



**UNIVERSITY OF NAIROBI**

**SCHOOL OF ENGINEERING**

**DEPARTMENT OF ENVIRONMENTAL AND BIOSYSTEMS ENGINEERING**

**ASSESSMENT OF IRRIGATION WATER SUPPLY LOSSES IN MAJOR IRRIGATION  
CANALS IN BAL'AD DISTRICT OF MIDDLE SHABELLE REGION IN SOMALIA**

**By**

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### Declaration of originality

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## **ABSTRACT**

The main objective of this study is to determine the main causes of irrigation water supply losses in canals in Somalia. The impact of the study is to help Somali authorities and communities identify the areas where they need to concentrate on, to improve the irrigation water application and operation management. The study outlines and defines more types of irrigation systems in common and then looks at the irrigation systems used in Somalia. .

During the study, I reviewed the literature from the field using field records and scheduled interviews, GPS coordinates, and from ancillary information such as remote sensing images and existing national maps. A comparison was done using secondary sources such as academic journals and information from authorities on irrigation and water loss. The study was carried out in Bal'ad District. The district boasts a population of approximately 642,000 across 82 villages and it is known for good performance in agriculture, livestock and marine resources in Somalia.

The study targeted irrigation-based farmers and NGO employees in Bal'ad. The response rate for farmers was 80% while that of NGO employees was 75.76%. The study found out that the main ways through which irrigation water is lost include evaporation, seepage through the canal bunds, overtopping of the bunds, overflow losses, and overwatering.

In terms of preventing the loss of irrigation water, the respondents mainly suggested daily supervision, proper maintenance, water allocation to farmers, good management, lining of canals, management of irrigation methods, ongoing evaluation, good land preparation, and training farmers. .



The results also showed that the average field application efficiency was 25 percent while the conveyance efficiency was 30 percent. This translated to a scheme irrigation efficiency of 7.5 percent which is poor for surface irrigation prevalent in the study area. The typical irrigation efficiency of unlined canal systems in loam-clay soil is 65% at field application. Furthermore, the study also found out that most farmers from the study area have been using irrigation for over 150 years. More than half of the farmers own over 10 acres of farming land; implying, that irrigation farming is done on a large scale in the district. Most farmers have their farming lands over 1000 meters away from the irrigation source; hence, more water is lost because of the long distance. The loss is mainly through seepage and runoffs, evaporation, runoffs and percolation.

## **ACRONYMS AND ABBREVIATIONS**

EA - Field Application Efficiency

Ec - 100 (Wf/Ws)

Ei - Irrigation Efficiency

Es - stockpiling efficiency

FAO \_Food and Agriculture Organization of United Nation

GIS – Geographical Information System

GDP – Gross Domestic Product

NGO -Non-government organizations

UN - United Nations

Wf - Water conveyed to field

Wc - Water accessible for utilization by the crop

Ws - Water occupied from source

Wb - Water used usefully

WUE – Western Undergraduate Exchange

## **CHAPTER ONE**

### **INTRODUCTION**

#### **1.1 Background Information**

Surface water is the major source of irrigation water in Somalia. Juba and Shabele rivers are the main surface water sources, both of which flow from Ethiopia and drain into the Indian Ocean. Over 95% irrigation water demand in south Somalia is met by this water source. Irrigation practices in Somalia started in 1920 with implementation of Jowhar Sugar Estate (FAO-SWALIM, 2007). Since then, the scale of irrigation development has increased and by 1980 some 60 000 ha had been developed in Jowhar and Bal'ad districts in Middle Shabele region (MottMcDonald and Partners, 1969). The estimates of area under controlled irrigation for the all projects in Juba and Shabele rivers before the break out of the civil war was 161 583 ha. Though some of those projects were partially operating all the time, the Ministry of agriculture estimated that the 1987/88 cropping year had 112 950 ha under controlled irrigation while 110 000 ha were under flood recession irrigation. This made the total area of irrigation to be 222 950 ha (Ministry of Agriculture, 1988).

The irrigation systems (pump or gravity supply) were originally based on a limited gated gravity fed river intakes (FAO-SWALIM, 2007). The Shabele River had storage of 200 million cubic meters at Jowhar Off Stream Storage (JOSS) which was intended to reduce flood risk and future use for animal and pump-fed irrigation farms. Due to national instability and lack of proper management JOSS became non-functional. No proper rehabilitations occurred since 1991. In Juba River, there was a proposal for construction of Baardeere Dam which if built, was to impound flood flow and store 5000 million cubic meters, irrigate 200 000 hectares, and generate

105 megawatt hydroelectric power. The implementation of this project was interrupted by the collapse of the central government (Noor, 1996). Nonetheless, a number of barrages of irrigation exists for purposes of rice and banana irrigation projects which have seen a high density of population resettlements spring up near to Juba river such as Mareerey Sugar Project in 1987 (FAO-SWALIM, 2007).

The present irrigation potential in Somalia is two hundred and forty thousand hectares (FAO-SWALIM, 2007). The irrigation belt has gone through major obstacles from the collapse of central government of Somalia since 1991 (FAO-SWALIM, 2007). The bulk scale irrigation schemes are non-existence at present while the rest irrigation facilities are not active due to lack of maintenance and management (FAO-SWALIM, 2007). In the Most parts of the country that were previously under irrigation are currently used for rain-fed farming and grazing which include Middle Shabele region, Lower Shabele region and Galguduud region. The pastoral and agriculture, both rain-fed and irrigated, are the two major economic sources in Somalia. Water points and infrastructure developments are very poor, which sometimes become the source of conflict between livestock and agricultural communities, (Kammer, 1989).

Most of the irrigation infrastructures water supply that was established before 1990 was open irrigation canals/earthen canals with gravity-fed systems. The efficiency of such surface irrigation canals was 60% with standard conditions (Ministry of Agriculture 1988). When it was abandoned and the maintenance and management neglected, the efficiency decreased up to 25-30%. This can translate to the loss and failure of crops and negatively impact the farmer income generation, yield productivity, and water loss.

The country is now recovering from all the hardships and moving towards filling the most important and necessary gaps including reconstruction of the country food security. One of the important components of agriculture development under consideration is water for irrigation and irrigation infrastructures. The government has received a lot of support from its development partners such as UN agencies and other INGO's. These development partners had done a lot of work towards rehabilitation of the irrigation infrastructures and farmer-capacity building. However, the irrigated agricultural production is still too low, in part, due to losses and due to insecurity issues. This study investigated the major causes and contributors to irrigation water losses for the purpose of helping management know where to focus on improvement in irrigation water development and management.

## **1.2 Statement of the Problem and justification**

Somalia is one of the countries that has been severely affected by droughts in the last decade. In The country has annual average rain fall of (200 to 300 mm) Since the annual average rain fall is poor, the agriculture production relied on surface irrigation, canal is the preferred irrigation water supply system and canal Irrigation supply efficiency is very important to all users and managements, past researches indicate that poor irrigation systems in Somalia is result of low irrigation supply efficiency (FAO-SWALIM, 2007), hence the study looked the main contributors of low supply efficiency, hence there is a need to evaluate irrigation canal water conveyance efficiency in Somalia and support decision making process. All of the irrigation projects that existed in the pre-conflict time are now totally reduced. Only small scale irrigation practices are active and are privately owned. The government of Somalia, UN agencies and other international organizations recently renewed their interest in rehabilitating the irrigation schemes

in Somalia. They have spearheaded different and joint agricultural developments to improve the sector productivity and water use efficiency. However, their effort is still marred by the poor state of the irrigation conveyance systems by unknown losses of irrigation water. This study has been instituted to help in bringing to knowledge the amount and major contributors to irrigation water losses in the irrigation belt in Somalia. The study focused on Bal'ad District, Middle Shebelle, Somalia, as a showcase for the larger irrigation belt in Somalia. The research attempted to answer the questions that are related to water conveyance loss in Bal'ad district including such as the amount of conveyance efficiency of the canals, the major water loss contributors in Bal'ad district etc.,.

### **1.3 Objectives of the Study**

#### **1.3.1 Overall Objectives:-**

The overall objective was to analyze the amount and major contributors of irrigation water supply losses in Bal'ad District in Middle Shabelle region in Somalia.

#### **1.3.2 Specific Objectives**

The specific objectives of this study were to:

- i) Determine irrigation supply efficiency in Bal'ad district in Somalia.
- ii) Determine the major contributors of water loss in irrigation canals in Bal'ad district Somalia.

#### **1.4 Research Questions**

The research questions for the study include:

- i. How efficient is the irrigation supply in Bal'ad?
- ii. What are the major types of water losses in Bal'ad?
- iii. What causes water loss in irrigation canals in Bal'ad district?

#### **1.5 Scope of the Study**

This study area was Bal'ad district in Somalia. The study assessed irrigation water supply and determine the losses in irrigation canals in the field. The study focused only on the primary supply side of irrigation water; that is irrigation water losses between intake and secondary canals in the field. It relied on secondary data, digital image applications, questionnaire and limited field visit, the period of the field study was end of Nov to end of Dec 2015 but viewed data from August 2015 to Dec 2016.

## **CHAPTER TWO**

### **LITERATURE REVIEW**

#### **2.0 What is Irrigation?**

Irrigation is application of water to plant to meet their water demand in water shortage time, it is considered as the supplementation of water that is readily offered by rain with other sources of water. The main reason for undertaking irrigation is to ensure that the plants can gain from water losses that are expected during dry spells (Fanadzo, Chiduzza & Mnkeni, 2010). Water is considered as a limited resource hence there is need to come up with ways to ensure that we conserve it as well prevent its over-use.

#### **2.1 Types of Irrigation practices in Somalia**

Somalia, with an aggregate range of area 637 660 km<sup>2</sup>, has the longest coastline in Africa: in the north on the Gulf of Aden and in the east on the Indian Ocean. It is circumscribed by Kenya in the south, by Somalia in the east and by Djibouti in the north-east. The cultivable range was evaluated at around 8 million ha in 1985, or 13% of the aggregate territory (Salami, Kamara & Brixiova, 2010). In 1984, it was assessed that around 980 000 ha were developed with yearly yields, i.e. 12% of the cultivable region. Around 18 000 ha comprised of changeless crops in 1993.

The aggregate populace is around 9.25 million (1995), of which 74% is provincial. Normal populace thickness is close to 15 tenants/km<sup>2</sup>. The yearly demographic development rate is more or less 3.1 % (Siebert & Döll, 2010). Farming is one of the main customary occupation for most Somalis, after migrant domesticated animals brushing. In the ballpark of 70% of the working populace was occupied with farming in 1991 and this part represented 65% of the nation's GDP, including ranger service and fisheries. Bananas are the vital money crop, representing 40.3 % of



fare profit in 1988. Somalia has two main permanent rivers Jubba and Shabelle rivers which are the main irrigation water sources, from 1920, well established surface irrigation systems were established (Mott McDonald and Partners, 1969). diverting water from Shabelle river to farming land by gravity or pumping and gravity, most irrigation practices known well in Somalia was and still is gravity or surface irrigation.

### **2.1.1 Gravity irrigation**

Surface irrigation is common practiced type in Somalia and basically partitioned in basin, border, and wrinkle systems (FAO). It is generally used in Jubba river and some parts in Shabelle rivers in Somalia, so it is used as conveying water through connected open earthen canals, the canals are diverted either on barrages on river bed or diversion boxes along Shabelle river which on their turn distributes in to primary, secondary and tertiary canals in the field, it is huge work serious than different irrigation routines. Legitimate configuration of surface irrigation systems considers the mud sort (composition and admission rate), salinity, levelness of the field, canal size, and length of canal. It is by and large more hard to acquire high consistency of water circulation in long fields on coarse textured soils (rock and sands) than on fine textured soils (top soils to mud) (Siebert & Döll, 2010). Leveling the fields and building the water trench and supplies may be lavish, however once this is done, expenses are low and the self-improvement limit is high.

Surface irrigation remains for an extensive gathering of irrigation methods in which water is disseminated by gravity over the surface of the field (note: surface irrigation does exclude spate irrigation, FAO)). The three most basic systems are basin irrigation, border irrigation and furrow irrigation (Siebert & Döll, 2010). Water Source is regularly presented at the most elevated location or with corner strips of the field, which permits to covering the field via overland

stream. Verifiably, gravity irrigation has been the most widely recognized technique for flooding rural area. The characterizing component of surface irrigation strategies is that the mud is used as the vehicle medium rather than pipelines .

Surface irrigation strategies contain two essential classes: ponding (surface water pooled in a puddle, (Siebert & Döll, 2010) and conveying water. The moving water techniques oblige some overflow or ponding to ensure sufficient invasion at the lower end of the field. The mud sort controls the length of the run and the profundity of penetrated after some time. The better the nature of the mud is the less is the superfluous spillover and the better the penetration into the mud and consequently the utilization for the crops (Portmann et al, 2010). Because of ponding anyway, it is imperative not to inundate the yields amid the day but rather in the early morning or during the evening with a specific end goal to maintain a strategic distance from water loss due to evaporation.

Every surface system has its own particular interesting favorable circumstances and burdens relying upon such variables as introductory advancement expenses, size and state of individual fields, soil attributes, nature and accessibility of the water supply, atmosphere, trimming example, social inclinations and structures, and chronicled experience (Sun et al., 2010)

### **2.1.2 Surface irrigation**

is where water is applied and distributed over the soil surface by gravity. It is by far the most generic form of irrigation throughout the world and has been practiced in many areas virtually unchanged for thousands of years.

