's project and households that are not. Data was collected pertaining to issues listed as objectives in Section 1.3 and were then analyzed using both descriptive and inferential statistics.

## 3.4. Data Collection

Both primary and secondary data were gathered from households who are part of the project and households that were not for comparative analysis. This was done through household survey, focus group discussions and key informant interviews (FGDs).

### 3.4.1. Household Survey

Primary data was collected from households by way of household survey using a structured questionnaire as a data collection tool (Annex 1). The questionnaire inquired about agro-pastoralists' crop and livestock production, food security, their environment and environmental protection practices. The survey was conducted by enumerators who were from that area to make sure language would not be a barrier. They were also given a one-day training in order to make sure they were well acquainted with the tool.

Figure 10: Household Survey

**Measuring Effect on Environmental Rehabilitation**

This research also studied the environmental effect water-spreading weirs have on households living within the water-spreading weirs (project beneficiaries) and on Chifra Woreda. Particularly, its effect on vegetation cover, species diversity, diversity and production of crops, yield, groundwater and surface water, and erosion was studied. It also investigated other activities undertaken in the community that encourage and promote SLM.

Primary data was collected from agro-pastoralists themselves by asking them in the household survey questionnaire the types of crops they cultivate (diversity in number and production in ha), the increase in yield, and how long their growing seasons last before and after the construction of the weirs. They were also asked how many new users (new agro-pastoralists) have acquired land around the weirs as a result of the increase in cultivable land. Additionally, the household survey questionnaire inquired about the regeneration of local plant species in the area that were previously thought to have been lost, but have now reappeared around the weirs as a result of rehabilitation. It also asked about the land management practices of the local community in addition to participating in the construction of the weirs.

Previous studies have shown that weirs enable water to infiltrate soils, thereby increase the amount of cultivable land and yield (GIZ & KfW, 2012; Schöning et al, 2012; Bender, 2012). Therefore, secondary data for type of crop cultivated (diversity in number), production (in kg), yield (kg/ha), total cultivated land (in ha) were gathered.

Moreover, studies also showed that weirs increase groundwater and surface water of rehabilitated areas (ibid). Particularly, GIZ and KfW (2012) showed that agro-pastoralists interviewed in Chad bore witness that increase in groundwater and surface water was reflected in how far less they have to dig to get water in dry seasons and the fact that they do not have to travel elsewhere in search for water. Therefore, this research inquired about all these issues in the household survey before and after the construction of the weirs.

Furthermore, field study was also carried out to gather additional data. Since deep gullies are seen in areas where erosion persists, the depth and width of gullies were measured both in areas where the weirs are built and where they are not. The difference was used to show how much the weirs alleviate the loss of soil.

**Measuring Food Security**

The understanding this research employs for food security is based on FAO's definition which is, a situation whereby households "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, 1996 cited in FAO, 2006). Based on this, this research used a household food security/insecurity measuring indicator called Household Food Insecurity and Access Scale (HFIAS) for the purpose of providing information about food security/insecurity.

*Household Food Insecurity and Access Scale (HFIAS):* Household Food Insecurity and Access Scale (HFIAS) is an indicator developed by the World Food Programme (WFP) to capture a mix of sufficiency and psychological factors (Maxwell, Coates & Vaitla, 2013). It shows households' behaviors in times of insufficient quality and quantity, and their anxiety and uncertainty due to their insecure access or food supply, and will be administered through a household survey questionnaire.

HFIAS has standard tool for universal application with a recommended questionnaire format and guidance for calculating HFIAS score. The tool asks two types of standard questions. These questions are "nine *occurrence* and nine *frequency-of-occurrence* questions" (Coates, Swindale, & Bilinsky, 2007, p.4). Households were first be asked if they have experienced a certain occurrence (occurrence question) for which they answered yes or no. If they answer yes, they were asked with what frequency (rarely, sometimes, or often) (*frequency-of-occurrence* questions). This was carried out during a household survey and was part of the household survey questionnaire.

Moreover, it is important to note that the survey tool inquired about food security beyond the HFIAS questions (like extent of dependence on food aid and safety net programs) in order to gain a fuller understanding on the effect of the weirs on ensuring food security.

### 3.4.2. Focus Group Discussions (FGDs)

FGDs consisting were held using a semi-structured questionnaire as a data collection tool (Annex 2). One FGD was held for households within the project and another one for households who were not, two in total. Both discussions were held after the household survey was conducted and therefore was used to give further information and clarity about the questions in the survey.

### 3.4.3. Key Informant Interviews

Key informant interviews were conducted as well with a Chifra Woreda's officer, community leader and GIZ officer (three in total) who are situated in the area and who knew it well (Annex 3, 4 and 5). Similar to the FGDs, this was also used to give further information about the project and the area.

Figure 11: Focus Group Discussions held in Chifra Woreda

## 3.5.Sample Design and Sample Size

Since this research looked at two groups for comparative analysis, the first one being agro-pastoralists that are part of the project and the second one being those that are not. For the first group, since the population is just 38 households, all households were surveyed. For households that are not within the project, a total of 150 households were surveyed.

For households that are not within the project (a total of 150 households), stratified random sampling technique was used. Firstly, with the help of the woreda and kebele representatives, different sites that are affected by flood were identified along the same flooding plain. Even though these sites are much affected by flood, they do not have any weir constructed. Within each site, households were selected randomly for surveying.

In addition, there were two FGDs, one each from households that received the treatment and those did not. Each FGD had 8 participants which were drawn randomly.

The justification for the above number of sample size for the household survey is a study on sample size determination that states comparative studies like this one should have at least 200 participants (Israel, 1992). Therefore, the sample size for the household survey is short by 12 from the advised number of participants. But, an effort was also made to address this shortage by selecting 16 FGD participants who did not take part in household survey.

Furthermore, much effort was made to make sure the selected non-beneficiaries were similar to beneficiaries aside from the issue of project participation. They were selected making sure that they were all agro-pastoralists who owned/had owned certain number of livestock, and, most importantly, owned certain ha of land which is located along the flooding plain in Chifra Woreda. Both these factors are also defining characteristics of beneficiary agro-pastoralists and also hold true for selected non-beneficiaries.

### 3.6. Method of Data Analysis

#### Analyzing Environmental Rehabilitation

Primary data collected using household survey questionnaire regarding diversity and production of crops, yield, species diversity, and groundwater and surface water was analyzed by comparing the result obtained for both the households within the project and households outside the project.

Secondary data from GIZ Ethiopia was analyzed by making a 'before-after' analysis where the difference in the above-mentioned attributes were compared before and after the construction of water-spreading weirs for households who received the treatment.

This study also analyzed the effect water-spreading weirs have had in the reduction of erosion/gullies in Chifra Woreda along the flood plain. A study on the measurement of the geometry of gully erosion states that although there is uncertainty involved in the measurement of gullies due to the “wide range of variability in gully cross section shapes found in the field”, measuring their width and depth is widely used (Casalí, Giménez, & Campo-Bescós, 2015). Therefore, field data collected was collected of the depth and width of gullies around areas where the weirs are built and where they are not in order to compare to find out how much water-spreading weirs have alleviated erosion.

**Analyzing Food Security**

Responses from HFIAS household survey were used to generate the HFIAS Score for each household. This was done by summing the frequency-of-occurrence for the 9 food insecurity-related conditions. This ranged from 0 to 27, indicating the degree of insecure food access. Additionally, households were categorized as food secure, mildly food insecure, moderately food insecure, or severely food insecure (Coates et al, 2007). Table 8 shows how each household were classified.

Following this, the score of households who are part of the project was compared to that of those who did not. Additionally, food source and extent of reliance on food aid of both beneficiaries and non-beneficiaries were explored for comparison between the two groups. The number of months households go without/insufficient food was also quantified for both groups for comparison.

Table 10: HFIAS Score Category

| **Category** | **HFIAS Score** |
|---|---|
| Food secure | 0-1 |
| Mildly food insecure | 2-8 |
| Moderately food insecure | 9-16 |
| Severely food insecure | 17-27 |

Source: Coates et al, 2007

## CHAPTER 4: RESULTS AND DISCUSSION

### 4.1.Demographic and Socio-economic Characteristics

The basic demographic and socio-economic characteristics of household heads, such as sex, age, education level, family size and land size owned were analyzed. Although 79% - 85% of the respondents were male for both beneficiaries and non-beneficiaries, there was no statistical significance at 10% probability level in the difference in sex for both groups. This was also true for education level and family size as shown in Table 9. Most respondents were found to be male with up to 4 years of education and having 4-7 number of family members. The difference in age was found to be statistically significant at 10% probability level making the average beneficiary younger. The difference in land size owned was found to be statistically significant at 1% probability level. It ranged from 2 ha to 0.5 ha and had a mean of 1.16 ha among beneficiaries and 1.65 ha among non-beneficiaries. All respondents were engaged in crop and livestock production for their livelihood.

Table 11: Demographics Summary

| **Variable** | **Mean** | | **t-value** | **df** | **p-value** |
|---|---|---|---|---|---|
| | **Beneficiaries** | **Non-beneficiaries** | | | |
| Sex | 1.76 | 1.85 | 1.337 | 186 | 0.183*** |
| Age | 2.82 | 3.05 | 2.121 | 186 | 0.094** |
| Education | 1.68 | 1.49 | 2.238 | 186 | 0.145*** |
| Family Size | 2.39 | 2.67 | 2.128 | 186 | 0.124*** |
| Land Size | 1.158 | 1.653 | 5.817 | 186 | 0.000* |

Note: * and ** statistically significant at 1% and 10% probability levels, respectively.
*** is statistically insignificant at 10% probability level.

Source: Own computation

### 4.2. Production and Productivity

#### 4.2.1. Production, Productivity and Diversity of Crops

According to respondents, their most preferred crop for cultivation before the construction of the weirs was maize. This was true for both beneficiaries and non-beneficiaries. This was due to the fact that maize serves as food for the agro-pastoralists and feed for their livestock both in good season and in bad season. In bad seasons, even though the crop fails, they would still have feed for their livestock. Because of this assurance maize offers, it has been the most preferred crop in Chifra Woreda by agro-pastoralists. In addition, maize is also the dominant crop in the whole of Afar Region (CSA, 2017/18).

But after the construction of the weirs, GIZ supplied project beneficiaries with seeds for other high yielding and drought resistant food crop varieties and fodder varieties. Food crop seeds include maize, chickpea, cowpea, mung bean, sorghum and teff. Forage varieties include elephant grass, pigeon pea and lablab which are leguminous that can provide higher protein for livestock.

Secondary data showed that project beneficiaries cultivated all these crops both in the meher and belg season for the last two years (since the inception of the project/since the seeds were handed out) (Table 10 and 11).

Table 12: Crop and Fodder Production after the construction of Weirs in Meher Season 2017

| Crop Variety | Area (ha) | Yield (qt/ha) | | Production (qt) | |
|---|---|---|---|---|---|
| | | Air Dried Biomass | Grain Yield | Air Dried Biomass | Grain Yield |
| Maize | 26.5 | 161.3 | 59.9 | 4,274.5 | 1,587.4 |
| Cowpea | 3.7 | 34.8 | 13.4 | 128.8 | 49.6 |
| Sorghum | 1.2 | 167.0 | 62.0 | 406.8 | 74.4 |
| Mung Bean | 3.4 | 21.7 | 19.1 | 73.8 | 64.9 |
| Teff | 1.7 | 26.0 | 3.0 | 44.2 | 5.1 |
| **Sub Total** | **36.5** | **-** | **-** | **4,928.1** | **1,781.4** |
| **Fodder Variety** | | | | | |
| Cowpea | 4.4 | 60 | - | 264 | - |
| Elephant Grass | 0.3 | 600 | - | 180 | - |
| Pigeon Pea | 0.8 | 140 | - | 112 | - |
| Lablab | 4.3 | 80 | - | 344 | - |
| **Sub Total** | **9.8** | **-** | **-** | **900** | **-** |
| **Total** | **46.3** | | **-** | **5,828** | **-** |

Source: Tilahun, 2018

Table 13: Crop and Fodder Production after the construction of Weirs in Belg Season 2017

| Crop | Area (ha) | Yield (qt/ha) | |
|---|---|---|---|
| | | Air Dried Biomass | Grain Yield |
| Maize | 2.72 | 132 | 21 |
| Cowpea | 0.08 | 79 | 23 |
| Maize-Cowpea | 2.01 | - | - |
| Mung Bean | 1.5 | 18 | 12 |
| Elephant Grass | 0.16 | - | - |
| Pigeon pea | 0.46 | 71 | - |
| Lablab | 0.57 | 63 | - |
| Chickpea | 0.8 | 3.9 | - |
| **Total** | **8.3** | - | - |

Source: Tilahun, 2018

This study, on the other hand, found that although agro-pastoralists had adopted the cultivation of the above mentioned crops in two previous years, they have currently shifted back to cultivating predominantly maize only. FGDs revealed that this was because maize had the highest grain and feed yield in comparison to any other crop. Maize is also the dominant crop cultivated in the whole of Afar region. In addition, improved seeds of hybrid varieties of maize are available in the market and provided to the agro-pastoralists through the Woreda. The dominant hybrid maize variety found in the study area is BH-140. According to the Woreda Agriculture Office, this hybrid maize variety is also wildly cultivated in other Zones and Woredas of the Afar region. This is because maize produces high grain yield and stalk as well as leaf than any other food and forage crop. It is also responsive to inputs such as fertilizer, moisture, and improved crop management practices such as weeding and hoeing. Thus, although lablab and other leguminous forage species have higher nutrient value for livestock, maize has a dual purpose and much higher feed yield.

The agro-pastoralists also stated that worsening climatic conditions has led to their choice of a crop that offered a higher guarantee of grain and feed yield. Table 12 shows the current level of production and yield in the same area by the same agro-pastoralists (project beneficiaries) as found by this study.

Table 14: Crop Production and Yield of Beneficiaries

| Crop | Area (ha) | Total Production (qt) | Average Grain Yield (qt/ha) |
|---|---|---|---|
| Maize | 44 | 2,213 | 58.26 |
| Teff | 4 | 4 | 2.82 |
| **Total Land** | **48** | **-** | **-** |

Source: Own computation

It can be seen from Table 14 that at the present time, beneficiaries all together cultivated 48 ha of land and produced 2,213 qt and 4 qt of maize and teff, respectively. The average yield of their land was 58.26 qt/ha and 2.82 qt/ha for maize and teff, respectively.

### 4.2.2. Comparing Beneficiaries against Non-beneficiaries and other regions

We can see from Tables 12, 13 and 14 that the agro-pastoralists situated within the water-spreading weirs have a high yield both in grain for food and feed for their livestock. To put this into perspective, Table 15 compares beneficiaries' grain yield of maize, sorghum, teff and mung bean against sampled non-beneficiaries, the whole of Afar region, other selected regions and Ethiopia.

Table 15: Comparing Current Maize Yield (qt/ha)

| Crop | Beneficiaries | Non-beneficiaries | Afar | Amhara | Oromia | SNNP | Tigray | Ethiopia |
|---|---|---|---|---|---|---|---|---|
| **Maize** | 58.26* | 18.37* | 32 | 39.83 | 35 | 30.75 | 25.59 | 39.44 |
| **Sorghum** | 62 | - | - | 26.49 | 24.8 | 20.4 | 28.52 | 27.26 |
| **Mung Bean** | 19 | - | - | 12.73 | - | 9.31 | - | 12.35 |
| **Teff** | 2.82* | - | - | 17.92 | 17.88 | 14.93 | 15.37 | 17.48 |

Note: * is for findings of this study.

Source: Tilahun, 2018 and CSA, 2017/18

As can be seen numerically from Table 15, there is clear difference in the yield of maize, sorghum and mung bean when comparing with the results of beneficiaries against that of sampled non-beneficiaries, the regional, other selected regions and the national average. It can be seen that beneficiaries are able to produce more than 3 times higher maize gain on average than sampled non-beneficiaries, almost double than that of the regional average and 1.5 times than the national average. In addition, it can also be seen that teff is cultivated among beneficiaries when it is not cultivated by non-beneficiaries and not registered in Afar Region by CSA. But, its average yield is far below the national average (2017/18). Teff is a very resilient crop as it grows both on water logged soils and dry areas. In addition, teff can be stored longer when necessary and its "*chid*" is an excellent feed source. Therefore, this is a positive contribution towards food and feed production. The introduction of mung bean is also a very positive trend. Mung bean is an early legume crop that matures in less than 60 days. In addition, it is a good cash crop that is traded in ECX floor (MoA, 2018).

The results obtained in this study are in agreement with GIZ and KfW (2012), Bender (2012) and Schöning et al (2012). GIZ and KfW (2012) showed that because of the weirs, rehabilitated regions in Burkina Faso, Niger and Chad saw an increase crop yield. This was because the weirs increased the supply of water in the area from the incoming flood which carries with it soil from nearby elevations. Hence, fine soil was deposited within the area where the weirs were built and organic matter of soils also increased.

As discussed in the above mentioned studies, the findings presented in this study in agreement shows the significant increase in production and yield of crops as a result of the construction of the weirs in Chifra Woreda.

### 4.2.3. Comparing Beneficiaries and Non-beneficiaries

Since maize is the dominant crop for both groups, the yield for maize will be used to compare the two groups before and after the construction of the water-spreading weirs. Before the construction of the weirs, there was little difference in the maize yield between beneficiaries and non-beneficiaries which has been found to be statistically insignificant (Table 14). But after the construction of the weirs, there is a statistically significant difference in the yield of maize between beneficiaries and non-beneficiaries. It has been found that beneficiaries are able to harvest an average of 39.89 qt/ha of maize more than non-beneficiaries. A difference of 39.89 qt/ha of yield between the two groups represents a potential economic value of 43,879 birr according to the current retail price of maize in

Chifra Woreda. This represents amount of production non-beneficiaries are foregoing or missing out in monetary terms.

Table 16: Statistical Comparison of Maize Yield

| **Descriptive and Inferential Statistics** | | ***BEFORE*** | ***AFTER*** |
|---|---|---|---|
| Mean Yield | Beneficiaries | 18.92 | 58.26 |
| | Non-beneficiaries | 19.24 | 18.37 |
| Mean Difference | | 0.32 | 39.89 |
| t-value | | 0.65 | 121.67 |
| Df | | 186 | 158 |
| p-value | | 0.52* | 0.000** |

Note: * is statistically insignificant at 10% probability level.
** is statistically significant at 1% probability level.
Source: Own computation

This result is also in agreement with GIZ and KfW (2012), Bender (2012) and Schöning et al (2012). As discussed in these studies, the findings in this study also show the significant increase in production and yield as a result of the construction of the weirs. Hence, this leads to the conclusion that beneficiaries are better off than non-beneficiaries on average as such significant increased level of production and yield have positive implications on income and food security.

### 4.2.4. Production of Livestock

As livestock production is an integral part of the livelihood of agro-pastoralists, this study also covered the ownership of livestock, number sold annually, estimated income generated from livestock sells annually, annual livestock deaths and its cause.

It was found that beneficiaries owned a greater number of livestock on average when compared to non-beneficiaries. This was true for cattle, goats, sheep, camels and donkeys. Beneficiaries owned 16 cattle, 14 goats, 2 sheep, 3 camels and one donkey more than non-beneficiaries on average. As shown in Table 15, the difference in livestock ownership has been found to be statistically significant at varying probability levels.

Table 17: Livestock Owned

| Livestock Owned | Mean Value | | t-value | df | p-value |
|---|---|---|---|---|---|
| | Beneficiaries | Non-beneficiaries | | | |
| Cattle | 21 | 5 | 19.209 | 186 | 0.000* |
| Goat | 24 | 10 | 15.097 | 186 | 0.000* |
| Sheep | 10 | 8 | 2.715 | 186 | 0.007** |
| Camel | 11 | 8 | 2.899 | 186 | 0.004** |
| Donkey | 3 | 2 | 2.710 | 186 | 0.007** |

Note: * and ** are statistically significant at 1% and 5% probability levels, respectively.
Source: Own computation

It is important to note that increased number of livestock has an implication on food security for agro-pastoralists. Primarily, the various types of dairy products they get from them makes livestock a source of food. In addition, having oxen means being able to farm. During the survey, 14% of non-beneficiaries have stated that all their oxen have died and do not know how they are going to be able to farm in the coming rainy season.