In Somalia, between 1980 and 1990, irrigated areas benefited from a well-established network of canals and drains, allowing a consistent supply of water that was supplemental to the scarce and unreliable rains, with abundant surface and underground waters from the Shabelle and Juba

Rivers. For any years, the fertile soils and climate had sustained superior performance of both cash and food crops under irrigated conditions, while extra water was used for leaching practices that kept salinity build-up under control.

Irrigation systems were originally based on a limited number of gated gravity – fed river intakes, feeding main canals designed in such a way as to have enough head to command the fields through secondary canals and, further down, smaller tertiary canals to individual farms' intakes. But, due to over 20 years of an stability the majority of these schemes have collapsed. River embankments have eroded, and barrages, pump intakes and canal systems show some degree of sedimentation and vegetation growth which have reduced the canals' hydraulic sections. Silting up of the drainage system was accelerated by the lack of terminal outlets and the flat topography of the irrigation area which restricted drainage water to return by gravity into the rivers. The rivers also spread into large swamps, never reaching their ends (EC, 2002). As a result, only fractions of design discharges were delivered, thus considerably reducing the area under irrigation.

### **2.1.3 Basin Irrigation**

Basin irrigation is the most widely recognized type of surface irrigation, especially in locales with formats of little fields. If a field is level in all bearings, is incorporated by a dyke to prevent runoff, and gives an undirected stream of water into the field, it is in this called a basin.

If the basins are little or if the release rate accessible is generally vast, there are few muds not amiable to basin irrigation. For the most part, basin irrigation is supported by moderate to slow intake soils and profound established, firmly separated yields. Crops, which don't endure flooding and soils subject to crusting can be basin inundated by wrinkling or utilizing raised bed

planting. Basin irrigation is a compelling technique for filtering salts from the mud profile into the deeper groundwater (Sun et al., 2010).

Basin irrigation systems can be computerized with moderately basic and modest stream controls at the basin gulf (Turrall, Svendsen & Faures, 2010). On the other hand, basin irrigation has various constraints in relationship with horticulture in the less created nations: Accurate area leveling is essential to high consistencies and efficiencies, however this is hard to fulfill in little areas; the border embankments must be very much kept up to wipe out breaking and waste; and it is troublesome and regularly infeasible to join the utilization of modem homestead hardware in little basins, subsequently restricting little scale basin irrigation to hand and creature fueled development (Turrall, Svendsen & Faures, 2010).

#### **2.1.4 Border Irrigation System**

Much of the time, border irrigation can be seen as a development of basin irrigation to incorporate long rectangular or formed field shapes, longitudinal however no horizontal slant, and free depleting or blocked conditions at the lower end.

Examples of border irrigation systems; (a) Typical reviewed fringe irrigation system. (b) standard level border irrigation system. (c) Typical form levee or fringe irrigation system (Turrall, Svendsen & Faures, 2010)

In border irrigation, the field is isolated into strips isolated by border edges running down the slant of the field. The width of the stripes is ordinarily from 20 to 100 feet (6 to 30 meters) (FAO). The range between the edges is overflowed amid irrigation. Border irrigation is used for tree crops and for yields as hay (*Medicago sativa*) and little grains (Turrall, Svendsen & Faures, 2010).

### **2.1.5. Furrow Irrigation**

A different option for supplying water to the field as flooding the whole field surface is to develop little channels along the essential course of water development. Water presented in these wrinkles invades through the wetted edge and moves vertically and horizontally from that point to refill the mud, this type is used in Jowhar and Bule Burte districts in Middale and Hiran Regions, Wrinkles can be used as a part of conjunction with basins and fringes to overcome land variety and crusting (Turrall, Svendsen & Faures, 2010). Wrinkles are all around adjusted to column crops and plantations or vineyards (Sun et al., 2010).

### **2.1.6. Advantages and disadvantages of surface irrigation**

#### **Advantages**

Gravity irrigation also known as surface irrigation which is the only irrigation type practiced in Somalia, due to the simplicity of its infrastructure and it is most economical.

The energy requirements for its operation are practically nil, thanks to the use of gravitational energy.

Wind is not a limiting factor in the distribution of water.

#### **Disadvantages**

- It is not convenient to use it in uneven terrains, since the water could be diverted and prevent its correct distribution.
- By moistening most of the land can cause the appearance of weeds and diseases of fungus type.

it is not convenient to use it in uneven terrains.

The surface irrigation is used commonly in Somalia specifically along Shabelle river where water course is higher than irrigation lands but in along Juba river people use water pumps and then use surface irrigation or gravity supply.

## **2.2 Other Irrigation practices**

### **2.2.1 Ditch Irrigation**

Ditch Irrigation is a somewhat conventional technique, where trench are uncovered, and seedlings are planted in columns (Fanadzo, Chiduzo & Mnkeni, 2010). The crops are watered by putting trenches or wrinkles in the middle of the lines of plants. Siphon tubes are used to move the water from the fundamental trench to the channels. This arrangement of irrigation was once extremely well known in Africa. However, most have been supplanted by advanced systems.

### **2.2.2 Terraced Irrigation**

This is a very labor-intensive serious technique for irrigation where the area is cut into steps and bolstered by holding dividers. The level regions are used for planting, and water streams down every stride while watering every plot. This permits steep area to be used for planting crops (Houghton-Carr, Fry, Gadain & Muchiri, 2010).

### **2.2.3 Drip Irrigation**

This is known as the most water productive technique for irrigation. Water drops right close to the root zone of a plant in a trickling movement (Houghton-Carr, Fry, Gadain & Muchiri, 2010). If the system is introduced appropriately, you can relentlessly diminish the loss of water through dispersal and overflow.

### **2.2.4 Sprinkler System**

This is an irrigation system that uses overhead sprinklers, showers or weapons, introduced on perpetual risers. One can likewise have the system covered underground, and the sprinklers

ascend when water weight rises, which is a mainstream irrigation system for utilization on fairways and parks (Houghton-Carr, Fry, Gadain & Muchiri, 2010).

### **2.2.5 Rotary Systems**

This system for irrigation is most appropriate for bigger regions, for the sprinklers can achieve separations of up to 100 feet. "Rotating" is demonstrative of the mechanical driven sprinklers moving in around movement, henceforth coming to more prominent separations (Obinna, 2011). This system waters a bigger zone with little measures of water more than a more extended time of time.

### **2.2.6 Center Pivot Irrigation**

This is a type of overhead irrigation. Steel or aluminum funnels are joined, upheld by trusses, mounted on wheeled towers. The sprinklers are arranged on the length of the tower, and they move in a roundabout movement (Obinna, 2011).

Efficiency evaluations get a considerable measure of consideration. We like proficient motors, aeration and cooling systems, water warmers, and heaters. Protectionists like effective water systems that convey water for its proposed utilization without loss because of spillage, spills or contamination (Qadir, Bahri, Sato & Al-Karadsheh, 2010). Since irrigation is the biggest appropriated water client in Somalia, irrigation systems likewise get legitimacy in light of how effective they are accounted for to be. While this may sound direct and basic, there is space for disarray because there are distinctive approaches to characterize efficiency. Efficiencies additionally differ in time and with an administration. Extremely "proficient" systems by a few definitions can be exceptionally poor entertainers by different definitions, for instance, if distribution consistency and conveyance sum are insufficient to satisfy product need. This

announcement will characterize and clarify a few normal efficiency terms being used for irrigation systems and indicate how these terms apply to some regular irrigation circumstances.

### **2.2.7. Advantages and disadvantages of pressurized irrigation**

#### **Advantages**

In general, sprinkler is most common used in the world, although depending on the system will be expensive.

They can cover large distances of

It is more efficient than all other irrigation types

Allows adequate growth on the root system, can maintain an almost constant humidity by continuously renewing the volume of water that is spent by the evapotranspiration process.

This guarantees a greater availability of nutrients to the root zone.

#### **Disadvantages**

Investment and labor can be high.

The most important disadvantages of this irrigation method is that the drip system can be covered if the water is not filtered.



## **2.3 Supply Irrigation Water Losses**

Supply Irrigation water losses incorporate air losses, shade losses, soil and water surface evaporation, overflow, and profound permeation, in Bal'ad area where the study area focuses, the losses are more than that, there illegal diversions, poor canal structures, silt on bed canals, zero management and over-watering. The size of every loss is reliant on the outline and operation of every kind of irrigation system. It demonstrates an assessment of the application efficiency of three sprinkler bundles, expecting ground vanishing, spillover, and profound permeation are insignificant, (FAO Manual module 4 for calculating CROPWAT), Conveyance losses mainly the seepage and evaporation losses are most challenging water conveyance problems as common issue, e.g. in Pakistan 35 to 40% of the water diverted to the main canal is lost through watercourse which is very high (Tariq Osman Saeed and Taj Ali Khan, 2013), Generally, the conveyance losses ranges from 25 to 50% of total diverted water to the canal, (Tariq from University of Khartoum)

In Somalia, the dominant irrigation supply losses are mainly two, (luck of control (zero management) and over flows, but most common losses include evaporation and seepages.

### **2.3.1 Sprinkler Irrigation Losses**

Air losses incorporate float and bead dispersal. Air losses can be huge if the sprinkler configuration or unnecessary weight delivers a high rate of good droplets. A float is ordinarily thought to be water particles that are expelled from the objective range while bead dispersal would be the loss of water by evaporation specifically from the drop of water while in flight. Direct development and bead dispersal differ, yet the general assessment of bead evaporation is little, presumably under 1 percent of the yield. Aggregate air loss under appropriately working sprinklers and low wind conditions is prone to be in the 1 to 3 percent range, albeit some more

established distributions have much higher qualities (Minhas et al., 2010). 3 percent for the effect sprinkler and 1 percent for the shower head at a 5-foot stature. Air losses were thought to be immaterial for the air pocket mode LEPA head (Minhas et al, 2010).

Shell losses incorporate losses because of water hung on the plant (foliage block attempt) and shade vanishing amid the irrigation. Water evaporation from the wetted surface of the plant does lessen evaporation by the plant.

On the other hand, vanishing from a free water surface is quicker than Evaporation through plant stomata. Net covering dispersal loss assessments range from 0.02 to 0.04 inch for every hour. Two hours of wetting was expected for the effect sprinkler and 45 minutes for the shower spout. The main loss indicated for the air pocket mode LEPA spout is surface water vanishing. Since the LEPA system utilizes an application rate as a part of the abundance of soil admission abilities, the free water surface must be hung on the mud surface until it can be invaded. The surface water vanishing loss evaluation is 0.01 inch/hour over the two hours assessed for admission to be finished.

Water development as overflow or redistribution of the surface water, profound permeation, and ground vanishing were considered to be irrelevant. Any spillover from the field or profound permeation would lessen application effectiveness by a rate of the aggregate application sum. An overflow of up to 60 percent of the application sum has been measured for in-overhang sprinkler heads on inclining ground.

### **2.3.2 Surface Irrigation Losses**

Include runoff, deep percolation, ground evaporation and surface water evaporation. Runoff losses can be significant if tailwater is not controlled and reused. Although use of tailwater reuse pits could generally increase surface application efficiency, many surface irrigators use a blocked furrow to prevent runoff. Usually the lower portion of the field is leveled to redistribute the tailwater over that portion. While runoff may be reduced to near zero, deep percolation losses may still be high with this practice. Surge irrigation can accomplish faster furrow advances. To further improve an advance time, large furrow flows may be used. However, care should be taken to avoid furrow erosion. Some chemicals (polymers) have been reported to be useful in reducing erosion. Rapid advance allows better water distribution efficiency and smaller application amounts, which can reduce deep percolation losses and improve overall irrigation efficiency. Evaporation loss percentages from a surface irrigated field are small. The components of the loss are furrow- water evaporation (under canopy), tailwater evaporation (where there is no canopy protection) and tail water pit evaporation, and are dependent on system operation.

Surge irrigation can fulfill speedier wrinkle propels. To further enhance a development time, substantial wrinkle streams may be used. Be that as it may care ought to be taken to maintain a strategic distance from wrinkle disintegration. A few chemicals (polymers) have been accounted for to be helpful in decreasing disintegration. Quick progress permits better water conveyance effectiveness and litter application sums, which can decrease profound permeation losses and enhance general irrigation efficiency.

### 2.3.3 Estimation of Water Conveyance Efficiency

The conveyance efficiency (EC) mainly depends on the length of the canals, the soil type or permeability of the canal banks and the condition of the canals.

In large irrigation schemes more water is lost than in small schemes, due to a longer canal system. From canals in sandy soils more water is lost than from canals in heavy clay soils. When canals are lined with bricks, plastic or concrete, only very little water is lost. canals in Bal'ad district are badly maintained, bund breaks are not repaired properly, and rats dig holes, a lot of water is lost.

Water Conveyance Efficiency (Ec); the rate of water source that reaches the field.

$$Ec = 100 (Wf / Ws) \quad \mathbf{1}$$

Wf = Water delivered

Ws = Water diveretd

Water Application Efficiency (Ea): The rate of water conveyed to the field is used by the crop.

$$Ea = 100 (Wc/Wf) \quad \mathbf{2}$$

Wc = Water accessible for utilization by the crop

Wf = Water conveyed to field

Water application efficiency gives a general feeling of how well an irrigation system performs its essential errand of getting water to the plant roots. On the other hand, it is conceivable to have a high Ea yet have the irrigation water so ineffectively conveyed that product anxiety exists in zones of the field. It is likewise conceivable to have almost 100 percent Ea

Maybe it causes crop disappointment if the mud profile is not filled adequately to meet yield water prerequisites. It is anything but difficult to control Wf so that Ea can be about 100 percent.