Furthermore, it was also found that beneficiaries earned a higher income annually on average from selling their livestock when compared to non-beneficiaries. As shown in Table 16, beneficiaries earn an average amount of 22,130 birr more annually than non-beneficiaries from livestock sales. This difference was found to be statistically significant at 1% probability level. Hence, it can again be concluded that beneficiaries are better off that non-beneficiaries on average.

Table 18: Livestock Income

| Descriptive and Inferential Statistics | Mean Value | | t-value | df | p-value |
|---|---|---|---|---|---|
| | Beneficiaries | Non-beneficiaries | | | |
| Income earned annually | 30,260 | 14,370 | 11.420 | 186 | 0.000* |
| Min. | 15,000 | 7,000 | | | |
| Max. | 54,000 | 30,000 | | | |

Note: * is statistically significant at 1% probability level.

Source: Own computation

In inquiring about the wellbeing of the livestock of agro-pastoralists, if was found that on average that beneficiaries have less number of their livestock die when compared to non-beneficiaries. This was also true for cattle, goats, sheep, camels and donkeys. There was a difference of almost two deaths in cattle, more than 4 deaths in goats and almost 3 deaths in sheep on average. Although it is not common for camel and donkey deaths, there is still more deaths occurring among non-beneficiaries' livestock.

Table 19: Livestock Annual Deaths

| **Livestock** | **Mean Value** | | **t-value** | **df** | **p-value** |
|---|---|---|---|---|---|
| | **Beneficiaries** | **Non-beneficiaries** | | | |
| Cattle | 0.66 | 2.44 | 7.942 | 163 | 0.000* |
| Goat | 0.97 | 5.24 | 14.553 | 113 | 0.000* |
| Sheep | 1.84 | 4.71 | 3.094 | 186 | 0.002** |
| Camel | - | 0.12 | 2.264 | 149 | 0.000* |
| Donkey | - | 0.12 | 2.264 | 149 | 0.000* |

Note: * and ** are statistically significant at 1% and 5% probability levels.

Source: Own computation

### 4.3.Availability of Water and Feed

With regards to availability of surface water and feed, all beneficiaries stated that water-spreading weirs significantly alleviated water and feed shortage problems. They also stated that before the construction of the weirs, they used to stay away from their homes looking for grazing land and water for an average of 7 months in a year. But now after the construction of the weirs, they only travel for an average of a month in search of water for their livestock. During this time, the entire family does not travel away as opposed to previous times. Instead, children take some of the livestock and travel for some weeks. Presently, they only travel "sometimes" to the nearby Mille River to fetch water for drink. Although they travel the same distance before and after the construction of the weirs (to Mille River to fetch drinking water), all beneficiaries stated that the weirs have decreased the frequency of travel and have significantly alleviated water shortage in doing so. Additionally, they stated that since as a result of the weirs their production of crops has increased, their feed shortage has been alleviated also. When making the before-after comparison for beneficiaries, the difference in the number of months of travel in search of water and feed has been found to be statistically significant at 1% level of probability (Table 19).

Non-beneficiaries, on the other hand, used to spend an average of 7 months in search of water and grazing land before the construction of the weirs. They stated that they still spend that many months away from their homes in search of water and grazing land and travel with the same frequency after the construction of the weirs. Some of them stated that they travel even greater distances than they used to few years ago (using the construction of the weirs as a time reference). An agro-pastoralist stated that it has been two years since his children left home with his livestock in search of water and grazing land and have not come back home since. But, on average, the before-after comparison for the months of travel for non-beneficiaries in search of water and feed has been found to be insignificant at 10% level of probability.

Table 20: Water Availability Comparison

| **Variable** | **Timeline** | **Beneficiaries** | **Non-beneficiaries** |
|---|---|---|---|
| **Frequency** | BEFORE | Often | Often |
| | AFTER | *Sometimes | *Often |
| **Month** | BEFORE | 7.08 | 7.34 |
| | AFTER | **1.03 | ***7.40 |

Note: *The t-value and p-value cannot be computed because the standard error of the difference is 0.
** is significant at 1% level of probability with t-value: 68.97 and df: 99.685.
*** is insignificant at 10% level of probability with t-value: 1.254 and df: 45.625.

Source: Own computation

Furthermore, when inquiring about groundwater level increase in the study area resulting from the increased soil infiltration caused by the weirs, it was found that digging wells in order to get water is not the custom in Chifra Woreda and is not even considered by the agro-pastoralists as an option for sourcing water. This was found to be true both for beneficiaries and non-beneficiaries.

### 4.4.Environmental Rehabilitation

#### 4.4.1. Erosion/Gully Prevention

This study also investigated the contribution of the weirs to decreasing erosion by measuring the depth and width of gullies in areas where the weirs are constructed and where they are not.

During the field survey, it was found from 13 sampled spots that gullies were 0.45 cm wide and 0.76 cm deep on average in areas where the weirs are constructed. In most places there were no gullies to be measured (Figure 12). The largest depth in these sites was found to be 80 cm deep and 1.2 meters wide. (By chance, it had rained for the first time in two years during this study. Therefore, these pictures were taken and measurements were made the morning after that so as to find out the magnitude erosion prevention.)

Figure 12: Erosion in sites where Weirs are constructed

On the other hand, in sites where weirs are not constructed, gullies were found to be 2.93 meters deep and 5.85 meters wide on average from 14 sampled spots.

Figure 13: Eroded sites where Weirs are not constructed

Additionally, households were also asked what the difference was in gullies and erosion in sites where the weirs are constructed and where they are not. Both beneficiaries and non-beneficiaries stated that the sites where the weirs are now found had gullies as deep as 4-5 meters. But these sites now have “no gullies” in them. On the contrary, the devastation of the land where non-beneficiaries are located is very severe that some gullies in these areas are so wide and deep that some agro-pastoralists covered in this study have stated that some of their neighbors moved to other kebeles because they had lost their entire farm land due to erosion.

Figure 14: The Devastation of Erosion

The findings of this study are in line with Ackermann et al (2014), GIZ & KfW (2012), Schöning et al (2012) and Bender (2012). In studying the impact of weirs for 12 years, these studies had shown that weirs had reduced land degradation and erosion in West Africa.

### 4.4.2. Vegetation Cover

The study revealed that the total vegetation cover within the coverage of the water-spreading weirs is 48 ha. This land is owned by 38 agro-pastoralists. As verified and clarified in FGDs and key informant interviews, this land was previously inhibited by the project beneficiaries. But since it was severely eroded by flash floods coming from the bordering highlands from Amhara region, these agro-pastoralists only cultivated the land once a year and had only one harvest season. Due to this, they used to travel to other areas for the rest of the year. In addition, due to the severe erosion, there were very wide and deep gullies in the area that prevented them from cultivating their whole land because the flood tore through it and carried away portions of it (Figure 15, picture on the left). As a result, they had reduced cultivable land size and had close to zero vegetation cover throughout the year with the exception of the single harvest season.

But at the present time, since the weirs capture and spread out flood water that carries with it fertile soil from Amhara Region's bordering highlands, the gullies have been filled which in turn have enabled the agro-pastoralists to cultivate their entire land (Figure 15, picture on the right). This land is now owned and cultivated by agro-pastoralists twice a year, each owning an average of 1.16 ha. Hence, it can be argued that the water-spreading weirs in the area have increased cultivable land and vegetation cover.

Figure 15: Land with and without Water-spreading Weirs

This result is in agreement with GIZ and KfW (2012), an impact study on water-spreading weirs conducted in West Africa where the weirs were first introduced 19 years ago.

Concurring with this evidence, this study has also shown that water-spreading weirs have also increased cultivable land size for agro-pastoralists in Chifra Woreda just after 3 years of construction.

### 4.5.Other Erosion Prevention Activities in the area

Additionally, during field survey, it was found that digging pits and placing large rocks in the path of the flood water were other effective methods of erosion prevention, recharging ground water and also source of water for the agro-pastoralists.

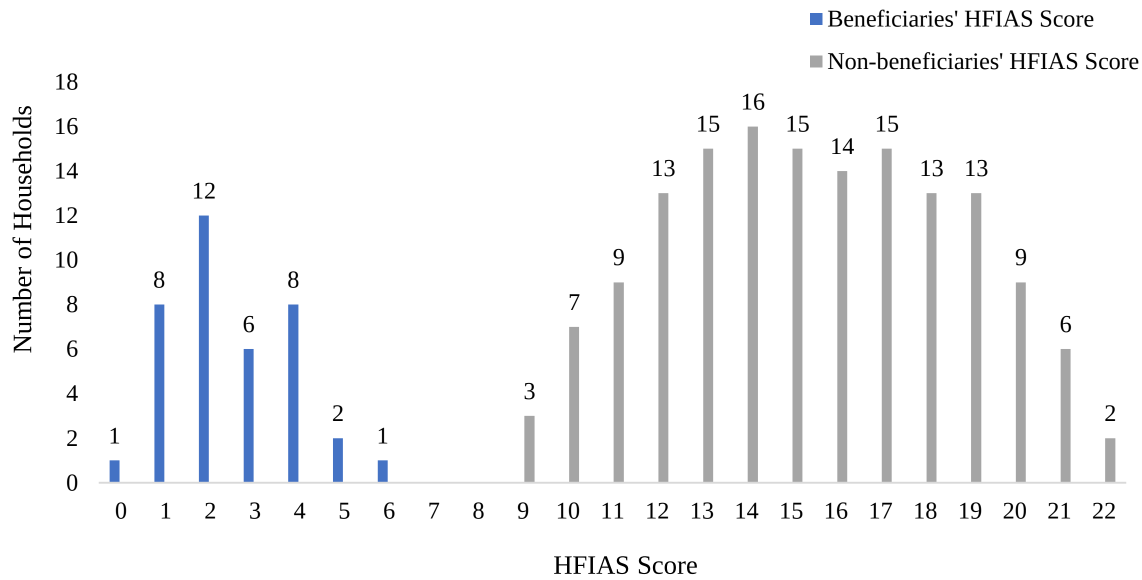
Figure 16: Other SLM Activities

**4.6.Food Security**

In order to give an indication of the food security of households, this study used a household food insecurity measuring indicator called HFIAS that is used to generate a HFIAS Score for each household (shown in Table 8, Section 3.5).