Any irrigation system from the most exceedingly awful to the best can be worked in a style to accomplish almost 100 percent  $E_a$  if  $W_f$  is adequately low. Expanding  $E_a$  in this way thoroughly overlooks the requirement for irrigation uniformity. For  $E_a$  to have pragmatic importance,  $W_c$  should be adequate to keep away from undesirable water stress.

Water application efficiency here and there is inaccurately used to allude to the measure of water conveyed to the surface of the mud in an inundated field by a sprinkler system. Water losses can happen subsequent to coming to the mud surface, prompting overestimation of the application efficiency.  $E_a$  is frequently mistaken for water stockpiling efficiency ( $E_s$ ), which is the part of an irrigation sum put away in the crop root zone. The utilization of this term is disheartened as a result of the trouble in deciding the yield root zone and because  $E_s$  can be low while adequate water is given to the crop.

Water losses incorporate surface spillover and profound permeation. In the event that an inside turn is furnished with a legitimately outlined spout bundle and worked utilizing best administration practices and irrigation booking, these losses can be irrelevant for some systems, these losses can be expensive and bring about ineffectively disseminated or nonunion-structure irrigation.

**Irrigation Efficiency ( $E_i$ ):** The rate of water conveyed to the field that is used usefully.

$$E_i = 100 (W_b/W_f)$$

**3**

$W_b$  = Water used usefully

$W_f$  = Water conveyed to field

Irrigation efficiency is more comprehensively characterized than water application efficiency in that irrigation water may have a greater number of employments than just fulfilling yield water

prerequisites. Other useful uses could incorporate salt filtering, crop cooling, pesticide or manure applications, or ice insurance. Then again, most Somalia irrigation systems have single objective that is to supply water for yield use, which permits water application efficiency and irrigation efficiency to be used reciprocally.

Water lost to permeation beneath the root zone because of non-uniform application or over-application water overflow from the field, wind float, and shower bead vanishing all lessen irrigation efficiency. For a superior understanding of the system execution, water dissemination ought to likewise be considered.

## **2.4 Major irrigation water losses in Somalia**

### **2.4.1 Over-watering**

Over-watering is the most critical reason for water loss in irrigation system Somalia. Regardless of how well the system is outlined, if more water is connected than can be usefully used by the yield, effectiveness will endure (Sun et al., 2010). In this way, legitimate irrigation booking is critical if high efficiencies are to be accomplished. Diverse types of conceivable water losses are particular to the kind of irrigation system used.

Beside over-watering, the real losses connected with surface irrigation systems are immediate dispersal from the wet soil surface, overflow losses, and leakage losses from water conveyance trench, evaporation miss-managment. Direct dispersal losses can be critical when inundating youthful plantation crops. Overflow losses can be practically disposed of with return stream systems that catch the spillover water and direct it back to the starting field, or to different fields. The measure of drainage loss from unlined trench will rely on upon soil qualities and the degree

of the trench system, yet may extend from 10 to 15% of the supplied water. Leakage losses are wiped out with lined waterways or channel dissemination systems.

If stream system losses ought to be low. In spite of the fact that a generally little parcel of the mud surface is wetted, the irrigation recurrence is high, so there will be some loss because of dispersal from wet soil. With great administration, losses because of holes, system waste, and flushing of channels and horizontal lines ought not to surpass 1%.

### **2.4.2 Irrigation Uniformity**

In a perfect world, an irrigation system would apply water in a totally uniform way, so that every piece of the inundated region gets the same measure of water. Sadly, there appears no chance accomplish this (Portmann et al., 2010). Indeed, even characteristic precipitation is not totally uniform. So the expression "irrigation consistency" really alludes to the variety or non-consistency in the measures of water connected to areas inside of the flooded range. Critical exertion in irrigation system outline and administration is coordinated towards managing issues identified with irrigation consistency, or the absence of it (Sun et al., 2010).

At whatever point water is connected with not as much as flawless consistency, a few sections of the product will get more water than others. If the irrigation system is worked so that the piece of the crop accepting the most water has its prerequisite met, then the rest of the product will be over-inundated. Along these lines, a non-uniform irrigation unavoidably brings about some level of under-or over-watering.

Irrigation consistency is identified with product yields through the agronomic impacts of under- and over-watering. Inadequate water prompts high soil dampness pressure, plant push and diminished product yields. Abundance water might likewise lessen product yields beneath potential levels through systems, for example, filtering of plant supplements, expanded ailment

frequency or inability to invigorate development of economically important parts of the plant. Irrigation consistency is likewise connected to the effectiveness with which agrarian assets are used.

## **2.5 Irrigation efficiency**

Irrigation efficiency is characterized as the proportion between the water put away in the mud profundity possessed with dynamic plant roots to the water connected by the irrigation system (Portmann et al., 2010). Consequently, water connected by the irrigation system and not being made accessible to be taken up by plant roots is squandered and decreases irrigation efficiency. The major foundations for decreased irrigation efficiency are waste of overabundance irrigation water to soil layers more profound than the profundity of dynamic roots. Spillage of irrigation water to profound soil layers could bring about contamination of the water table.

The instances of irrigation efficiency of 100 percent are for all intents and purposes nonexistent even in the most cutting edge irrigation systems (Portmann et al., 2010). Major troubles in acquiring high irrigation efficiency comes from the failure to get an exact evaluation of the amount of water expected to revive the mud root zone profundity and the absence of substantial, constant data concerning the genuine soil profundity of dynamic roots.

Moderate evaluations propose that even under ideal administration rehearses the normal irrigation efficiency is assessed to be 70 percent. Subsequently, the normal water loss under sprinkler and trickle irrigation is 30 percent yet could drop to estimations of more than 50 percent under wrinkle and surge irrigation (Portmann et al., 2010). Water losses of irrigation water under urban and scene irrigation could without much of a stretch achieve 50 percent of the connected water.



When we apply these appraisals to irrigation rehearses in Israel, a yearly sparing of 300 to 400 million metric volumes of irrigation water could be spared as a consequence of utilizing innovations equipped for expanding considerably irrigation efficiencies (Salami, Kamara & Brixiova, 2010).

The reaction of a crop to connected water can be condensed in a water yield capacity. This comparison is used to ascertain the yield from the occasional water application. It is helpful to express both yield and connected water in relative or dimensionless terms. Relative yield ( $y$ ) is characterized as the proportion of real respect most extreme yield, and relative connected water ( $w$ ) is characterized as the proportion of genuine connected water to that sum comparing to greatest yields. In the event that  $w$  is taken to incorporate successful precipitation and soil dampness put away toward the start of the season, the yield capacity will be genuinely broad and can be illustrative of more than one area or year. If the yield capacity is balanced with the goal that  $w$  alludes just to the water connected by the irrigation system, the essentialness of different irrigation alternatives is more evident, however some all-inclusive statement is lost. The state of the yield work additionally relies on upon the irrigation recurrence, yet it is for the most part expected that a yield capacity is legitimate for most "sensible" irrigation plans.

A specific yield capacity for sugar stick is given beneath. It is in view of information from various sources, and accepts that precipitation and soil dampness put away in the root zone toward the start of the season add up to 20% of the water fundamental for greatest yield, and that affectability to overabundance is generally low (Salami, Kamara & Brixiova, 2010).

## **2.6 Factors influencing irrigation efficiency**

Numerous elements influence WUE in the irrigation part. They incorporate drainage, permeation, soil profundity and surface, dispersal and evaporation, outline of irrigation structures and their operation and upkeep, and administration abilities. At different effectiveness levels, atmosphere and precipitation examples, size of inundated zones, and strategies for water application additionally assume imperative parts.

### **2.6.1. Vanishing and Evaporation**

Vanishing and Evaporation losses relate to open trenches, inundated fields and crop development. In Somalia, the yearly vanishing losses from irrigation channels are evaluated at 2 billion m<sup>3</sup> (Obinna, 2011). In Somalia, the high vanishing rates and leakage losses from open irrigation trenches in the Somalia are one of the fundamental drivers of water losses of up to 58 percent in the farming area (Houghton-Carr, Fry, Gadain & Muchiri, 2010). The study by Abu Taleb demonstrates that, if these losses are successfully diminished, the amount of water investment funds could achieve 50 million m<sup>3</sup> every year. Somalia has a high evaporation losses where most productive sites along Shabelle river with evaporation rate 5.2 to 6mm/day (Houghton-Carr, Fry, Gadain & Muchiri, 2010), because of direct sun shine and wind. The normal on-homestead efficiency in 1988 was assessed at 70 percent, and general efficiency 66 percent (Fanadzo, Chiduza & Mnkeni, 2010). The systems have effectively kept losses from both drainage and vanishing.

### **2.6.2. Distresses in Design of Irrigation Structures**

Distresses in Design of Irrigation Structures contribute enormously to wasteful water utilization. Numerous systems were intended to meet just restricted goals, and are not suitable for cutting

edge agrarian practices. Specialized limitations to these systems frequently constrain the likelihood for development through better administration, for example, in a few regions of Somalia (Fanadzo, Chiduza & Mnkeni, 2010), where numerous channels in the little regions in the good country territories are unprotected against disintegration. The headwork of channels is frequently washed away when surges happen.

Poor area leveling has been a limitation to fitting on-homestead water administration. Case in point, numerous territories in Upper Somalia that were changed over to perpetual irrigation after development spate irrigation on seasonal flush flooding rivers. Divided land and little and separate possessions farthest point setting up proficient irrigation routines. Surface irrigation systems are used as a part of most developed grounds of Somalia. The general water use efficiency of individual ranches is very low. Agriculturists apply intemperate irrigation water to reach zones at higher heights. Accordingly, water which is not devoured by plants penetrates and revives groundwater or streams into the waste system (Fanadzo, Chiduza & Mnkeni, 2010). Albeit downstream clients along the Somalia reuse a substantial piece of the depleted water, overabundance irrigation water prompts saltiness issues by raising groundwater tables.

The fundamental driver of high water losses in the irrigation systems of Somalia is the inadequately outlined structure of appropriation channels (Fanadzo, Chiduza & Mnkeni, 2010). Thus, the offices for water control are immature. Most entryways, physically worked, don't work on account of poor support and vandalism. Joints between units are frequently absent. By differentiation, the fundamental waterways especially those downstream of extensive stockpiling dams- - are better planned and more progressed, with remote checking and programmed control. Upkeep of the hardware is of an elevated requirement. Unmistakably, the fitting outline of irrigation systems is an essential for successful operations and administration.

### **2.6.3. Absence of Water Control during Night and Weekend Irrigation**

Absence of Water Control during Night and Weekend Irrigation is another issue in numerous creating nations. The study by Fanadzo, Chiduzza & Mnkeni (2010) demonstrates that, in Somalia, the normal transport losses between principle waterway admissions and circulation outlets was 25 percent. That between the conveyance outlets and fields was 11 percent. The joined impact prompts a system effectiveness of 67 percent. The principle purpose behind these losses was that agriculturists went without night irrigation. Irrigation systems were intended to work for 24 hours a day. In this manner, extensive measures of water were depleted inefficiently around evening time, when irrigation was not rehearsed. Accordingly, a few agriculturists confronted water deficiencies amid the day. A preservationist gauge for Somalia demonstrates that it is conceivable to build the ebb and flow flooded zone by 20-40 percent by diminishing irrigation water losses amid evenings and weekends (Abate, 1991). In Sudan, the first outline and operational idea of the Gezira plan embraced night stockpiling systems (Minhas et al., 2010). By changing water discharges as per interest, it was conceivable to diminish exorbitant water losses. Because of different reasons (see taking after area), the night stockpiling system was not used for a time of time. It was re-presented by the Government subsequent to modifying the configuration of the minor trenches (Minhas et al., 2010). The new system lessens operational water losses, as well as decreases siltation in the minor waterways downstream.

#### **2.6.4. Inadequacies in Management**

Inadequacies in Management imply poor execution of water control regulations and operation rules, and lacking support. It is an essential element clarifying water losses in the irrigation area. Lacking O&M has brought on extreme disintegration of irrigation waterways in numerous nations. The two Lam Pao extends in Thailand are illustrations of losses because of poor support of irrigation redirection structures (Minhas et al., 2010). The two tasks demonstrated lower than anticipated efficiencies (28 percent rather than the 55-58 percent evaluated at examination). The fundamental purpose behind water losses is leakage from the primary channels. Although the waterways were lined, splits and breakages happened everywhere throughout the trench linings as a result of disappointments in upkeep and lacking weed cleaning in the tertiary system. Subsequently, there was little contrast in drainage losses in the middle of lined and unlined channels. The same is valid for some undertaking regions in the Philippines (Salami, Kamara & Brixiova, 2010). In Somalia, for almost 25 percent of existing channels, the real widths surpass the outline widths because of debasement and the abuse of waterway banks. This has subsequently changed water levels and waterway releases.

The regulations for overseeing water systems are frequently insufficiently intended to meet variable supplies and requests. In Sudan, for case, irrigation administration works on the premise of 'upstream control'. The Ministry of Irrigation controls the conveyance of water to the heads of minor waterways. From that point on, field examiners have the obligation regarding managing the rotational conveyance of water to the fields. Agriculturists or rancher associations handle the on-homestead water administration. This division of obligation has been risky. Cultivating projects, which focus crops, edited range, turn and trimming force, regularly have not been reflected satisfactorily in the water conveyance programs (Salami, Kamara & Brixiova, 2010).

### **2.6.5. Seepage and Percolation**

Seepage and Percolation losses reflect irrigation water losses from unlined and ineffectively lined conveyance channels, trench, and from crop fields. In the Bas-Rhone locale of France, fundamental channels are completely lined and very much kept up. This outcome in a high system efficiency of 75-85 percent (Salami, Kamara & Brixiova, 2010). In Somalia, losses in transport systems are high. Around 25 percent of the supplies occupied from waterways is lost in the trench system through leakage and vanishing before it achieves dispersion bays. From the channels, losses through optional watercourses have been measured at 20-40 percent (Minhas et al., 2010).

Accordingly, just 45-60 percent of the supplies occupied from waterways are really conveyed to the fields (Minhas et al., 2010). In Somalia, drainage and spillage losses in the dispersion system are likewise extensive. Just 24 percent of the channels are lined, bringing about a system effectiveness of 55 percent (Minhas et al., 2010).

### **2.6.6. Soil Depth and Texture**

Soil Depth and Texture can have a noteworthy effect in efficiency levels. Two great cases are the Gezira plan (Sudan) and East India. The Gezira irrigation system has a greatly high system effectiveness of 93 percent (Qadir, Bahri, Sato & Al-Karadsheh, 2010). In spite of the fact that the configuration of the minor waterways is a contributing component, the high efficiency is because of the way of the mud. The mud is exceedingly impermeable and altogether diminishes spillages from the system. These elements represent a general efficiency level of 70 percent. In a few zones in East India, soils are shallow and rice irrigation is performed over hard-shake ranges. These adequately forestall water losses and lead to high handle efficiency levels of around 85 percent (Qadir, Bahri, Sato & Al-Karadsheh, 2010). Frederiksen's study likewise

demonstrates that water applications required for rice generation on overwhelming mud soils can be just a quarter of those on light textured soils. Waterways going through coarse materials, normal in alluvial fans, can lose tremendous amounts of water.

### **2.6.7. irrigation water loss assessment**

Conveyance of water from the source to the secondary canals is subject to water losses in the canal system due to seepage and evaporation and due to inappropriate regulation and management, resulting in poor distribution and spillage. Assessment of irrigation water losses is key activity on irrigation system to know the losses which are mostly happen at spill ways, seepages, evaporation, management and over watering, irrigation management check list tool is one of tools that is used to identify losses related to system and physical visits, open earthen canals are most related irrigation water losses, specifically at the intakes, diversion boxes and main water course that is freely open to the sun shine, beyond that the open earthen canals as part of surface irrigation losses in Somalia is subject to poor management, over-watering, overflows, seepage and deep percolation losses((FAO Manual module 4 for calculating CROPWAT).

In summary the literature shows that irrigation started long time ago and a lot of researches were done, irrigation is the only future for food security in the coming years, but it needs more investment and technology, in Somalia surface irrigation is mainly practiced, main factors that affect irrigation water supply losses includes: - over-watering, overflows, lack of control and maintenance seepage, poor maintenance and evaporation, since 1991 the systematic irrigation production as public management was zero but there was small irrigation practices on private basis which was subject to significant losses and continuous assessment and community capacity building will make difference in losses that are related to surface irrigation in Somalia.





## **CHAPTER THREE**

### **3.0 RESEARCH METHODOLOGY**

#### **3.1 Introduction**

This chapter explains the methods and procedures that were used to carry out the research. The discussion on the research design helps to identify, define and justify the design used and its suitability to the study. The chapter explains the population and sampling design, the methods used to collect data, research procedure, the data collection procedure and the data analysis.

##### **3.1.1 Study area**

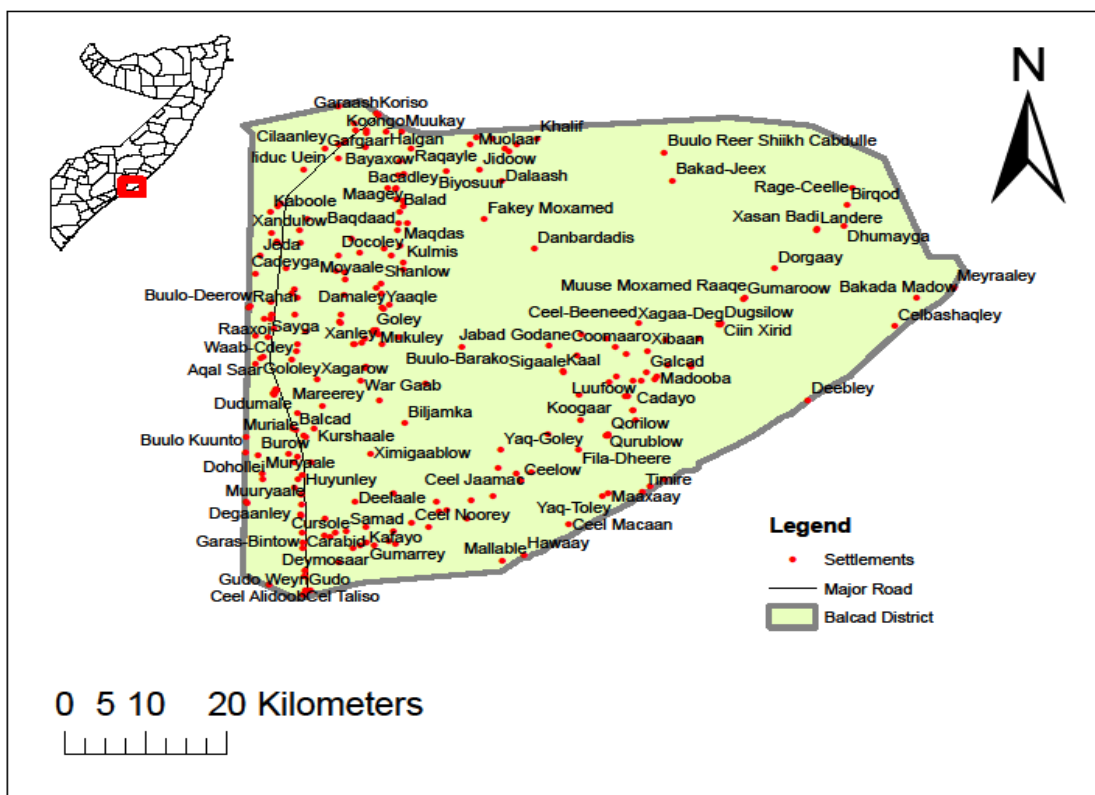
Bal'ad is among the districts in Middle Shabelle region of Somalia. Its location is about 36 kilometers from Mogadishu. It covers an area of 4400 square kilometers and has a population of about 642,000 within 82 villages. The district passes River Shabelle and this river passes through Bal-ad city. It borders the Indian Ocean and its coast is about 70 kilometers. The district is known for livestock, agriculture and marine resources (Samatar, 1989).

Bal'ad has a nature reserve that plays an essential role in the country. The location of this reserve is on Shabelle River's eastern bank which comes immediately to the south of the town. The Somali Ecological Study established it in 1985. It occupied 42 ha of land but in 1987, this enlarged to 190 ha. The site comprises of a few patches of the riverine forest remains along the Shabelle River in addition to the scrub savannah that surrounds it. The trees commonly found in the riverine forest are *Ficus sycamores*, *Mimusops fruticosa*, *Acacia elatior*, *Garcinia livingstonei* and *Tamarinus indica*. On the other hand, the surrounding scrub comprises of *Acacia nilotica* with a thick undergrowth of tall grass and herbs (Samatar, 1989).

Between 1985 and 1990, grazing, burning and cutting in the site were controlled. This showed signs of recovery and a rise in wildlife population. The textile industry is the leading in the area.

The SOMALTEX plant produces textile that supplies the entire domestic market. It is among the best textile plants in Africa with the best facilities. It is located in Bal'ad which has an idea climate for growing cotton. The administration of this district by the Somali Government encourages foreign and local investment (Samatar, 1989).

Bal'ad Map



### 3.1.2 Research design

Research design was a strategy, plan or structure for conducting a research project. The purpose of the research design was to ensure that the evidence obtained enables you to give a response to the initial question without ambiguity. Obtaining the right evidence simply means specifying the type of evidence needed to answer the research question, assessing a program, testing a theory or

accurately describing a certain phenomenon. In other words, the research design required a researcher to ask: from the given research question or theory, what type of evidence will be sufficient to test a theory or answer a given question convincingly? There was no connection between research design and the data collection method; you can use the research design with any data collection method. Besides, you can use either quantitative or qualitative data (Mitchell and Jolley, 2012).

This research adopted the non-experimental research design and particularly the descriptive research design. This design was suitable because it involved answering essential fact finding questions like Who, Where, How, When, Which, and How much (Cooper and Schindler, 2001). The use of descriptive study was essential for this study because usually, this design helps to depict the participants accurately. The researcher can do this through observation, case study or survey (Babbie, 2011). In this study, I used descriptive research by use of survey and specifically using a questionnaire and interview schedule to help know more about the participants and hence establish a relationship between political risks and foreign direct investment.

I assessed irrigation water supply losses in the major irrigation canal conveyance water loss in Bal'ad district. Descriptive studies are usually based on previous understanding of a research problem (Zikmund, 2003). I integrated this aspect by consulting a number of reputable and authoritative sources written by experts in the field of irrigation. This helped to find reliable information from secondary sources to help reinforce the understanding of the research problem. Moreover, descriptive survey helped to identify and describe the variables which exist in a certain situation and to explain the correlation between those variables thus helping to portray a picture of a certain phenomenon. Examples of descriptive statistics are the measures of central

tendency like mode, median, range, mean variance, standard deviation, measures of dispersion and frequency (Cooper and Schindler, 2003).

### **3.1.3 Target population**

Population was the total collection of elements with common observable characteristics that form the basis of making some inferences (Mugenda and Mugenda, 2003). The target population for this study was different irrigation canals, farmers and active NGO's in Bal'ad district.

### **3.1.4. Sampling frame**

The sampling frame can be part of a population or identical to that population. It may also relate to the population indirectly (Lohr, 2010). The sampling frame for this research includes a section of land surface in Bal'ad particularly one with various irrigation canals. This land surface is a part of the entire farming land in Bal'ad. This forms a suitable sampling frame because cotton and maize farmers practice different irrigation types in which water is lost in different ways.

### **3.1.5. Sample size**

Using snowballing sampling, the researcher identified and selected some of different irrigation canals in Bal'ad. These were drawn from the different areas within Bal'ad district. This is a suitable sample size because the farmers interact with diverse irrigation methods in their maize and cotton farming activities. Therefore, it was possible to assess irrigation water loss in these areas.

### **3.1.5. Sampling method**

The study has adopted the snowballing method. Snowballing is a non-probability sampling method used by researchers to identify potential respondents in studies where locating participants is hard. Researchers often use this approach if the sample for their study is either rare or limited to a small subset of the entire population. The sampling works in the same way as

chain referral. Once the researcher has observed the first subject, he goes ahead to ask the participant to help in identifying other people having a similar trait of interest. It is like asking your initial participants to nominate other individuals with similar traits. The researcher observes the nominated subject and goes on in the same way until a considerable number of participants have been obtained (Cooper and Schindler, 2003).

### **3.2. Type of data required and Data collection instrument**

This study used both secondary and primary data. Primary data refers to the collection of data that is unique to the specific research and that has never been used by others before in that Area.

The data required to use in my research mainly will be data related to the irrigation background of the area, climate information, and current status of irrigation canals specially the selected canals in Bal'ad district.

The data collection instrument method was basically identifying relevant water loss in irrigation canals from literature and from the field using remote sensing applications for the selected irrigation canals in order to identify/ determine irrigation supply efficiency of selected canals in Bal'ad district.

GPS coordinates of the selected irrigation sites helped in analyzing causes, locations of irrigation canal conveyance water loss, The questionnaire helped to verify the data collected, and confirmed from the field whether what had been measured were true thus verifying the causes of the water loss.

in order to identify water loss points of the canal supply I used direct measurement and questionnaires or management reports to validate what was captured.

The researcher compared data collected to other secondary sources of data such as academic journals and books containing relevant information from authorities in irrigation and water loss.

### 3.3. Data collection process

After the proposal was approved, I made a pre-visit to different locations of the district to be familiar with the specific areas containing irrigation canals, I assessed major irrigation water loss contributors, and collected data from different irrigation canals and field data collection tools (questionnaire) and measurement in the site. This helped me to collect useful data and properties of the irrigation canals. I have taken direct measurement of the canals at the intake, middle and end tails to calculate the flow rate and average velocity of the canals to evaluate over all conveyance losses of the canals.

### 3.4. Determination of irrigation supply efficiency in Bal'ad district in Somalia

- After selection of the sample canals in Bal'ad district, the canal course was assessed to identify current status of the canals; relevant measurements were taken by calculating Area, ( $A \text{ m}^2$ ) of the intake, middle points of the canal and measure flow rate and outlet points of the canals and mean velocity of both points and then subtracted in order to find the loss as a ratio of water diverted to the canal divide by water delivered. Losses of the canals that are calculated was used as indicator of irrigation supply efficiency
- canals were all trapezium, I used calculating the cross sectional area below formula: -  $A = (b + a)/2 * h$ .
- $b =$  canal base,  $a =$  top width,  $h =$  height.
- $Q = AV$  4
- $Q =$  discharge,  $A =$  cross-sectional area of the canal,  $V =$  average velocity

- computed conveyance efficiency using (inflow- outflow equation) where Water losses percentage (%) = amount of water diverted minus amount of water delivered to the field divided by amount of water diverted multiplied 100 .
- $(Q_i - Q_0) / (Q_i \times 100)$  as common canal length lose percentage. 5
- Losses (% per 100m) =  $[(Q_i - Q_0) / Q_i \times 100] \times (100/L) = (\% \text{ losses} / \text{total length}) \times 100$  6

Using questionnaire and management reports and design documents (literature review), the researcher computed the conveyance efficiency of the canals.