It can be seen from Figure 17 below that households that are situated within the weirs (beneficiaries) were much less food insecure than those who are not (which means they had much lower HFIAS score than non-beneficiaries). It can also be seen from Table 20 that the average beneficiary had a HFIAS score of 2.58, while the average non-beneficiary had a score of 15.37.

Figure 17: HFIAS Score of Households




Source: Own computation

Table 21: HFIAS Score Descriptive Statistics

| Descriptive Statistics | HFIAS Score | | Difference |
|---|---|---|---|
| | Beneficiaries | Non-beneficiaries | |
| Average | 2.58 | 15.37 | -12.79 |
| Min. Score | 0 | 9 | -9.00 |
| Max. Score | 6 | 22 | -16.00 |

Source: Own computation

In addition, after generating the score, Table 8 (in Section 3.5) was used to categorize each households into four groups, food secure, mildly food insecure, moderately food insecure and severely food secure (shown Table 21 below). It can be seen from the table that beneficiaries have fallen under the food secure and mildly food insecure categories, while non-beneficiaries have fallen under the moderately food insecure and severely food insecure categories. This difference was also found to be statistically significant at 1% probability level. Hence, it can be concluded that project beneficiaries are more food secure that non-beneficiaries.

Table 22: HFIAS Category based on Households' Score

| Category | Beneficiaries | | Non-beneficiaries | | p-value |
|---|---|---|---|---|---|
| | **Number** | **Percentage** | **Number** | **Percentage** | |
| Food secure | 9 | 24% | - | - | **0.000*** |
| Mildly food insecure | 29 | 76% | - | - | |
| Moderately food insecure | - | - | 78 | 52% | |
| Severely food insecure | - | - | 72 | 48% | |
| **Total** | **38** | **100%** | **150** | **100%** | |

Note: * is significant at 1% level of probability.
Source: Own computation

The results of this study agrees with the findings of GIZ and KfW (2012), Bender (2012) and Schöning et al (2012). These studies stated that the construction of weirs assures the food security of households by increasing their crop production levels.

With regards to reliance on food aid, this study found that 98% of non-beneficiaries receive food aid while 42% of beneficiaries receive food aid as shown in Table 22. This difference was also found to be statistically significant at 1% probability level.

Table 23: Food Aid Received

| Group | Receive Food Aid | | Do not receive Food Aid | | p-value |
|---|---|---|---|---|---|
| | **Number** | **%** | **Number** | **%** | |
| Beneficiaries | 16 | 42% | 22 | 58% | **0.000*** |
| Non-beneficiaries | 147 | 98% | 3 | 2% | |

Note: * is significant at 1% level of probability.
Source: Own computation

When further inquiring about food aid receipts and dependence of food aid during FGDs and key informant interviews, non-beneficiaries stated that they rely on food aid for 6 months in a year. They also sell their livestock to buy food for themselves, eat just once a day, eat foods that are not meant for humans (eg. "*furishka*"), borrow feed from their neighbors and relatives some of whom are project beneficiaries. Beneficiaries also testified that they have relatives with whom they share their produce who are not part of the project.

This finding also concurs with Indris and Adam (2013), a study that investigated food insecurity and coping strategies of agro-pastoralists in Chifra Woreda. The study had shown that food insecurity was a prevalent condition in the woreda showing that 65.8% of sampled households were food insecure.

### 4.7.Contribution towards Food Security

Focusing more closely on food security, the following section shows the contribution livestock sales, increased yield and project participation (owning land within a water-spreading weir) made on food security for agro-pastoralists. It also shows which of these made a larger contribution using linear regression analysis.

Table 24: List of Variables

| **Variable** | **Type** | **Definition** | **Measurement** |
|---|---|---|---|
| **Dependent Variable** | | | |
| HFIAS | Continuous | Food insecurity score of households | Scale ranging from 0-27 |
| **Independents Variable** | | | |
| Project participation | Dummy | Beneficiary or Non-beneficiary | 1=Yes, 0 =No |
| Income | Continuous | Income earned from livestock sales | Ethiopian Birr ('000) |
| Yield | Continuous | Yield of Maize | Qt/ha |

Source: Own compilation

The bivariate correlations between the above listed variables shown in Table 24 shows that there was strong relationship between each pair of the variables. Since HFIAS is a measure of food insecurity, there is a strong negative relationship between it and the rest of the variables. For the rest of the variables, there is a strong positive relationship between each pair.

Table 25: Pearson's Correlation Matrix of Variables

| **Variable** | HFIAS | Yield | Income | Participation |
|---|---|---|---|---|
| HFIAS | 1.000 | -0.915 | -0.786 | -0.869 |
| Yield | | 1.000 | 0.780 | 0.984 |
| Income | | | 1.000 | 0.723 |
| Participation | | | | 1.000 |

Source: Own computation

The unstandardized coefficients of independent (explanatory) variables generated using linear regression is shown in Table 25. All coefficients were found to be statistically significant showing that they all account for a significant amount of unique variance in the level of food insecurity (HFIAS Score) of agro-pastoralists. This means that the amount of variance that each of them accounts for (explains or predicts) in the level of food insecurity unique to itself is statistically significant.

Table 26: Coefficients of Variables

| **Variables** | **Unstandardized Coefficients** | **Standardized Coefficients (Beta weights)** | **Std. Error** | **t-value** | **p-value** |
|---|---|---|---|---|---|
| (Constant) | 40.555 | - | 3.374 | 12.018 | 0.000* |
| Yield | -0.622 | -1.713 | 0.065 | 9.575 | 0.000* |
| Income | -0.57 | -0.085 | 0.031 | 1.850 | 0.066** |
| Participation | -12.937 | -0.879 | 2.387 | 5.420 | 0.000* |

Note: * and ** are statistically significant at 1% and 10% levels of probability.

Source: Own computation

The model that is derived from the table above is shown below.

$$\mathbf{HFIAS = 40.555 - 0.622Yield - 0.57Income - 12.937Participation}$$

It can be seen from the model that an increment in the yield of maize by 1qt/ha reduced the level of food insecurity (HFIAS Score) of agro-pastoralists who earned the same amount of income from livestock sales and had the same level of participation in the project by 0.622 points. This was found to be statistically significant at 1% level of probability. Moreover, an addition of a thousand Birr in income generated from livestock sales reduced the level of food insecurity of agro-pastoralists who had the same yield of maize and the same level of project participation by 0.57 points. This was also found to be statistically significant at 10% level of probability. Participating in GIZ's project (owning land within a water-spreading weir) reduced the level of food insecurity of agro-pastoralists who had the same yield of maize and the same amount of income from livestock sales by 12.937 points. This was found to be statistically significant at 1% level of probability. Hence, it can be concluded that water-spreading weirs, the resulting increased yield of maize and livestock income reduce the level of food insecurity (HFIAS Score) of agro-pastoralists in Chifra Woreda in that particular order.

It is also important to note here that for this regression model, the constant is deemed to be meaningless. The rule for interpreting the constant is that it is the mean of the dependent variable when all coefficients of independent variables are zero. But in cases where at least one of the coefficients of the independent variables cannot be zero, the constant is regarded meaningless. In this particular model, it is impossible to have all coefficients of all independent variables set at zero. This is because all surveyed households are agro-pastoralists who own a certain hectare of land, cultivate a certain crop and own a certain number of livestock, and therefore, have a livelihood based on crop cultivation and livestock rearing. Due to this, it is reckoned that the constant holds no meaning.

Table 27: Summary of Fit

| **Model Summary** | |
|---|---|
| $R^2$ | 0.872 |
| Adjusted $R^2$ | 0.869 |
| Std. Error of the Estimate | 2.142 |

Source: Own computation

Therefore, owning a land within the coverage of the weirs had the highest contribution in alleviating food insecurity in Chifra Woreda, followed by increased yield of maize and income from livestock sales. It can be concluded that water-spreading weirs have significantly mitigated and relieved food insecurity in Chifra Woreda.

Table 27 shows how much of the variation in the level of food insecurity of agro-pastoralists (HFIAS Score) is explained by the above regression model. It can be seen that 87% of the variation in average the level of food insecurity (HFIAS Score) of agro-pastoralists is explained by variability in project participation, yield of maize and income generated from livestock sales when taken as a set. Therefore, the model is a good fit.

Table 28 below presents the ANOVA test to check whether the above shown $R^2$ is significantly greater than zero. As can be seen from the p-value, it is significantly greater than zero. This means that project participation, yield of maize and income generated from livestock sales are able to account for a significant amount of the variance in the level of food insecurity (HFIAS Score) of agro-pastoralists in Chifra Woreda. This also means that the overall regression model was significant, $F(3,184) = 416.24$, $p<0.001$, $R^2 = 0.87$.

Table 28: The ANOVA Table

| | **Sum of Squares** | **df** | **Mean Square** | **F-value** | **p-value** |
|---|---|---|---|---|---|
| Regression | 5727.52 | 3 | 1909.18 | 416.24 | 0.000* |
| Residual | 843.97 | 184 | 4.59 | | |
| Total | 6571.49 | 187 | | | |

Note: * is statistically significant at 1% level of probability.

Source: Own computation

Furthermore, F-test was used to test the overall statistical significance between the dependent variable (level of food insecurity of agro-pastoralists) and the independent variables (project participation, yield of maize and income generated from livestock sales). The null hypothesis says all coefficients in the model equal zero and the alternative says that not all of them equal zero. Comparing the F-value from the ANOVA table (Table 28) to the critical value of F (0.05, 3, 184) which was found from the F-Distribution Table (at $\alpha = 5\%$) showed that the F-value from the ANOVA table (416.236) was greater than the critical F-value (8.53). This has led to the rejection of the null hypothesis which means that there is a statistical significance in the regression relation between the dependent and independent variables.

### 4.8.FGDs Summary

FGD were held for both beneficiaries and non-beneficiaries. They were used to gather qualitative data and clarify some patterns of responses observed in the household survey. All participants in both groups unanimously stated that water-spreading weirs are tremendously impact the livelihood of agro-pastoralists positively.