### **3.5. Determination of major irrigation canals water loss contributors in Bal'ad district**

After collection of existing remote sensing data and aerial photographs specially dry season images, canals were assessed, to identify any greenness in areas along the canal that receive water through breakage or leakage, I compared the amount of water extracted and the amount of water delivered in the tertiary canals, and used the climate data of the area to I identify and estimate evaporative losses of the selected canals.

Using questionnaire, field visits, and literature review, data collected related to the irrigation background of the area, climate information, and status of irrigation canals specially the selected canals in Bal'ad district.

Analysing information and data collected through questionnaire from direct interviews and identify main factors affecting irrigation supply efficiency in Bal'ad district, Somalia. To avoid high percentage of biasness, I counter check the available water and the production of the farmers in growing seasons, this will reflect the results from questionnaire that will confirm the reality of interviews and what we saw in the field.



## **CHAPTER 4: RESULTS and DISCUSSIONS**

### **4.1 Introduction**

This chapter describes the findings/results on the assessment of irrigation water supply losses in major irrigation canals in Bal'ad district of middle Shabelle region in Somalia, also this chapter gives a detailed discussion of the findings stated in this chapter.

The findings are described under the study's objectives: determine irrigation supply efficiency, the major contributors of water loss in irrigation canals and the types of water losses in Bal'ad irrigation canals. The findings in this study are presented in the form of frequency tables, bar graphs and pie-charts.

#### **4.1.1 Response Rate**

The respondents for the study comprised of two groups of people: farmers using irrigation and NGO employees. The study targeted 33 NGO employees and 20 farmers, and out of these, 25 NGO employees and 16 farmers responded. Therefore, the response rate for farmers was 80% and that of NGO employees was 75.76%.

## 4.2. Socio-Demographic Characteristics of Respondents

### 4.2.1. Socio-Demographic Characteristics of NGO Employees

**Table 1: Socio-Demographic Characteristics of NGO Employees**

<b>Variable</b>	<b>Attribute</b>	<b>Frequency</b>	<b>Percentage</b>
Age	18-30 years	6	24%
	31-45 years	10	40%
	Above 45 years	7	28%
Level of education	Primary level	0	0
	High school level	11	44%
	University level	12	48%
Employment period	Less than a year	0	0
	1-2 years	2	8%
	3-5 years	10	40%
	Over 5 years	11	44%
Position in the organization	Low level	0	0
	Mid level	15	60%
	High level	8	32%

From table 1, the highest number of NGO employees (40%) was aged between 31 and 45 years. On the other hand, 24% of them were aged between 18 and 30 years while 28% employees were above 45 years. As far as the level of education is concerned, 44% of employees had high level of education while 48% had university education.

None of the employees has worked with the NGO for less than a year. 8% of them have worked for 1 to 2 years; 40% of the employees have worked for 3-5 years and 44% have worked for over 5 years. The study's findings also show that 60% of the respondents hold middle level positions in the organization while 32% of them are in the high (management) level. None of the employees is in the low level.

The responses of the above group are captured and summarized in the below sections 4.3 up to 4.3.3.2, this group was one of the main target groups and interviewed individually using questionnaire and discussions, it is answering all the questions in the questionnaire related irrigation efficiency, conveyance losses, length of the canals, maintenance of the canals and field applications.

#### 4.3 Irrigation Efficiency and Loss

**Table 2: Ways in Which Irrigation Canals Lose Water**

Water loss method	Frequency	Percentage
Evaporation from water surface	25	100%
Seepage through canal bunds		
Bund breaks	25	100%
Deep percolation to the soil layers beneath the canals		
Runoff through the drain	7	28%
Overtopping the bunds	17	68%
Rat holes in canal bunds	3	12%

All the respondents agreed that irrigation canals lose water through evaporation from the water surface and seepage through the canal bunds. On the other hand, 28% of them suggested that

water is lost through runoff through the drain; 68% stated that overtopping the bunds contributes to water losses at the irrigation canals and 12% suggested that irrigation canals lose water through rat holes in the canal bunds.

#### 4.3.1. The Length of Irrigation Canals in Bal’ad District

**Figure 1: The Length of Irrigation Canals in Bal’ad District**

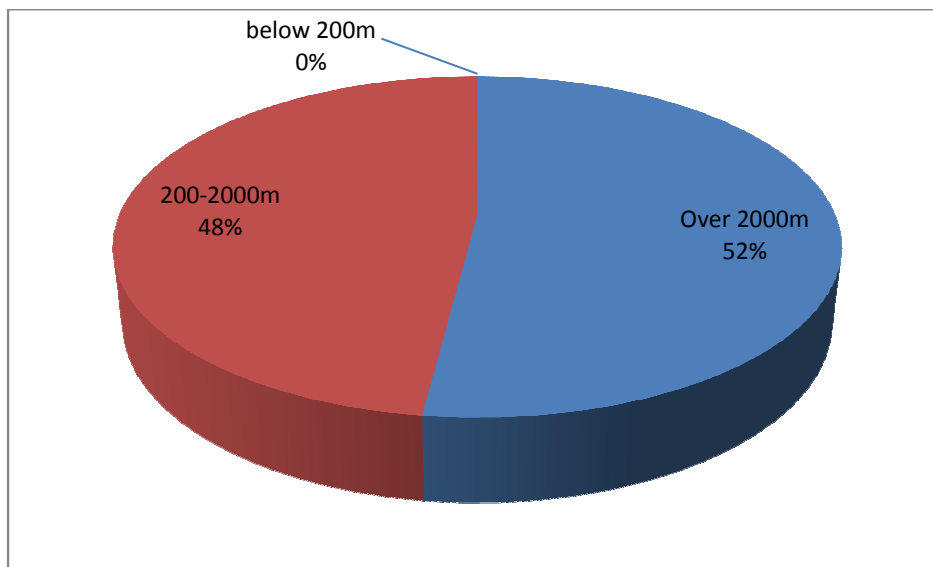
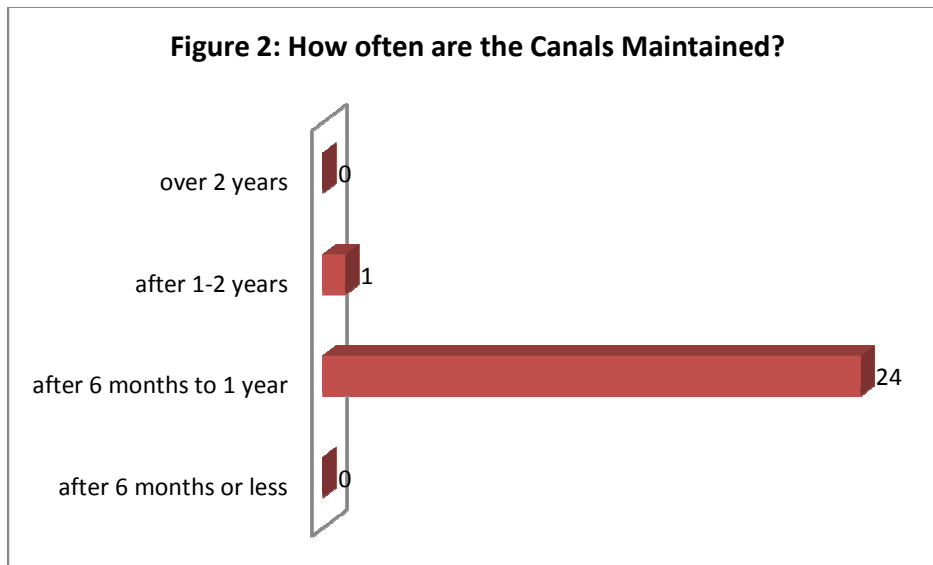


Figure 1 above shows that 52% of the respondents said that the irrigation canals are long (over 2000 meters); 48% of the respondents said that the canals are medium (200-2000 meters) and none of the respondents said the canals are short (below 200 meters).

#### 4.3.2. How often are the Canals Maintained?

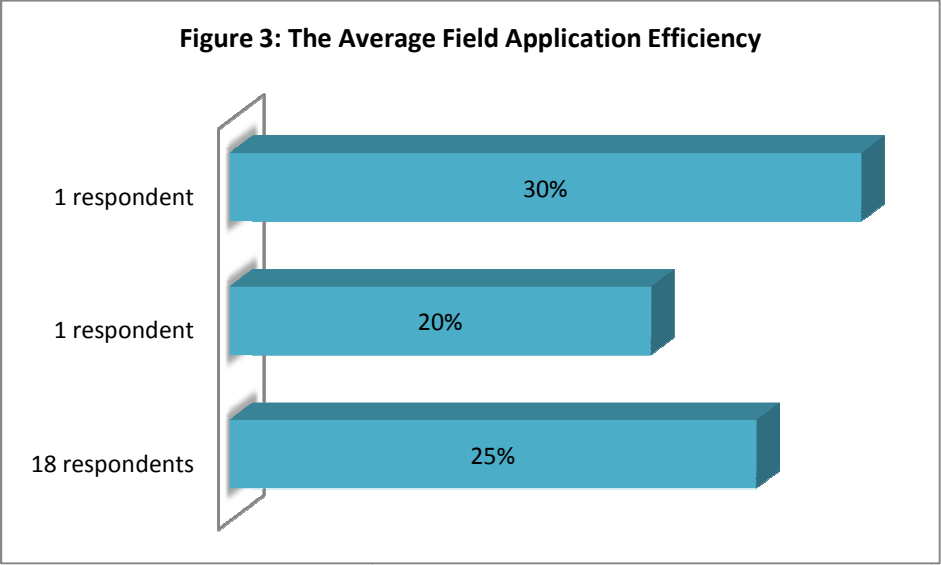


From figure 2 above, 24 of the respondents suggested that the canals are maintained after between 6 months to one year, 1 respondent maintained that they are maintained after 1 to 2 years, and no one suggested they are maintained after over 2 years or below 6 months.

#### 4.3.3. The Average Field Application Efficiency and Conveyance Efficiency

##### 4.3.3.1. The Average Field Application Efficiency

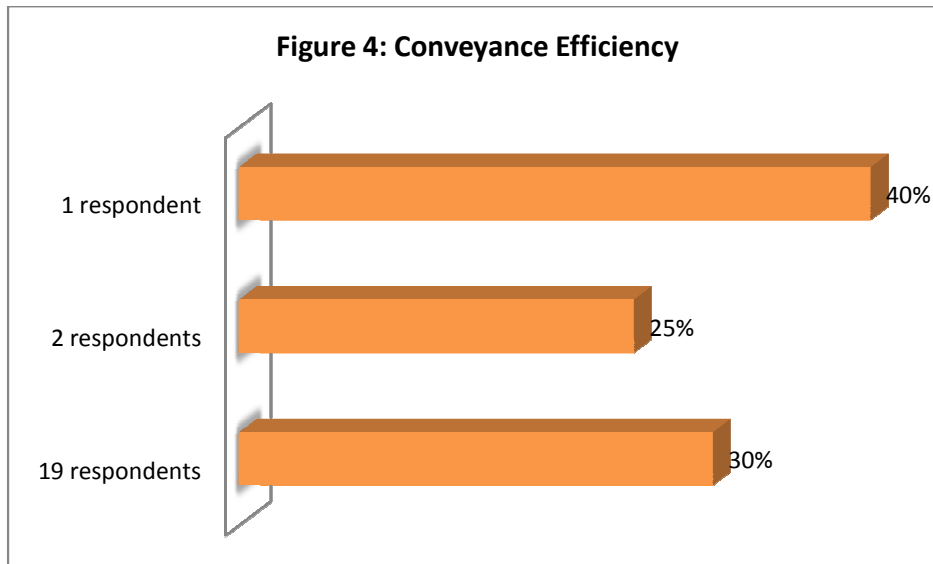
Respondents were asked to give the average field application efficiency and conveyance efficiency for Bal'ad district's irrigation methods and the results were as shown in the figure below.



From figure 3, 18 respondents gave the average field application efficiency as 25%; one respondent gave it as 20% and another respondent gave it as 30%.

#### 4.3.3.2. Conveyance Efficiency

Figure 4: Conveyance Efficiency



From figure 4, Two of respondents stated that the average conveyance efficiency of irrigation methods in Bal'ad district is 25%; 19 respondents stated that the conveyance efficiency is 30% while one more stated that it is 40%.

#### 4.3.4. Ways of Preventing Irrigation Water Losses at the Canals

All the respondents answered this question and provided different ways for preventing irrigation water losses at the canals. They suggested the following ways: capacity building of the farmers and management, good land preparation, continuous maintenance of the canals, lining of the canals, daily supervision, continuous assessment and evaluation, and good management of irrigation methods.

The second group who are the farmers using the canals in Bal'ad District have been interviewed to answer conveyance losses of their canals according to their experiences in the past.