Beneficiaries stated how there is a stark difference in their level of production and productivity of crops, livestock production, water and feed availability and income generated from livestock sales when compared to non-beneficiaries in the two years of the project. They have stated that although the weirs are able to increase the diversity of crops they cultivate and had successfully done so in the first year of the project, they now cultivate mainly maize because it has the highest yield of grain and feed when compared to other crops. The weirs have augmented their level of production of maize which serves as source of food and feed for their livestock. It has also led to increased livestock ownership and much less number of livestock deaths which is attributed to the increased water and feed availability made possible by the weirs. They also earn higher income from livestock sales which they sell whenever they are in need of cash in order to buy anything for their household, like clothes for their children. They also stated that they received all the help they require from the woreda's agricultural bureau with regards to farming methods. In addition, they stated that they have witnessed the regeneration of local grass species that had been lost in previous years because of the severe flooding and erosion.

Moreover, beneficiaries stated that some of them have received training on how to keep maintaining the weirs in future years. When asked about how they plan to use those skills to sustain the weirs in the future, answers given were found to be insufficient. Some even clearly said they expect GIZ to keep coming and do the work of maintenance and supplying high yielding and drought resistant crops. They also stated that they do not have plans of sharing the cost of the construction of the weirs because it is too expensive for them.

The fact that beneficiaries expect GIZ to keep maintaining the weirs and keep supplying high yielding and drought resistant crops for them is a serious issue that needs to be addressed and may mean the success of this project could be short lived putting its future success in jeopardy.

Non-beneficiaries also acknowledge the stark difference that exists between them and beneficiaries. Some even stated that they are being treated unfairly by GIZ. They stated that they suffer from sever poverty, hunger, livestock deaths and continued loss of their cultivable land due to the severe erosion. Some household heads stated that it has been years since their children and livestock have relocated to other areas since living in Chifra has caused devastating losses for them. The women that have stayed behind travel half a day (the whole day for two way travel) to fetch water from the nearby Mille River to provide drinking water for the ones who have stayed behind. They are stated that their future look very grim and are desperate for help.

### 4.9.Key Informant Interviews Summary

Interviews held with a community leader and Chifra Woreda agricultural officer revealed the similar results as with the FGDs and household interviews. They showed that before the construction of the weirs, agro-pastoralists in Chifra Woreda used to suffer from the devastating flash floods multiple times a year that come from the neighboring Amhara Regions' highlands. In addition, the prevalent situation before the construction of the weirs was annually lowering production and productivity levels of crops, decreasing cultivable land size, persistent water and feed shortages, livestock deaths and deepening poverty. But this situation has completely changed for beneficiaries.

Although there are clear differences between beneficiaries and non-beneficiaries, there has not been any reports of conflicts or raidings between the two because the agro-pastoralists that live in this area are from the same clan. Because of this, beneficiaries also share from the abundance of their produce to some non-beneficiaries especially to their close relatives.

Therefore, in addition to the bylaws that are in place that govern communities, being from the same clan has promoted a more peaceful living in the area among agro-pastoralists.

Furthermore, the key informant interview with a GIZ field officer has also reiterated the same success achieved by GIZ with the weirs they had built in 2015 and shared that they also have plans of expanding the project as a result of that. But the interviewee also highlighted his concern over the sustainability of the project in the woreda. Although GIZ has trained some beneficiaries on how to keep maintaining the weirs, there is concern whether agro-pastoralists who do not have experience in construction would take the initiative to maintain the weirs in the years to come.

# CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS

## 5.1. Conclusions

With water stress being the most prevailing phenomenon in drylands, it has been known to be a major challenge for the livelihood of pastoralists and agro-pastoralists (Koohafkan & Stewart, 2008; UNEMG, 2011; Davies, 2017). Cognizant of this, GIZ's water harvesting technique called water-spreading weirs first implemented in West Africa have now been introduced in Chifra Woreda in Afar Region. This technique has been known to increase vegetation cover, production and yield, and decrease erosion, land degradation and improve food security. After three years of the implementation of this project, assessing the effect it has had on beneficiaries and their livelihood revealed that the results in Chifra Woreda were similar to that of the results found in West Africa.

This study found that the constructed water harvesting technique called water-spreading weirs increased cultivable land and vegetation cover in the woreda by filling wide and deep gullies that had been rampant in the agro-pastoralists' farm lands. Both beneficiaries of the project and non-beneficiaries predominantly cultivate maize, the most dominant crop in the whole region of Afar. This is because maize has a very high grain yield for food and feed for their livestock. It is also highly responsive to fertilizers. Due to this, maize production and yield was used as a factor of comparison between beneficiaries and non-beneficiaries.

In line with this, this study found that beneficiaries had statistically significant larger maize production levels than sampled non-beneficiaries, the regional and national average. In addition, the production level of beneficiaries was found to be much higher than what they used to produce before the implementation of the water harvesting technique called water spreading weirs.

With regards to livestock ownership and income generated from livestock sales, it was found that beneficiaries owned significantly higher cattle, goats, sheep, camels and donkeys. It was also found that they earned more than non-beneficiaries from livestock sales. Livestock death occurs in both groups. It is caused by three major reasons: dry spells, shortage of feed and lack of vaccination services. Although this is experienced by beneficiaries also, shortage of feed is not a cause for them.

Water-spreading weirs were also found to alleviate water and feed shortage for beneficiaries. In comparison to non-beneficiaries, they were found to travel much less number of months away from their homes in search of water and animal feed. They also travelled less frequently to the nearby Mille River in search for drinking water. Therefore, is has been found that the increased water availability made possible by the weirs had also resulted in increased production, productivity, feed availability and livestock ownership.

Moreover, the contribution of the weirs in reducing land degradation was found to be immense. The depth and width of gullies was been found to be very little to zero in sites where weirs are constructed. Since the weirs capture and spread flood water that carries with it fertile soil, gullies that were 4-5 meters deep are now plain and are being used by agro-pastoralists for farming.

In addition, the increased production level and yield of food crops and the alleviated shortage of feed and water for humans and livestock were found to considerably contribute towards food security. After being part of the project of the weirs for two years, beneficiaries were found to be much less food insecure than non-beneficiaries.

Regression analysis also revealed that owning a land within the coverage of the weirs had the highest contribution in alleviating food insecurity in Chifra Woreda, followed by increased yield of maize and income from livestock sales. It can be concluded that water-spreading weirs have significantly mitigated and relieved food insecurity in Chifra Woreda.

In general, water-spreading weirs are found to be instrumental in improving the lives of households who own land and situated within their coverage. They have also made them significantly better off than other households. They also have the potential to greatly reduce the number of people that need to be resettled in Afar Region and the Awash Basin due to the devastation caused by floods, drought, poverty and food insecurity. It has led to the conclusion that water-spreading weirs are instrumental water harvesting techniques and highly suitable for Chifra Woreda that can be used as a method of achieving both agricultural and environmental sustainability objectives.

### 5.2. Recommendations

This study recommends the expansion of the water-spreading weirs not only in Chifra Woreda among sites (*"gots"*) that are found along the flooding plain (downstream) but also in other woredas that are severely eroded and have very deep and wide gullies. Among these, Mille and Ewa Woreda are highly recommended.

Providing training to the local agro-pastoral community on how to maintain the already constructed weirs is also recommended. When the incoming flood fills the gullies and over a period of time also fills the one meter high dam-like barriers, the local community needs to know how they can add one more meter high on the already built weir.

Additionally, introducing other high yielding and drought resistant crops like sweet potato that yield food for humans and feed for livestock higher than or as high as maize is also advantageous. This would be instrumental in further improving food security.

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# Appendices

## Annex 1: Household Questionnaire

**Section 1: Background**

| No. | Question | Answer |
|---|---|---|
| 1.1. | Kebele | |
| 1.2. | Village Name | |
| 1.3. | Household ID | |
| 1.4. | Name of Enumerator | |
| 1.5. | Time and Date | |

**Section 2: General Household Characteristics**

| No. | Question | Answer |
|---|---|---|
| 2.1. | Sex of Household head | 1 = Female, 2 = Male |
| 2.2. | Age of household head | 1 = <20, 2 = 21-30, 3 = 31-40, 4 = 41-50, 5 = 51-60, 6 = >61 |
| 2.3. | Marital Status | 1 = Single, 2 = Married, 3 = Divorced, 4 = Separated, 5 = Widowed/Widower |
| 2.4. | Education level of household head (number of education years) | 1 = 0, 2 = 1-4, 3 = 5-8, 4 = 9-12, 5 = >12 |
| 2.5. | Family size | 1 = <3, 2 = 4 - 5, 3 = 6-7, 4 = 8-9, 5 = >10 |
| 2.6. | Number of children living in the house | |
| 2.7. | Number of children attending school | |
| 2.8. | Own land | 1 = Yes, 2 = No |
| 2.8.1. | Ownership type | 1 = Permanently owned, 2 = Clan/communal, 3 = Rented, 4 = Other ________________ |
| 2.8.2. | Land size owned | |
| 2.8.3. | Own land near weir | 1 = Yes, 2 = No |
| 2.8.4. | Percentage from total land | |
| 2.8.5. | What is it used for? | 1 = Crop cultivation, 2 = Forage, 3 = Other ________________ |
| 2.9. | Use of farm inputs | 1 = Yes, 2 = No (if no, jump to 2.9.6) |
| 2.9.1. | Where do you get them from? | 1 = Government/PADO, 2 = ICRISAT, 3 = Other research institute, 4 = NGOs, 5 = Market, 6 = Other ________________ |
| 2.9.2. | If no, why | 1 = The soil is fertile, 2 = Inputs are not available, 3 = Inputs are too expensive, 4 = Collateral is required for credit, 5 = Other ________________ |
| 2.10. | Access to credit | 1 = Yes, 2 = No |
| 2.11. | Distance traveled from the nearest market in hours? | |
| 2.12. | Are you a project beneficiary? | 1 = Yes, 2 = No |

**Section 3: Crops (ለምግብነት የሚውል) Cultivated and Sold *Annually* in *Kg*, Income earned in Birr and Yield in Kg/ha**

| Period | Question | 3.1.<br>*Maize/ በቆሎ* | 3.2.<br>*Cowpea/ የላም አተር* | 3.3.<br>*Sorghum / ማሽላ* | 3.4.<br>*Mung Bean/ ማሾ* | 3.5.<br>*Teff/ ጤፍ* | 3.6.<br>*Perennial* crops |
|---|---|---|---|---|---|---|---|
| **Current Period (*Previous year*)** | 1. Cultivation | | | | | | |
| | 2. Amount sold | | | | | | |
| | 3. Income earned | | | | | | |
| | 4. Yield (kg/ha) | | | | | | |
| **Previous Period (*5 years ago*)** | 5. Cultivation | | | | | | |
| | 6. Amount sold | | | | | | |
| | 7. Income earned | | | | | | |
| | 8. Yield (kg/ha) | | | | | | |
| 3.7. | Most preferred crop currently | | | | | | |
| 3.8. | Most preferred crop 5 years ago | | | | | | |
| 3.9. | Why this preference (if there is change or has remained the same)? | | | | | | |

**Section 4: Fodder Crops (ለመኖ የሚውል)) Cultivated in the previous year**

| Question | 4.1. | 4.2. | 4.3. | 4.4. | 4.5. |
|---|---|---|---|---|---|
| **Crop cultivated annually in kg** | ***Cowpea/ የላም አተር*** | ***Elephant Grass/ የዝሆን ሳር*** | ***Pigeon Pea/ የእርግብ አተር*** | ***Lablab/ ላብላብ*** | ***Other*** |
| 1. Current Period | | | | | |
| 2. Previous Period | | | | | |

**Section 5: Livestock Herd Size and Income earned from Annual Sales in the previous year**

| Question | 5.1.<br>*Cow/Oxen* | 5.2.<br>*Goats* | 5.3.<br>*Sheep* | 5.4.<br>*Camels* | 5.5.<br>*Mules/Donkeys* |
|---|---|---|---|---|---|
| 1. Number Owned | | | | | |
| 2. Number Sold | | | | | |
| 3. Income earned | | | | | |
| 4. Number of deaths in the last year | | | | | |
| 5.6. If any deaths have occurred, why | 1 = Shortage of forage, 2 = Livestock disease, 3 = Occurrence of drought,<br>4 = Lack of vaccination services, 5 = Other _______________ | | | | |

**Section 6: Access to Vaccination and Other Social Services**

| No. | Question | Answer |
|---|---|---|
| 6.1. | Change in vaccination services for livestock since the construction of weirs | 1 = Significant, 2 = Slight, 3 = No change, 4 = Don't know |

| No. | Question | Answer |
|---|---|---|
| 6.2. | Change in relationship with PADO | 1 = Significant, 2 = Slight, 3 = No change, 4 = Don't know |
| 6.3. | Change in visits from PADO | 1 = Significant, 2 = Slight, 3 = No change, 4 = Don't know |
| 6.3.1. | Frequency of visit prior to the project | 1 = Often, 2 = Sometimes, 3 = Rarely, 4 = Never |
| 6.3.2. | Current frequency of visits | 1 = Often, 2 = Sometimes, 3 = Rarely, 4 = Never |
| 6.4. | Change in market linkages | 1 = Significant, 2 = Slight, 3 = No change, 4 = Don't know |
| 6.4.1. | If 1 or 2, new market linkages created | |
| 6.5. | Change in extension services | 1 = Significant, 2 = Slight, 3 = No change, 4 = Don't know |
| 6.5.1. | Type of extension service now available | |
| 6.6. | Change in relationship with neighboring communities | 1 = Significant, 2 = Slight, 3 = No change, 4 = Don't know |
| 6.6.1. | Kinds of changes that took place | |
| 6.7. | Change in schooling services | 1 = Significant, 2 = Slight, 3 = No change, 4 = Don't know |
| 6.8. | Change in healthcare services | 1 = Significant, 2 = Slight, 3 = No change, 4 = Don't know |
| 6.9. | Other social services | 1 = Significant, 2 = Slight, 3 = No change, 4 = Don't know |
| 6.9.1. | Kinds of other services | |

**Section 7: Availability of Feed**

| No. | Question | Answer |
|---|---|---|
| 7.1. | Frequency you endeavor beyond your immediate surrounding looking for feed ***before*** the construction of weirs | 1 = Often, 2 = Sometimes, 3 = Rarely, 4 = Never |
| 7.2. | ***Number*** of months you used to experience feed shortage and had to **go elsewhere** in search for pasture (***before*** the construction of weirs) | |
| 7.3. | Frequency you endeavor beyond your immediate surrounding looking for feed ***after*** the construction of weirs | 1 = Often, 2 = Sometimes, 3 = Rarely, 4 = Never |
| 7.4. | ***Number*** of months you now experience feed shortage and have to **go elsewhere** in search for pasture (***after*** the construction of weirs) | |
| 7.5. | Contribution of ***the weirs*** in alleviating feed shortage | 1 = Significant, 2 = Slight, 3 = No change, 4 = Don't know |
| 7.6. | Have any animal feed stored? | 1 = Yes, 2 = No, If no, jump to 7.7. |
| 7.6.1. | If yes, number of months it would last | |
| 7.7. | Sell feed? | 1 = Yes, 2 = No, If no, jump to the next section. |
| 7.7.1. | Income earned annually in birr | |
| 7.8. | Number of months you have sufficient amount to be able to sell | |

**Section 8: Availability of Water**

| No. | Question | Answer |
|---|---|---|
| 8.1. | Frequency you were faced with water shortage and had to leave your community ***before*** the construction of weirs | 1 = Often, 2 = Sometimes, 3 = Rarely, 4 = Never |
| 8.1.1. | Number of months you were away | |
| 8.1.2. | Distance you used to travel to fetch water | |
| 8.2. | Frequency you are now faced with water shortage and have to leave ***after*** the construction of weirs | 1 = Often, 2 = Sometimes, 3 = Rarely, 4 = Never |
| 8.2.1. | Number of months you are away | |
| 8.2.2. | Distance you travel to fetch water | |
| 8.3. | How far you used to dig to get water in meters ***before*** the construction of weirs (groundwater impact) | |
| 8.4. | How far you now dig to get water meters ***after*** the construction of weirs | |
| 8.5. | Contribution of the weirs in alleviating water shortage problems | 1 = Significant, 2 = Slight, 3 = No change, 4 = Don't know |
| 8.6. | What else can be done to alleviate water shortage? | |
| 8.7. | Water conservation method used during dry seasons (eg. tank) | 1 = Yes, 2 = No, If no, jump to the next section. |
| 8.7.1. | If yes, most important method | |
| 8.8. | Why choose these method= | |

**Section 9: Grazing Land, Land Conservation Activities and Conflicts**

| No. | Question | Answer |
|---|---|---|
| 9.1. | Challenge faced in accessing suitable grassland for grazing ***before*** the construction of weirs | 1 = Often, 2 = Sometimes, 3 = Rarely, 4 = Never |
| 9.2. | Challenge faced in accessing suitable grassland ***after*** the construction of weirs | 1 = Often, 2 = Sometimes, 3 = Rarely, 4 = Never |
| 9.3. | Participate in land conservation activities | 1 = Yes, 2 = No, If no, jump to 9.4. |
| 9.3.1. | If yes, what kind of conservation activities | |
| 9.4. | Fence your land for protection | 1 = Yes, 2 = No, If no, jump to 9.4.2. |
| 9.4.1. | If yes, why fence your land | |
| 9.4.2. | Raiding from neighboring communities ***before*** the construction of the weirs | 1 = Often, 2 = Sometimes, 3 = Rarely, 4 = Never |
| 9.4.3. | Raiding from neighboring communities ***after*** the construction of the weirs | 1 = Often, 2 = Sometimes, 3 = Rarely, 4 = Never |
| 9.5. | Are there conflicts in your area? | 1 = Yes, 2 = No, If no, jump to 9.5.2. |

| No. | Question | Answer |
|---|---|---|
| 9.5.1. | If yes, most common reason for conflict | |
| 9.5.2. | If no, why? | |
| 9.6. | Conflict with neighboring communities ***before*** the construction of the weirs | 1 = Often, 2 = Sometimes, 3 = Rarely, 4 = Never |
| 9.7. | Conflict with neighboring communities ***after*** the construction of the weirs | 1 = Often, 2 = Sometimes, 3 = Rarely, 4 = Never |
| 9.8. | Method of conflict resolution | 1 = Formal, 2 = Informal, 3 = Other _______________ |
| 9.9. | Contribution of the weirs in environmental rehabilitation | 1 = Significant, 2 = Slight, 3 = No change, 4 = Don't know |
| 9.10. | Attack from wild animals | 1 = Yes, 2 = No, if no, jump to the next section. |
| 9.10.1. | If yes, type of wild animals that attack communities | |

**Section 10: Gullies and Erosion**

| No. | Question | Answer |
|---|---|---|
| 10.1. | Do the weirs contribute to reduction of erosion? | 1 = Yes, 2 = No, If no, jump to 10.3. |
| 10.2. | If yes, contribution of this project in reducing the depth of gullies | 1 = Very significant, 2 = Moderately significant, 3 = Slightly significant, 4 = Don't know |
| 10.3. | Depth of gullies in your area in meters ***before*** the construction of weirs | |
| 10.4. | Depth of gullies in your area in meters ***after*** the construction of weirs | |
| 10.5. | Plant any plants to tackle erosion in your area | 1 = Yes, 2 = No, If no, jump to 10.6. |
| 10.5.1. | If yes, types of plants | 1 = Cowpea, 2 = Elephant Grass, 3 = Pigeon Pea, 4 = Lablab, 5 = Other _______________ |
| 10.6. | Any local species (indigenous plants) that had disappeared now growing back again | 1 = Yes, 2 = No, If no, jump to 10.7. |
| 10.6.1. | If yes, names of indigenous plants: | |
| 10.7. | Any *invasive species or weeds* coming with the flood water | 1 = Yes, 2 = No, If no, jump to 10.8. |
| 10.7.1. | If yes, names of species: | |
| 10.8. | Any animal species that have inhibited your area as a result of the fostering environment created | 1 = Yes, 2 = No, If no, jump to the next section. |
| 10.8.1. | If yes, names of animal species: | |