#### 4.4. Socio-Demographic Characteristics of Farmers Using Irrigation

**Table 3: Socio-Demographic Characteristics of Farmers Using Irrigation**

<b>Variable</b>	<b>Attribute</b>	<b>Frequency</b>	<b>Percentage</b>
Age	18-30 years	0	0
	31-45 years	4	25%
	Above 45 years	12	75%
Level of education	Primary level	2	12.5%
	High school level	4	25%
	University level	10	62.5%
Duration of using irrigation	Less than a year	0	0
	1-2 years	0	0
	3-5 years	1	6.25%
	Over 5 years	15	93.75%
Size of farming land	Less than 1 acre	0	0
	2 acres	0	0
	3 acres	0	0
	4 acres	0	0
	5 acres	3	18.75%
	6-10 acres	6	37.5%
	Over 10 acres	8	50%



From table 3, above, 25% of the farmers were aged 31 to 45 years whereas 75% were above 45 years. None of them was in the 18 to 30 years category. A greater percentage of the farmers (62.5%) have university education; 25% have high school level education, and only 12.5% have primary level education.

The findings also show that 93.75% of the farmers have been using irrigation farming for over 5 years and only 6.25% of them have been using it for 3 to 5 years. The findings for the farmers' size of farming land show that 18.75% of the respondents have 5 acres; 37.5% of them have 6 to 10 acres and 50% of them have over 10 acres of land.

Thus, the responses of the second group (the farmers using the canals) that were interviewed are summarized in the below sections from 4.5 up to 4.5.4.

#### **4.5. Irrigation Type and Water Loss**

##### **4.5.1. The Distance between the Farm and Irrigation Source**

The respondents were asked to state the distance between their farms and irrigation source and here were the results.

**Table 4: Distance between the Farm and Irrigation Source**

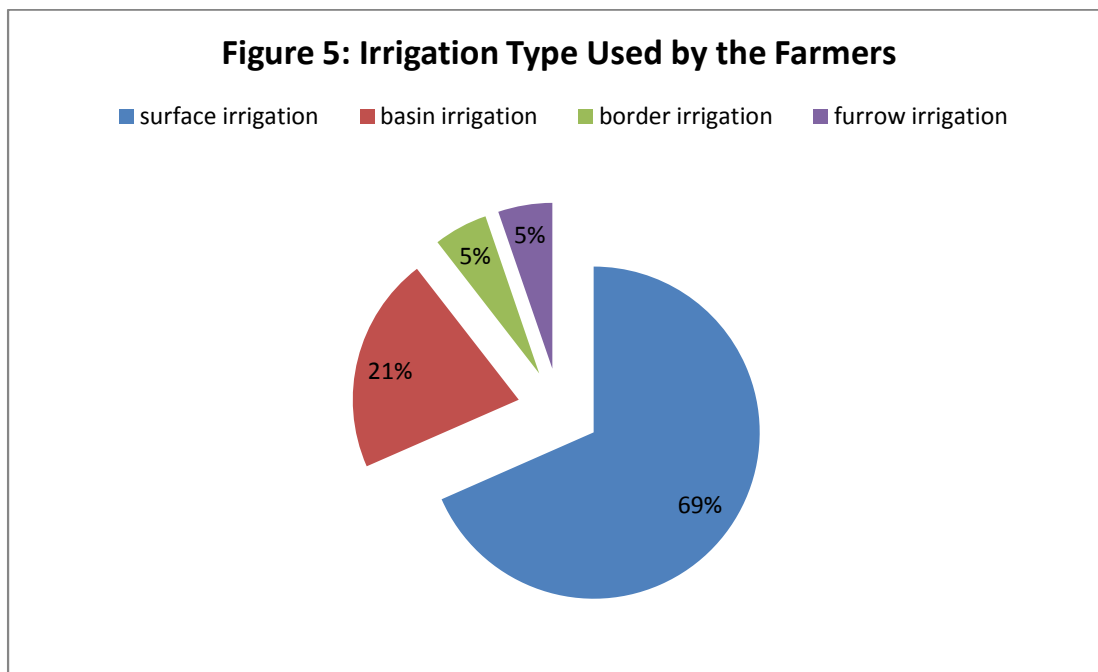
Distance	Frequency	Percentage
100-200 meters	1	6.25%
200-250 meters	1	6.25%
500-1000 meters	6	37.5%
More than 1000 meters	8	50%

From table 4, only 6.25% of the respondents said that the distance between their farms and irrigation is between 100 and 200 meters. The same number of respondents said the distance is

between 200 and 250 meters. However, 37.5% of them stated that the distance between their farms and source of irrigation is 500 to 1000 meters while 50% said their farms are more than 1000 meters from the irrigation source.

#### 4.5.2. Irrigation Type Used by the Farmers

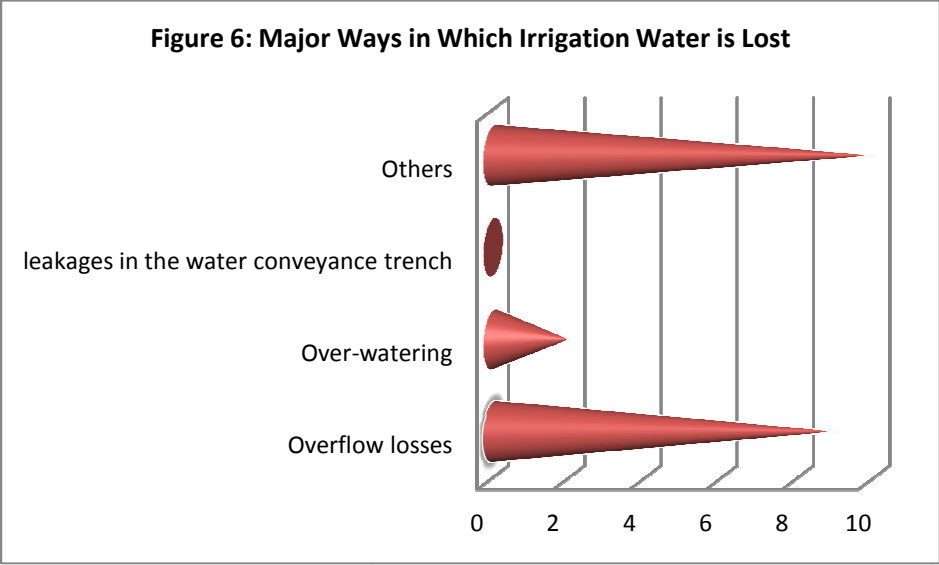
The farmers were asked to state the type of irrigation they use on their farming lands and their responses were as follows:



From figure 5, 69% of the respondents said they use surface irrigation, 21% said they use basin irrigation. 5% of them use border irrigation and another 5% uses furrow irrigation.

#### 4.5.3. Major Ways in Which Irrigation Water is Lost

The respondents were required to state the major ways through which irrigation water is lost.



From figure 6, 9 respondents stated overflow losses as the major way in which irrigation water is lost. 2 of the respondents choose overwatering and 10 of them stated other methods of water loss including evaporation, mismanagement, growth of grass on the canal bunks, illegal water diversion and debris.

**4.5.4. Ways of Preventing Irrigation Water Loss on Farming Land**

The respondents were asked to explain some of the ways they think could help to prevent loss of irrigation water on their farms. 100% of them responded and their answers were daily supervision to know when and where water is lost, proper maintenance, water allocation for each farmer, good management, and good preparation of land, lining of the canals, and training of farmers on proper use of irrigation water.

On the other and, field measurements on the canals were taken, specially intake dimensions, middle and end tails to know the amount of water that was diverted and amount of water that reached the secondary canals at the current canal status and results are presented below :-

#### 4.5.5. Comparison of percentage loss per hundred meters of the Canals

Looking for canals if there is a canal more efficient, if all are same condition

Using inflow – outflow equation

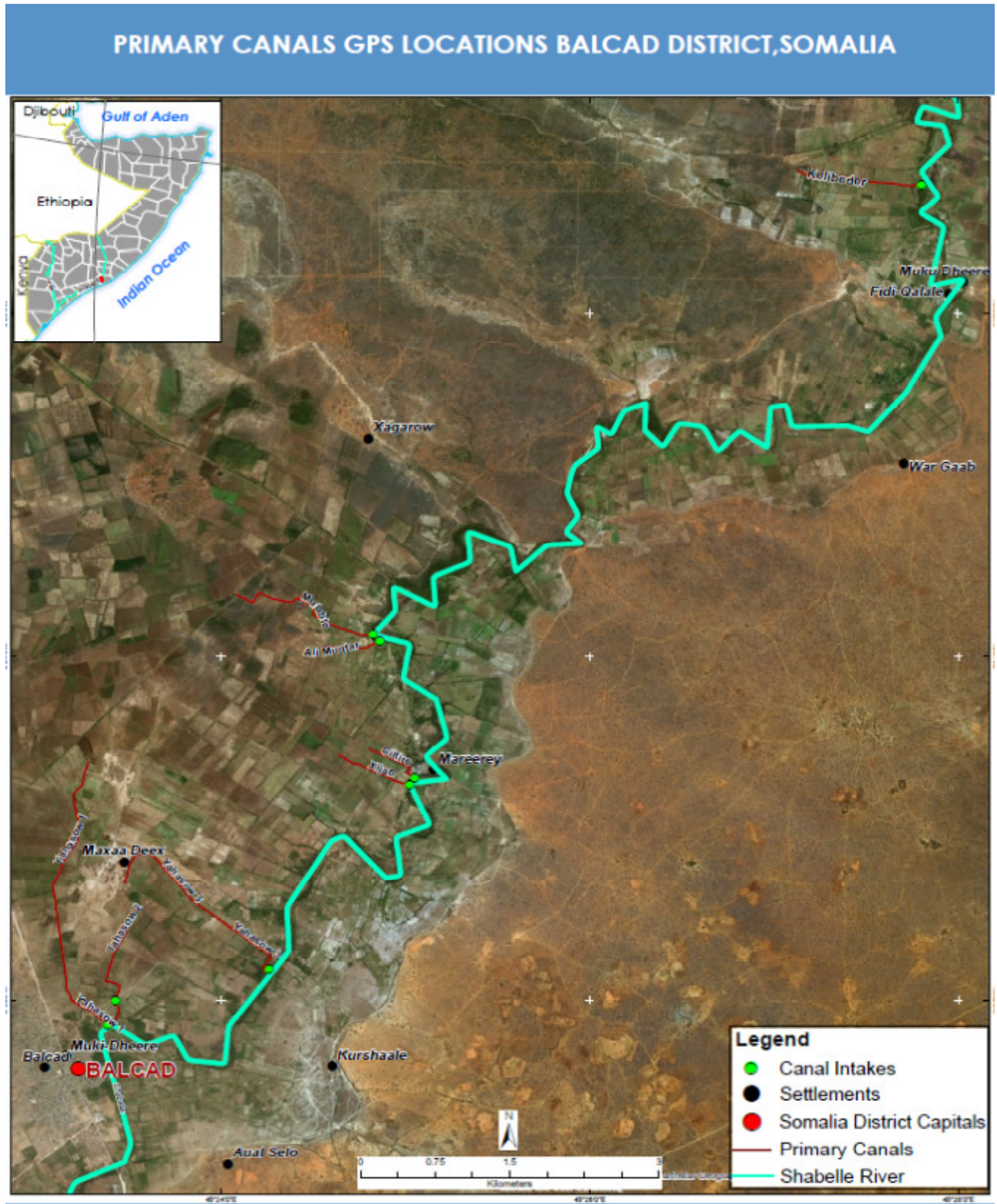
Water losses percentage (%) = amount of water diverted minus amount of water delivered the field divided by amount of water diverted multiplied 100  
 $(Q_i - Q_o)/Q_i \times 100$

Losses (% per 100m) =  $[(Q_i - Q_o)/Q_i \times 100] \times (100/L) = (\% \text{ losses/total length}) \times 100$

S/N	A (intake)	B (Middle)	C (outlet)	A-B loss% and loss % for each 100m	B-C loss% and 100m lose % each
Canal1 (1.8km)	0.253m <sup>3</sup> /s	0.189m <sup>3</sup> /S	0.149M <sup>3</sup> /S	25.3%, and each 100m lose % = 2.811	21.16% And each 100m lose % = 2.35%
Canal2 (2km)	0.1037M <sup>3</sup> /S	0.0855M <sup>3</sup> /S	0.0783M <sup>3</sup> /S	17.55% and each 100m Lose % = 1.755%.	8.42 % and lose % each 100m 0.842 %
Canal3 (3.8km)	0.1047M <sup>3</sup> /S	0.082M <sup>3</sup> /S	0.067M <sup>3</sup> /S	21.16% And each 100m lose % = 1.12736	18.3%. and each 100m lose 0.95%. % =

Canal 4(2 km)	0.1687m <sup>3</sup> /s	0.153m <sup>3</sup> /s	0.135m <sup>3</sup> /s	9.3% and each 100m lose = 0.93%.	11.76% and each 100m lose = 1.176%.
Canal 5 (2km)	0.165m <sup>3</sup> /s	0.136m <sup>3</sup> /s	0.133m <sup>3</sup> /s	17.57%, And each 100m lose % = 1.757%.	2.2%, and each 100m lose % = 0.22%
Canal 6(2km)	0.185m <sup>3</sup> /s	0.180m <sup>3</sup> /s	0.11475m <sup>3</sup> /s	2.7%, and each 100m lose % = 0.27%.	36.25% and each 100m lose % = 3.625%
Canal 7(2km)	0.1181m <sup>3</sup> /s	0.0936m <sup>3</sup> /s	0.0765m <sup>3</sup> /s	20.75%, And each 100m lose % = 2.0%	18.27 %, and each 100m lose % = 1.827 %
Canal 8(3km)	0.189m <sup>3</sup> /s	0.175m <sup>3</sup> /s	0.166m <sup>3</sup> /s	7.4% and each 100m lose % = 4.9%	5.14% and each 100m lose % = 3.42%
Canal 9(4.2km)	0.1113m <sup>3</sup> /s	0.0855m <sup>3</sup> /s	0.0689m <sup>3</sup> /s	24.7%, and each 100m lose % = 1.175%.	19.4%, and each 100m lose % = 0.92%

#### 4.5.6. GPS locations and Sterlite images of the Bal'ad Canals



#### **4.6.0. Discussion**

##### **4.6.1. Response Rate**

From the findings, 80% of the farmers and 75.76% of NGO employees responded to the study. This implies that farmers in Bal'ad district have been using irrigation in their farming methods and have something to say regarding the loss of irrigation water in their farms and at the canals. It also shows that the NGO employees are experienced enough to provide adequate information regarding loss of irrigation water along the canals in Bal'ad.

##### **4.6.2. Socio-Demographic Characteristics of NGO Employees**

40% of NGO employees were aged between 31 and 45; 24% of them were aged between 18 and 30 years while 28% employees were above 45 years. This shows that most of the NGOs in Bal'ad hire experienced employees since people aged 31 years and above have probably worked in other places before. This shows how these organizations value experience of its employees as it mainly translates into expertise and effective service delivery.

As far as the level of education is concerned, 44% of employees had high level of education while 48% had university education. This shows that these organizations go for highly educated employees who are able to manage the companies effectively and make technical decisions.

Besides that, advanced irrigation farming methods are mainly taught in high school and tertiary institutions and hence, none of the employees had worked with the NGO for less than a year. 8% of them have worked for 1 to 2 years; 40% of the employees have worked for 3-5 years and 44% have worked for over 5 years. This shows that the organizations have a low staff turnover and have experienced employees.

The study's findings also show that 60% of the respondents hold middle level positions in the organization while 32% of them are in the high (management) level. None of the employees is in the low level. The implication of this is that the respondents for this study are senior employees in the organizations and they have more expertise, knowledge and experience on irrigation farming as a topic.

#### **4.6.3. Irrigation Efficiency and Loss**

All the respondents stated that irrigation canals lose water through evaporation from the water surface and seepage through the canal bunds (here the kind of soil of Bal'ad irrigating farmer's using is loom clay very compacted and saturated for more than 200 years so seepage losses in this area is not significant, but evaporation was calculated using evaporation rate of Bal'ad district which is 6mm per day multiplied the surface area of the canal and captured as a loss. On the other hand, 28% of them said that water is lost through runoff through the drain; 68% stated that overtopping the bunds contributes to water losses at the irrigation canals and 12% suggested that irrigation canals lose water through rat holes in the canal bunds. Mainly, the low efficiency here is based on miss management and conflict of resources no matter how people are educated or they get resources.

The response implies that the main ways through which irrigation canals lose water is through evaporation from the water surface, seepage through the canal bunds, and overtopping the bunds.

This coincides well with what is in the literature regarding the main ways through which irrigation water is lost as evaporation from the water surfaces, overtopping of canal bunds and leakage through the canals' bunds (Sun, et al, 2010),



#### **4.6.4. The Length of Irrigation Canals in Bal'ad District**

From the results, 52% of the respondents said that the irrigation canals are over 2000 meters long. 48% of the respondents said that the canals are 200-2000 meters long and none of the respondents said the canals are below 200 meters. These results imply that the major losses of irrigation water are seepage through the canal bunds and evaporation. This is because the length of irrigation canals determines water loss through evaporation and seepage. A greater length increases the cross-sectional area of the water surface which increases the amount of water the canal loses through evaporation. Seepage losses depend on the canal's geometry which constitutes its length (Ghazaw, 2011).

#### **4.6.5. How often are the Canals Maintained?**

According to 24 of the respondents, the maintenance of irrigation canals takes place after 6 months to one year. This could be the time interval set aside by the NGO's staff to carry out maintenance on these sites. Canal maintenance should take place during times of low water demand or between two irrigation seasons (Qadir, et al, 2010).

Somalia experiences water shortage and the demand of water for farming lands is always high which possibly makes it hard to carry out regular maintenance. Nevertheless, taking long to maintain the canals will only increase irrigation water loss through seepage, evaporation, overtopping and more.

#### **4.6.6. The Average Field Application Efficiency and Conveyance Efficiency**

18 respondents gave an average field application efficiency of 25%; one respondent gave it as 20% and another respondent gave it as 30%. This means the efficiency of water application in

the farming lands in Bal'ad is low which may point to a low level of farmer discipline in the region.

On the other hand, two respondents stated that the average conveyance efficiency is 25%; 19 respondents stated that the conveyance efficiency is 30% and one respondent stated that it is 40%. This shows there is low efficiency of water transport along the canals. The low efficiency may result from poor maintenance of the irrigation canals, sandy soils in Bal'ad farms and longer canal systems (FAO, n.d). The latter confirms the results in section 5.2.4 that irrigation canals are more than 2000 meters long.

Calculating the scheme irrigation efficiency, e,

$$e = \frac{ec \times ea}{100}$$

7

$$e = (25 \times 30)/100$$

$$e = 7.5\%$$

Thus the scheme irrigation efficiency is 7.5% which is poor for a surface irrigation system that's prevalent in Bal'ad district.

#### **4.6.7. Ways of Preventing Irrigation Water Losses at the Canals**

The respondents suggested several ways that can help prevent irrigation water losses along the canals. The suggested ways include: capacity building of the farmers and management, good land preparation, continuous maintenance of the canals, lining of the canals, daily supervision, continuous assessment and evaluation, and good management of irrigation methods.

Capacity building is important because from the field application value reported above, the discipline level of farmers in Bal'ad seems to be low and that means they should be educated on proper use of irrigation water. The low field application efficiency also means there is poor land preparation. Farmers need to prepare land by clearing bushes, removing rocks and stones, leveling the soil and ripping to make it easy for the soil to absorb and utilize the irrigation water.

Canals should undergo regular maintenance because, as already reported from the findings, they contribute towards water loss through runoffs, overtopping the bunds, rat holes, bund breaks and evaporation.

Lining of the canal is important as it helps to reduce water loss through seepage. Canals which transport 30 to 150 liters per second can lose from 10 to 15 percent of this flow through seepage. Weeds may also consume more water leading to further losses. While lining a canal won't eliminate such losses, it will save about 60 to 80 percent of water that flows on unlined canals.

Highly permeable canal banks lose massive amounts of water through seepage. The leaking water causes waterlogged and wet conditions not to mention standing water on nearby roads or fields. However, lining the canal can correct this problem since lined canals are not as permeable as unlined banks; depending on the canal's lining material, the permeability of a lined canal can even be zero. Lining a canal reduces its cross-sectional area. A lined canal offers less resistance to flow than an unlined one. Therefore, a lined canal allows a higher flow velocity than the unlined one. Besides, the solid surface of the canal's lining material contributes to a higher velocity since it is not easy to erode it. Given that the canal discharge is given as the product of the flow velocity and canal's cross section, a higher velocity obtainable and allowable in lined canals can lead to a cross-section that is smaller than that of the unlined canal (The Constructor,

2015). Canal lining will also reduce maintenance costs of canals. A surface lining like plastic, concrete and brick along the canal surface impedes hole-making by rats and prevents plants from growing. Consequently, maintaining a lined canal becomes easier than unlined canal. Besides, the higher velocity of flow along a lined canal ensures that small soil particles within the moving water don't settle and accumulate to cause siltation (The Constructor, 2015).

Daily supervision of water use is also paramount because if it's not implemented, some farmers can easily divert irrigation water to other uses. Additionally, an essential approach is continuous assessment and evaluation of the canals' performance. After carrying out maintenance procedures, it is crucial to check the canals and the irrigation systems and calculate the efficiency to establish whether maintenance procedures were effective and whether there are new water losses that require attention.

- From the results, the main types of irrigation used by Bal'ad farmers include surface irrigation and basin irrigation. These irrigation methods can lead to water losses too and so, they should be managed from time to time. Before a growing season comes, the basins need to be checked to ensure they are level. The bunds in basins are prone to erosion which can be caused by flooding or footpaths by passing people. Rats may also create holes in the bunds. It's therefore paramount to inspect these bunds on a regular basis and fix them to prevent a greater damage. Moreover, it is essential to keep the field channels free from silt deposits and weeds (FAO), To improve the efficiency of irrigation, farmers ought to be more disciplined in the amount and duration of irrigation. On the hand, the management has the responsibility of creating a maintenance schedule for canals and an

#### **4.7.0. Socio-Demographic Characteristics of Farmers Using Irrigation**

##### **4.7.1. Age**

From the results, 25% of the farmers were aged 31 to 45 years whereas 75% were above 45 years. None of them was in the 18 to 30 years category. This shows that farming is the main source of livelihood for most households in Bal'ad because typically, those aged 31 and above are the main providers in families. It also implies that most of the youth (18-30 years) engage in other economic activities other than farming.

##### **4.7.2. Level of Education**

From the findings, 62.5% of the farmers have university education; 25% have high school level education, and only 12.5% have primary level education. The implication of this is that the Bal'ad farmers have a greater understanding of irrigation farming methods because most of these concepts are taught at high school and university levels, majority of the Bal'ad farmers are University graduate as per results and for that reason Bal'ad district is the second biggest production sites in Somalia after Afgoye Dsitric, level of education has direct impact on irrigation supply lose , whenever level is higher the irrigation losses are identified and dealt with or prevented.

##### **4.7.3. Duration of Using Irrigation Farming**

From the findings, 93.75% of the farmers have been using irrigation farming for over 5 years while 6.25% of them have been using it for 3 to 5 years. This implies that irrigation farming has been sustainable in Somalia and farmers rely on it for production. It also shows that there has been no reliable rainfall in the region for a long time.

#### **4.7.4. Size of Farming Land**

18.75% of the respondents have 5 acres; 37.5% of them have 6 to 10 acres and 50% of them have over 10 acres of land. These results imply that irrigation farming in Somalia is done on a large scale. It also implies that farming is a leading economic activity in Somalia and that if not managed properly, a greater percentage of irrigation water can be lost on farming land because the land is huge.

#### **4.7.5. Irrigation Type and Water Loss**

##### **4.7.5.1. The Distance between the Farm and Irrigation Source**

37.5% of the respondents stated that the distance between their farms and source of irrigation is 500 to 1000 meters while 50% said their farms are more than 1000 meters from the irrigation source. From the findings, a greater percentage of farmers have their farms farther away from the irrigation source. This implies that longer distances between farming lands and irrigation sources increase the amount of water lost. As water flows from the source to the farms, it is lost through seepage to the soil and runoffs.

##### **4.7.6. Irrigation Type Used by the Farmers**

From the findings, 69% of the respondents use surface irrigation, 21% use basin irrigation and 10% of them use border and furrow irrigation. The implication here is that plenty of irrigation water is lost through surface irrigation and particularly through evaporation from the surface of the soil, runoffs and seepage from the water distribution ditches. The amount of water seeping through unlined ditches depends on soil characteristics and how big the ditch network is; water seepage in ditches may contribute to anywhere between 10% and 15% of the supplied water.

#### **4.7.7. Major Ways in Which Irrigation Water is Lost**

From the results, water is mainly lost through overflow losses and overwatering. Overflow losses occur when the river overflows, causing canals to overflow. This causes excess water to spill over to the farming fields or away. Overwatering means that more water is applied to the farms than what the crops can take.

#### **4.7.8. Irrigation Type and Water Loss**

##### **4.7.8.1. The Distance between the Farm and Irrigation Source**

37.5% of the respondents stated that the distance between their farms and source of irrigation is 500 to 1000 meters while 50% said their farms are more than 1000 meters from the irrigation source. From the findings, a greater percentage of farmers have their farms farther away from the irrigation source. This implies that longer distances between farming lands and irrigation sources increase the amount of water lost. As water flows from the source to the farms, it is lost through seepage to the soil and runoffs.

#### **4.7.9 Irrigation Type Used by the Farmers**

From the findings, 69% of the respondents use surface irrigation, 21% use basin irrigation and 10% of them use border and furrow irrigation. The implication here is that plenty of irrigation water is lost through surface irrigation and particularly through evaporation from the surface of the soil, runoffs and seepage from the water distribution ditches. The amount of water seeping through unlined ditches depends on soil characteristics and how big the ditch network is; water seepage in ditches may contribute to anywhere between 10% and 15% of the supplied water.

#### **4.7.10. Major Ways in Which Irrigation Water is Lost**

From the results, water is mainly lost through overflow losses and overwatering. Overflow losses occur when the river overflows, causing canals to overflow. This causes excess water to spill

over to the farming fields or away. Overwatering means that more water is applied to the farms than what the crops can take.

#### **4.7.11. Ways of Preventing Irrigation Water Loss on Farming Land**

When asked to give examples of preventing irrigation water loss on their farms, the respondents gave different ways including daily supervision, water allocation for each farmer, proper maintenance, good preparation of land, good management, lining of canals and capacity building of the farmers.

This means that the Bal'ad farmers have great knowledge on irrigation farming such that they understand how water is lost and what can be done to prevent these losses. It also implies that they are ready and willing to participate in implementing measures that can reduce water loss.

The daily supervision activities that can prevent water loss include undertaking certain measures to know the daily amount of water that goes towards irrigation, this is private farming not the public or government managed farming. This will help to know how much water is lost and thus, take steps to minimize further losses. To know the amount of daily water being used, private water meters should be installed in different farming fields. Readings should be taken daily to monitor water usage.

Daily supervision also means checking for leaks which should be done during peak periods when there is little or negligible water in use. They should watch the water meter to find out if the counter moves as such a movement may mean there is leakage at some point. Signs for the presence of leakage include: sudden high consumption of water, damp ground over buried pipes for several days, and an unexplained drop in the pressure of water.