**Section 11: Off-farm Activities and Livelihood Viability**

| No. | Question | Answer |
|---|---|---|
| 11.1. | Received training as part of this project | 1 = Yes, 2 = No, If no, jump to 11.2. |
| 11.1.1. | If yes, type of training received | 1 = Farming practices, 2 = Construction, 3 = Other _______________ |
| 11.2. | Engaged in off-farm activity | 1 = Yes, 2 = No, If no, jump to 11.3. |
| 11.3. | If yes, why engage in in off-farm activities? (Is it out of necessity?) | |
| 11.3.1. | Main type of activity | |
| 11.3.2. | Income earned annually | |
| 11.3.3. | Change in work opportunities because of the training | 1 = Increase, 2 = No change, 3 = Decrease, 4 = Don't know |
| 11.3.4. | Number of months you participate in such activities | |
| 11.3.5. | Expenses it helps you cover | 1 = Health expenses, 2 = Food, 3 = Children's education expenses, 4 = Home appliances, 5 = Work expense/appliances, 6 = Loan repayment, 7 = Other _______________ |
| 11.4. | If no, most important reason for not being engaged in off-farm activities | |

**Section 12: Disaster Management**

| No. | Question | Answer |
|---|---|---|
| 12.1. | Have a drought contingency plan that is laid out at least partially | 1 = Yes, 2 = No, If no, jump to 12.3. |
| 12.2. | If yes, kind of plan = | |
| 12.3. | Community leaders make plans and take action for the community to cope with changes in weather patterns | 1 = Yes, 2 = No |
| 12.4. | Have a saving mechanism? | 1 = Yes, 2 = No, If no, jump to 12.5. |
| 12.4.1. | What kind = | |
| 12.5. | Have access to credit for times of trouble | 1 = Yes, 2 = No |
| 12.6. | Are you a member of the productivity program (PSM)? | 1 = Yes, 2 = No, If yes jump to 12.7. |
| 12.6.1. | If no, why | 1 = Have graduated, 2 = Not eligible to be a member, 3 = Other _______________ |
| 12.7. | Have access to early-warning information | 1 = Yes, 2 = No, If no, jump to 12.6. |
| 12.7.1. | If yes, frequency of information obtained | 1 = Often, 2 = Sometimes, 3 = Rarely, 4 = Never |
| 12.7.2. | Where do you get it from = | |
| 12.7.3. | Reliability of information obtained | 1 = Often, 2 = Sometimes, 3 = Rarely, 4 = Never |
| 12.8. | Receive help from PADO during times of disaster | 1 = Yes, 2 = No, If no, jump to the next section. |
| 12.9. | Frequency of help obtained | 1 = Often, 2 = Sometimes, 3 = Rarely, 4 = Never |
| 12.9.1. | Kind of help provided = | |

**Section 13: Source of Food**

| No. | Question | Answer |
|---|---|---|
| 13.1. | Do you generally face food shortage? | 1 = Yes, 2 = No, If no, jump to 13.3. |
| 13.2. | If yes, food challenge felt the most | 1 = Availability only, 2 = Access only, 3 = Affordability only, 4 = Availability and Access, 5 = Availability and Affordability, 6 = Access and Affordability, 7 = All three, 8 = Other _______________ |
| 13.3. | What is your source of food? | 1 = Own farm, 2 = Market, 3 = Food aid, 4 = Other _______________ |
| 13.3.1. | For more than two sources, first choice | |
| 13.3.2. | Second choice | |
| 13.3.3. | Third choice | |
| 13.4. | Percentage of food acquired from own farm | |
| 13.5. | Percentage of food bought from market | |
| 13.6. | Receive food aid | 1 = Yes, 2 = No, If no, jump to 13.7. |
| 13.6.1. | If yes, percentage of food acquired from food aid | |
| 13.6.2. | Number of months you received food aid | |
| 13.6.3. | Why receive food aid | 1 = Intensity/Frequency of drought, 2 = Don't have land, 3 = Don't have livestock, 4 = Food production/food acquired not sufficient, 5 = Family size increase, 6 = Other _______________ |
| 13.6.4. | Who provides this aid | |
| 13.7. | New food items consumed since the construction of the weirs | |
| 13.8. | Food items hard to obtain | |
| 13.9. | Other blockades to getting food | |

**Section 14: Food Security**

| No. | Question | Answer |
|---|---|---|
| 14.1. | Were you or any household member ***not able to eat the kinds of foods you preferred*** because of a lack of resources this year? | 1 = Yes<br>2 = No, If no, jump to 14.2. |
| 14.1.1. | How often did this happen? | 1 = Very rarely (few weeks in a month), 2 = Rarely (for 2-3 months)<br>3 = Sometimes (3-6 months), 4 = Often (6-9 months)<br>5 = Very often (9-12 months) |
| 14.2. | Did you or any household member have to ***eat a limited variety*** of foods due to a lack of resources this year? | 1 = Yes<br>2 = No, If no, jump to 14.3. |

| No. | Question | Answer |
|---|---|---|
| 14.2.1. | How often did this happen? | 1 = Very rarely (few weeks in a month), 2 = Rarely (for 2-3 months)<br>3 = Sometimes (3-6 months), 4 = Often (6-9 months)<br>5 = Very often (9-12 months) |
| 14.3. | Did you or any household member have to ***eat some foods that you really did not want to eat*** because of a lack of resources to obtain other types of food this year? | 1 = Yes<br>2 = No, If no, jump to 14.4. |
| 14.3.1. | How often did this happen? | 1 = Very rarely (few weeks in a month), 2 = Rarely (for 2-3 months)<br>3 = Sometimes (3-6 months), 4 = Often (6-9 months)<br>5 = Very often (9-12 months) |
| 14.4. | Did you or any household member have to ***eat a smaller meal than you felt you needed*** because there was not enough food this year? | 1 = Yes<br>2 = No, If no, jump to 14.5. |
| 14.4.1. | How often did this happen? | 1 = Very rarely (few weeks in a month), 2 = Rarely (for 2-3 months)<br>3 = Sometimes (3-6 months), 4 = Often (6-9 months)<br>5 = Very often (9-12 months) |
| 14.5. | Did you or any other household member have to ***eat fewer meals in a day*** because there was not enough food this year? | 1 = Yes<br>2 = No, If no, jump to 14.6. |
| 14.5.1. | How often did this happen? | 1 = Very rarely (few weeks in a month), 2 = Rarely (for 2-3 months)<br>3 = Sometimes (3-6 months), 4 = Often (6-9 months)<br>5 = Very often (9-12 months) |
| 14.6. | Was there ever ***no food to eat of any kind in your household*** because of lack of resources to get food this year? | 1 = Yes<br>2 = No, If no, jump to 14.7. |
| 14.6.1. | How often did this happen? | 1 = Very rarely (few weeks in a month), 2 = Rarely (for 2-3 months)<br>3 = Sometimes (3-6 months), 4 = Often (6-9 months)<br>5 = Very often (9-12 months) |
| 14.7. | Did you or any household member ***go to sleep at night hungry*** because there was not enough food this year? | 1 = Yes<br>2 = No, If no, jump to 14.8. |
| 14.7.1. | How often did this happen? | 1 = Very rarely (few weeks in a month), 2 = Rarely (for 2-3 months)<br>3 = Sometimes (3-6 months), 4 = Often (6-9 months)<br>5 = Very often (9-12 months) |

| No. | Question | Answer |
|---|---|---|
| 14.8. | Did you or any ***household member go a whole day and night without eating anything*** because there was not enough food this year? | 1 = Yes<br>2 = No, If no, jump to 14.9. |
| 14.8.1. | How often did this happen? | 1 = Very rarely (few weeks in a month), 2 = Rarely (for 2-3 months)<br>3 = Sometimes (3-6 months), 4 = Often (6-9 months)<br>5 = Very often (9-12 months) |
| 14.9. | Did you ***worry that your household would not have enough food*** this year? | 1 = Yes<br>2 = No |
| 14.9.1. | How often did this happen? | 1 = Very rarely (few weeks in a month), 2 = Rarely (for 2-3 months)<br>3 = Sometimes (3-6 months), 4 = Often (6-9 months)<br>5 = Very often (9-12 months) |

**Section 15: Other Weir Construction**

| No. | Question | Answer |
|---|---|---|
| 15.1. | What other places do you recommend for weir construction? | |
| 15.2. | Why? | |
| 15.3. | How much does the occurrence of flood contribute to the need of weirs in these areas? | 1 = Significantly, 2 = Slightly, 3 = Not at all,<br>4 = Don't know |

**Section 16: Future Plans (For beneficiaries only)**

| No. | Question | Answer |
|---|---|---|
| 16.1. | Do you have any plans of sustaining the constructed weirs after the project phases? | 1 = Yes<br>2 = No |
| 16.2. | If yes, what are those plans? | |

# Annex 2: FGD Questionnaire

**Section 1: Background**

| No. | Question | Answer |
|---|---|---|
| 1.1. | Group of beneficiaries | 1 = Yes, 2 = No |
| 1.2. | Number of participants | |

**Section 2: Discussion Questions**

| No. | Question | Answer |
|---|---|---|
| 2.1. | How are living conditions in Chifra these past few years? | |
| 2.2. | How has the availability of basic needs of households changed in recent years? | |

| No. | Question | Answer |
|---|---|---|
| 2.3. | Do you think this project benefited your community positively? | |
| 2.3.1. | If yes, how? | |
| 2.3.2. | If no, how? | |
| 2.4. | What grain crops and fodder crops do you now cultivate? Why have you chosen these varieties? | |
| 2.5. | Is there change in your preferences regarding which crops to cultivate in the past few years? Why? | |
| 2.6. | How has it affected your mobility in search of water and pasture? | |
| 2.6.1. | Impact with regards to water availability | |
| 2.6.2. | Impact with regards to feed availability | |
| 2.6.3. | Impact with regards to food availability | |
| 2.6.4. | Impact with regards to child nutrition and reducing child mortality | |
| 2.6.5. | Impact with regards to reducing cattle deaths | |
| 2.6.6. | Impact with regards to reducing erosion | |
| 2.6.7. | Impact with regards to reducing conflict | |
| 2.7. | Do you help each other on the basis of being part of a certain clan? | |
| 2.8. | What is the benefit of the weirs in comparison to previous methods of water conservation and erosion reduction methods? | |
| 2.9. | How had the trainings you have received as part of this project helped you? | |
| 2.10. | What changes have you seen relating to your relationship with the PADO? | |
| 2.11. | Any changes in social services received (like schooling, health care, cattle vaccination, extension services, etc)? | |
| 2.12. | Has your food habit changed (new items consumed) since the project was launched? If yes, how? | |
| 2.13. | Have you encountered any problems due to the project? | |
| 2.14. | Any new plant (indigenous plants, *invasive species or weeds*) coming in with the flood water? | |
| 2.15. | Any animal species seen in your area as a result of the fostering environment created by the weirs? | |
| 2.16. | How do non-beneficiaries feel/say about this project? | |
| 2.17. | How do you plan to sustain this project in the coming years? | |