Water allocation for each farmer means there is an imbalanced distribution or misuse of irrigation water by some farmers. To avoid this situation, the management should visit each farming land to establish its size and the amount of water the soil can hold, depending on the soil type. They should then allocate irrigation water to each farmer according to the farmer's needs.

Proper maintenance means removing debris, sediments and other blockage that can restrict capacity. It entails repairing cracks, spalls and weathered regions in concrete surfaces of the canal. It also involves an immediate of any breaks and cracks within the canal lining. This may require investigating the cause prior to repair and taking measures to curb re-occurrence.

Additionally, proper maintenance involves the eradication of rodents and other burrowing animals and fixing any damage caused by them.

Good land preparation implies that farmers should level their fields, remove rocks and stones, and remove all bushes before planting. This prevents unnecessary water losses when the fields are irrigated.

Good management means taking measures to ensure irrigation canals are working effectively, coordinating with farmers to minimize water losses and having the right personnel to address irrigation matters impartially. In practical terms, it may involve maintaining the heights and widths of soil beams near the lining, avoiding use of tillage equipment around the lining as it could accelerate soil removal.

Capacity building and lining of canals had been suggested earlier by NGO employees as ways that can be used to reduce irrigation water loss. This means that both farmers and NGO employees are aware of ways through which irrigation water is lost, and even know the right

ways to help prevent such losses. This means it's possible for the two parties to agree on strategies to prevent irrigation water loss on farming land.

#### **4.8.0. Field Measurements**

In the calculations and figures that came out as result of the evaluation of the inlets and out lets of the each canal at Bal ad district shows that higher losses occur at section one (A to B), then section two (B to C) and this is because of poor intake shapes, lack of controlled gates, river bank and river bed are already in same height because of siltation in the river bed. The canals have minimum of once 6 to 12 months maintenance cycle according to site observations in the field and findings of the community interviews that I did through questionnaires, the figures from the study shows high percentage of losses in most of the canals, this can be either poor or zero management/maintenance or changing canal dimensions due to siltation, debris and growing grass in canal beds. The standard earthen canal efficiency in good management goes up to 55-60 percent (FAO) and in Somalia like the case in Bal'ad district as a sample of Irrigation belt in the country, the efficiency of earthen canals always very low, conveyance losses is the main challenge that the farmers face. Unfortunately According to studies related to this research that was done before in the same area was not there but I found Conveyance losses mainly the seepage losses are most challenging water conveyance problems as common issue, e.g. in Pakistan 35 to 40% of the water diverted to the main canal is lost through watercourse which is very high (Tariq Osman Saeed and Taj Ali Khan, 2013), Generally, the conveyance losses ranges from 25 to 50% of total diverted water to the canal, (Tariq from University of Khartoum).

This is because of no water user management in farmer level and un availability of continuous maintenance. The study concentrated on what I got from the current situation and how to

improve the conveyance efficiency of the canals specially the conveyance or primary canals, this supports the one of the main specific objectives of the study that was to evaluate the supply efficiency of the canals from the intake to the outlets.

To improve the supply efficiency of Bal' ad District canals, lining was one the best interventions or suggestions, farmers capacity building and continues assessment pre and post rainy seasons along canal course. The filed measurement was based on field visit, taking direct measurement on the selected canals at the intake, middle and outlets, also measuring each section's average velocity to compute the discharge and compare amount of water diverted and amount of water delivered, this was a tool to identify the sections that water is lost.

## Summary

This chapter has stated the findings of the research on the assessment of irrigation water supply losses in major canals in Bal'ad District. The results have been given for irrigation efficiency and water loss along canals, determinants of water loss along the canals, methods of preventing water losses along the canals, over all irrigation conveyance loss, irrigation water loss and ways to prevent those losses: -

- In terms of preventing the loss of irrigation water, the respondents mainly suggested daily supervision, proper maintenance, water allocation to farmers, good management, lining of canals, management of irrigation methods, ongoing evaluation, good land preparation, and training farmers.
- most farmers use surface irrigation which results in more water loss through evaporation, runoffs and percolation.
- Low/poor irrigation supply efficiency was the main cause of under performing agriculture production in Somalia for the past two decades.

## **CHAPTER 5: CONCLUSION AND RECOMMENDATIONS**

### **5.1. Summary**

The study targeted irrigation-based farmers and NGO employees in Bal'ad. The response rate for farmers was 80% while that of NGO employees was 75.76%. According to the results, the main ways through which irrigation water is lost include evaporation, seepage through the canal bunds, overtopping the bunds, overflow losses, and overwatering.

In terms of preventing the loss of irrigation water, the respondents mainly suggested daily supervision, proper maintenance, water allocation to farmers, good management, lining of canals, management of irrigation methods, ongoing evaluation, good land preparation, and training farmers.

The average field application efficiency was 25 percent while the conveyance efficiency was 30 percent. This generated a scheme irrigation efficiency of 7.5 percent which is poor for surface irrigation prevalent in the study area.

Most farmers from the study area have been using irrigation for over years and a greater percentage of them (50 percent) own over 10 acres of farming land implying that irrigation farming is done on a large scale in Bal'ad. Most farmers have their farming lands over 1000 meters away from the irrigation source hence more water is lost because of the long distance mainly through seepage and runoffs. Besides, most farmers use surface irrigation which results in more water loss through evaporation, runoffs and percolation.

## **5.2. Conclusion**

Farming is a common practice in Somalia and more so, in Bal'ad. Farmers in this area have huge tracts of land and heavily rely on surface irrigation. However, this irrigation is not efficient owing to different ways through which water is lost both in the canals and farming lands. The main ways of water loss around the canals include seepage through the canal bunds, rat holes around the canals, and run offs. In the farming lands, water is lost through evaporation from the surface, overwatering and percolation.

Both farmers and those managing irrigation canals know the venues of water loss and are willing to take the necessary measures to prevent further losses. To improve the efficiency of irrigation, farmers ought to be more disciplined in the amount and duration of irrigation. On the hand, the management has the responsibility of creating a maintenance schedule for canals and an irrigation schedule. The two main conclusions I found are: -

- Irrigation supply efficiency in Bal'ad district is very poor because of only primary supply has more than 31.9% of losses.
- Evaporation, bund breaks and over watering are the main water loss cause factors in Bal'ad district.

### **5.3. Recommendations**

The results showed that it takes over 6 months for the canals to be maintained. The NGO management should come up with a better maintenance schedule; one in which they inspect and repair the canals after less than 6 months. Besides, proper irrigation scheduling should be done to reduce water losses and improve irrigation efficiency.

The management of organizations in charge should inspect the canals and carry out effective maintenance which should include removal of any bushes or trees from the canal embankments whose roots can open up the compacted soil, causing leakages. They should clean the canals, and to achieve this, they should remove silt, plants and debris from the canals. While cleaning these canal beds, they should be careful to preserve the canal cross section's original shape because distorting it might mean losing more water.

They should also inspect the embankments and fill them with compacted soil. For effective compacting, they should wet the soil first. To stop runoffs, they should check for weak sections around the embankments where animals and people cross. They should then use bricks and compacted soils to strengthen those places. They should also rebuild the eroded sections of the canals to their original shape.

To eliminate seepage losses, the irrigation system managers should line the canals or install pipe distribution systems. If there are leaks, the management should engage a licensed plumber to repair them promptly. To stop runoff losses, return flow systems should be used to capture the runoff water to direct it back to the field it came from or to other fields.

To prevent flooding and hence overflows from reaching the low-lying farming fields, dykes should be set up to train the movement of the river. On-stream dams should be set up to act as

the regulating dams and the catchment should be conserved using run-off disposal and collection systems (Mati, n.d).

To prevent overflowing, they should apply only the required quantity of irrigation water and not exceed the field capacity. The other way of preventing this problem is to adopt other efficient irrigation methods such as drip irrigation. There should be economic water usage such as leveling of the fields and not applying more water than water the soil can accommodate. Besides, they should restrict irrigation in those areas that have a high water table and only provide supplemental irrigation in dry season (Mati, n.d).

To minimize the amount of water lost between farms and the irrigation source, a reservoir should be built near farms to store irrigation water. Also, dams and locks should be build between canals and water sources and only open them when water is needed in the canals.

The management should also schedule irrigation to match the needs of different crops. This will require that they know how much water the crops require and at what time. With good scheduling, they can reduce wastage and water loss on farming lands and improve the field application efficiency. To further reduce wastage of water, farmers should be charged for the excess volume of irrigation water they use that is after establishing the amount of water certain soils and crops can take.

Another recommendation for preventing irrigation water loss is to limit the irrigation duration. Reducing the time farmers are allocated water may help to minimize the losses. This will enable water users to be willing to maintain quaternary, tertiary and field channels to raise the flow rates (Burton, 2010).



After the study lights on the losses that are associated with water conveyance canals in Bal'ad district which are very significant from 25% and above 40% conveyance losses, I recommend to take further research on the quantities that are lost in conveyance losses. Summary of my recommendations are: -

- Model should be developed that records and alerts on differences between water diverted and amount of water delivered.
- Further research should be done on the secondary canals to know total supply losses from intake to tertiary canals
- Develop field level management tool to reduce bund breaks and irrigate early in the morning or late afternoon to reduce evaporation

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## **APPENDICES**

### **APPENDIX 1: QUESTIONNAIRE**

#### **For Farmers Using Irrigation**

##### **Introduction**

I am pursuing an MSc with University of Nairobi. As part of my thesis, I am carrying out research on the analysis of the amount and major contributors of irrigation canal water losses in Bal'ad District in Middle Shabelle region in Somalia.

##### **Consent**

Thanks a lot for your willingness to participate in this study. Answering the questionnaire will take about 20 minutes. Please respond to all the questions honestly. Your answers will be used for academic purposes only and will not be shared with any other parties.

##### **Participant Characteristics** (Tick the correct one)

1. What is your age? [ ]

A. 18-30 years [ ]

B. 31-45 years [ ]

C. Above 45 years [ ]

2. What is your level of education?

A. Primary level [ ]

B. High School Level [ ]

C. University level [ ]

3. For how long have you been using irrigation based farming?

A. Less than a year [ ]

B. 1-2 years [ ]

C. 3-5 years [ ]

D. Over 5 years [ ]

4. What is approximate size of your irrigation based farming land?

- A. Less than 1 acre [ ]
- B. 2 acres [ ]
- C. 3 acres [ ]
- D. 4 acres [ ]
- E. 5 acres [ ]
- F. 6-10 acres [ ]
- G. Over 10 acres [ ]

**Irrigation Type and Water Loss**

5. What is the distance from your farm to the irrigation source? (Tick the correct one)

- A. 100-200 meters [ ]
- B. 200-500 meters [ ]
- C. 500-1000 meters [ ]
- D. More than 1000 meters [ ]

6. What is the irrigation type used on your farm? (Tick the correct one)

- A. Surface irrigation [ ]
- B. Basin irrigation [ ]
- C. Border irrigation system [ ]
- D. Furrow irrigation [ ]
- E. Other (specify)

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7. What do you think are the major ways in which irrigation water is lost? (Tick the correct one)

- A. leakages in the water conveyance trench [ ]
- B. Overflow losses [ ]
- C. Over-watering [ ]

D. Other

(specify).....  
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8. In what ways do you think irrigation water losses can be prevented on your farm? (Please explain one or two ways)

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## **QUESTIONNAIRE**

### **For NGO Employees**

#### **Introduction**

I am pursuing an MSc with University of Nairobi. As part of my thesis, I am carrying out research on the analysis of the amount and major contributors of irrigation canal water losses in Bal'ad District in Middle Shabelle region in Somalia.

#### **Consent**

Thanks a lot for your willingness to participate in this study. Answering the questionnaire will take about 20 minutes. Please respond to all the questions honestly. Your answers will be used for academic purposes only and will not be shared with any other parties.

#### **Personal characteristics**

1. What is your age? (Tick where applicable)

A. 18-30 years        [ ]

B. 31-45 years        [ ]

C. above 45 years    [ ]

2. What is your level of education? (Tick where applicable)

A. Primary level     [ ]

B. High School Level [ ]

C. University level   [ ]

3. For how long have you been working in the organization? (Tick where applicable)

A. Less than a year   [ ]

B. 1-2 years            [ ]

C. 3-5 years            [ ]

D. Over 5 years        [ ]

4. What is your position in the organization? (Tick where applicable)

A. Low level            [ ]

B. Mid level            [ ]



C. High level/Management [ ]

### Irrigation Efficiency and Loss

5. In what ways is irrigation water lost in canals?

Water loss method	Tick all that apply
A. Evaporation from water surface	
B. Seepage through the canal bunds	
C. Bund breaks	
D. Deep percolation to the soil layers beneath the canals	
E. Runoff through the drain	
F. Overtopping the bunds	
G. Rat holes within canal bunds	

6. How long are the irrigation canals in Bal'ad district? (Tick one that applies)

A. Long (Over 2000 meters) [ ]

B. Medium (200-2000 meters) [ ]

C. Short (below 200 meters) [ ]

7. How often are the canals maintained?

A. After 6 months or less [ ]

B. After 6 months to 1 year [ ]

C. After 1 – 2 years [ ]

D. Over 2 years [ ]

8. What is the average field application efficiency and conveyance efficiency for irrigation methods used in Bal'ad district?

A. Field application efficiency (in %) -----

B. Conveyance efficiency (in %) -----

9. In what ways do you think irrigation water losses can be prevented in the canals?

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