## Annex 3: Key Informant Interview Questionnaire: Community Leader

**Section 1: Respondent Background**

| No. | Question | Answer |
|---|---|---|
| 1.1. | Respondent name | |
| 1.2. | Sex | 1 = Female, 2 = Male |
| 1.3. | Role in the community | |
| 1.4. | Are you involved in the project? | 1 = Yes, 2 = No |
| 1.4.1. | If yes, in what way? | |
| 1.4.2. | For how many years? | |

**Section 2: Impact of the Project**

| No. | Question | Answer |
|---|---|---|
| 2.1. | What was the prevailing situation in the area before the implementation of the project? | |
| 2.2. | What changes have you observed after the project was implanted? | |
| 2.3. | What is the nature of the support you provide in the community? | |
| 2.4. | What changes have you seen in project beneficiaries from non-beneficiaries since the start of the project? | |
| 2.4.1. | Changes in food supply | 1 = Increase, 2 = No change, 3 = Decrease, 4 = Don't know |
| 2.4.2. | Why? | |
| 2.4.3. | Changes in water availability | 1 = Increase, 2 = No change, 3 = Decrease, 4 = Don't know |
| 2.4.4. | Why? | |
| 2.4.5. | Changes in feed availability | 1 = Increase, 2 = No change, 3 = Decrease, 4 = Don't know |
| 2.4.6. | Why? | |
| 2.4.7. | Changes in grazing land | 1 = Increase, 2 = No change, 3 = Decrease, 4 = Don't know |
| 2.4.8. | Why? | |
| 2.4.9. | Changes in conflict with other neighbors (who are not beneficiaries) | 1 = Increase, 2 = No change, 3 = Decrease, 4 = Don't know |
| 2.4.10. | Why? | |

| No. | Question | Answer |
|---|---|---|
| | | |
| 2.4.11. | Changes in raidings | [1] = Increase, [2] = No change, [3] = Decrease,<br>[4] = Don't know |
| 2.4.12. | Why? | |
| 2.5. | What do you do to resolve conflict in this area? | |
| 2.6. | Do you think this project has negative impacts | [1] = Yes, [2] = No |
| 2.7. | If yes, what are they? | |
| 2.8. | How do you evaluate the motivation of agro-pastoralists to learn new farming techniques, livestock management practices, land management practices, fodder production practices, etc? | [1] = Very motivated, [2] = Fairly motivated,<br>[3] = Neutral, [4] = Not much,<br>[5] = Not motivated at all |
| 2.8.1. | Factors that enhance motivation | |
| 2.8.2. | Factors that limit motivation | |
| 2.9. | What benefit did you get from the project? | |
| 2.10. | Did you receive trainings during the project period? | [1] = Yes, [2] = No |
| 2.10.1. | If so, on what? | |
| 2.10.2. | How beneficial was it? | [1] = Very beneficial, [2] = Fairly beneficial,<br>[3] = Not much, [4] = Not at all |
| 2.10.3. | Which of the trainings you received was most helpful to the project beneficiaries? | |
| 2.10.4. | What kind of support do you need in the future? | |
| 2.10.5. | What do you think can be done about it? | |
| 2.11. | Do you have plan to extend or sustain the interventions after the completion of the project? | [1] = Yes, [2] = No |
| 2.11.1. | If yes, how? | |
| 2.11.2. | If no, why? | |

## Annex 4: Key Informant Interview: Chifra Woreda Agricultural Officer

**Section 1: Respondent Background**

| No. | Question | Answer |
|---|---|---|
| 1.1. | Respondent name | |
| 1.2. | Sex | [1] = Female, [2] = Male |
| 1.3. | Position held | |
| 1.4. | Years of work in the PADO | |
| 1.5. | Extent of involvement with ICRISAT's project | |

| | | |
|---|---|---|
| | | |

**Section 2: Impact of the Project**

| No. | Question | Answer |
|---|---|---|
| 2.1. | What was the prevailing situation in the area before the implementation of the project? | |
| 2.2. | What changes have you observed after the project was implanted? | |
| 2.3. | What is the nature of the support you provided to the project beneficiaries with regards to the project? | |
| 2.4. | Do you consult project beneficiaries? | 1 = Yes, 2 = No |
| 2.4.1. | On what issues do you consult them? | |
| 2.4.2. | How often do you consult them? | |
| 2.4.3. | How often do you conduct field visits to monitor, supervise or the project beneficiaries? | |
| 2.5. | How do you evaluate the motivation of agro-pastoralists to learn new farming techniques, livestock management practices, land management practices, fodder production practices, etc? | 1 = Very motivated, 2 = Fairly motivated, 3 = Neutral, 4 = Not much, 5 = Not motivated at all |
| 2.5.1. | Factors that enhance motivation | |
| 2.5.2. | Factors that limit motivation | |
| 2.5.3. | For the ones that are motivated, what are they most interested to learn about? | |
| 2.6. | What changes have you seen in project beneficiaries from non-beneficiaries since the start of the project? | |
| 2.6.1. | Changes in food supply | 1 = Increased, 2 = Decreased, 3 = No change, 4 = Don't know |
| 2.6.2. | Why? | |
| 2.6.3. | Changes in water availability | 1 = Increased, 2 = Decreased, 3 = No change, 4 = Don't know |
| 2.6.4. | Why? | |
| 2.6.5. | Changes in feed availability | 1 = Increased, 2 = Decreased, 3 = No change, 4 = Don't know |
| 2.6.6. | Why? | |

| No. | Question | Answer |
|---|---|---|
| | | |
| 2.6.7. | Changes in grazing land | 1 = Increased, 2 = Decreased, 3 = No change, 4 = Don't know |
| 2.6.8. | Why? | |
| 2.6.9. | Changes in conflict with other neighbors (who are not beneficiaries) | 1 = Increased, 2 = Decreased, 3 = No change, 4 = Don't know |
| 2.6.10. | Why? | |
| 2.6.11. | Changes in raidings | 1 = Increased, 2 = Decreased, 3 = No change, 4 = Don't know |
| 2.6.12. | Why? | |
| 2.7. | Do you think non-beneficiaries have an eagerness to take part in the project? | 1 = Yes, 2 = No |
| 2.7.1. | If yes, how do you plan to reach them? | |
| 2.7.2. | If no, why aren't they interested | |
| 2.8. | Do you think this project has negative impacts? | 1 = Yes, 2 = No |
| 2.8.1. | If yes, what are they? | |
| 2.8.2. | What improvements do you think can be made to this project? | |
| 2.9. | Has this project benefited you? | 1 = Yes, 2 = No |
| 2.9.1. | If yes, in what ways? | |
| 2.10. | Did you receive trainings during the project period? | 1 = Yes, 2 = No |
| 2.10.1. | If so, on what? | |
| 2.10.2. | How beneficial was it to you? | 1 = Very beneficial, 2 = Fairly beneficial, 3 = Not much, 4 = Not at all |
| 2.10.3. | If you received trainings, which of the trainings you received was most helpful to the project beneficiaries? | |
| 2.11. | What kind of support do you wish to receive from the project in the coming years? | |
| 2.12. | Do you have plan to extend or sustain the interventions after the completion of the project? | |
| 2.12.1. | If yes, how? | |
| 2.12.2. | If no, why? | |

## Annex 5: Key Informant Interview: GIZ Field Officer

**GIZ KEY INFORMANT INTERVIEW QUESTIONNAIRE**

**Section 1: Respondent Background**

| No. | Question | Answer |
|---|---|---|
| 1.1. | Respondent name | |
| 1.2. | Sex | [1] = Female, [2] = Male |
| 1.3. | Organization | |
| 1.4. | Position held | |
| 1.5. | What is the extent of your involvement in ICRISAT's project? | |
| 1.5.1. | For how many years? | |

**Section 2: Impact of the Project**

| No. | Question | Answer |
|---|---|---|
| 2.1. | What was the prevailing situation in the area before the implementation of the project? | |
| 2.2. | What changes have you observed after the project was implanted? | |
| 2.3. | What is the nature of the support you provide to the project beneficiaries with regards to the project? | |
| 2.4. | How do you evaluate the motivation of agro-pastoralists to learn new farming techniques, livestock management practices, land management practices, fodder production practices, etc? | [1] = Very motivated, [2] = Fairly motivated, [3] = Neutral, [4] = Not much, [5] = Not motivated at all |
| 2.4.1. | For the ones that are motivated, what are they most interested to learn about? | |
| 2.4.2. | Why | |
| 2.5. | Do you think non-beneficiaries have an eagerness to take part in the project? | [1] = Yes, [2] = No |
| 2.5.1. | If yes, how do you plan to reach them? | |
| 2.5.2. | If no, why aren't they interested | |
| 2.6. | What improvements do you think can be made to this project? | |
| 2.7. | Did you provide trainings during the project period? | [1] = Yes, [2] = No |
| 2.8. | If so, on what and for whom? | |
| 2.9. | How beneficial was it? | [1] = Very beneficial, [2] = Fairly beneficial, [3] = Not much, [4] = Not at all |

| No. | Question | Answer |
|---|---|---|
| 2.10. | Which of the trainings you gave was most helpful to the project beneficiaries? | |
| 2.11. | What kind of support do you think they need in the future? | |
| 2.12. | What do you think can be done about it? | |
| 2.13. | Has this project benefited you (as an officer)? | 1 = Yes, 2 = No |
| 2.13.1. | If yes, in what way? | |
| 2.13.2. | What do you think can be done to sustain it? | |
| 2.14. | Do you have plan to extend or sustain the interventions after the completion of the project? | 1 = Yes, 2 = No |
| 2.14.1. | If yes, how? | |
| 2.14.2. | If no, Why? | |