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Water Crises, Food insecurity & Climate Change: Linkages & Options for Offsetting the Adverse Impacts - the case of Southeastern Oromia in Ethiopia

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Abstract

Fresh water is one of the scarcest and the most unevenly distributed resources in our globe. Its natural scarcity, combined with the multifaceted pressures on the ecosystem's ability to generate and retain water and the dire demand for it have resulted in water crises and food insecurity, particularly in Sub-Saharan Africa. In planning for any sort of socioeconomic transformation, water is a central part as it is the major input in production of biomass and energy. Moreover, it is the life blood of an ecosystem so that an environment with a diminishing water content becomes a desert and stops supporting life. Climate change affects the distribution and residence time of water, creating an ever increasing water crises in terms of water shortage and water threats. In different parts of the world, it is causing the most hydrologic events, droughts and flooding, that have resulted in losses of lives and assets.

Ethiopia is a good example where rain-water is the major limiting factor for economy, and land degradation and Climate change induced water crises have been evidently demonstrated themselves as a challenges to economy, livelihood deterioration and social instability. The country suffers severely from physical & economic water scarcity. The existing water scarcity & soil degradation coupled with the nature of agricultural practice of the country has made the local community highly vulnerable to manmade and natural shocks, making the situation extremely exasperating. The agricultural practice is mostly subsistence in which marketable surplus is under 25% of total production. Without properly addressing the water crises and doing a meaningful effort to create resilience towards social and economic shocks by the climatic uncertainties, it is difficult to ensure food security and livelihood transformation in a sustainable manner.

In this paper, the author tries to present the situation of mismanagement of soil and water resources and the role of climate change impacts in aggravating the water crises and livelihood deterioration in southeastern Oromia Regional State of Ethiopia. To reverse the existing trend of water crises in the target area, key factors driving to the current problems were identified, major challenges that need to be addressed and proposals for strategic interventions to be undertaken have been discussed. The major contributing factors for the water shortage and its consequences on the socio-economy and the environment were categorized under two major issues: manmade and natural factors. Climate change and altitude are the main natural factors whereas lack of effective management and improper utilization of land and water resources are the anthropogenic factors that led to vicious cycles of poverty driven natural resources degradation and vice-versa.

To offset the current trend, five strategic interventions that may address the dire need for focused investments in water infrastructure and the development of institutional and human capacities were recommended. These interventions are focused on the mechanisms that enhance the supply of water and aid for water demand management that mainly involve water harvesting, efficient water utilization, conservation works and physical and human capacity building. These proposed interventions are based on

theoretical relevance, personal experiences and proven success indicators that can be scaled up in some pockets areas of the locality. It is believed that the interventions are locally suitable and will help for an immediate utilization of the water resources to offset the current water crises that in turn would enhance the resiliency against the shocks due to uncertain and recurrent climate changes.

Keywords: Water crises; Food insecurity; Climate change and its impacts, Natural resources degradation; water harvesting and use; capacity building.

1.0 INTRODUCTION

Water is one of the principal vital goods that have made the planet Earth hospitable for human race and other living creatures. Besides its function as a critical component of life, fresh water is a crucial constituent for transforming the livelihood of a society throughout the entire course of human civilization. It is the major input in production of biomass (food, feed & fiber) and energy. It is the life blood of an ecosystem and an environment with a diminishing water content becomes a desert and stops supporting life.

Lowland areas of southern and southeastern Oromia Regional State in Ethiopia are among localities with the most fragile environmental conditions that are highly vulnerable to man-made factors and natural climatic shocks. As a result, this area is severely affected by various forms of social disputes and the adverse impacts of climate change which are mostly expressed in form of extreme hydrologic events such as flood and droughts. Since the recent decades, the recurrent drought events have translated themselves into loss of life and assets, severely impacting the national economy of the country and deteriorating the livelihoods of millions of people residing in the area.

The immediate impact of climate change and weather variability is that it affects the availability and accessibility to conventional water, creating water shortage for drinking and crop production. This will instantly grow to the level of drought that translates itself into devastation of assets and life. The impact of such devastating droughts phenomena can potentially be mitigated if meaningful measures are taken to ensure water security as part of an entire ecosystem restoration program. This can be considered as a portion of water-supply enhancement measures and will involve plans of diverse activities in a short-to-long term course of time as an integral part of related interventions such as water-demand management and water saving options outside of the water domain. Beside early warning and life-saving emergency measures, the right investments in activities that ensure water security will be an effective measure towards creating a realistic resiliency towards the existing drought impacts. That is, although droughts cannot be avoided, the loss of life and asset due to the lack of water can be prevented through working on the availability and accessibility of water. This is because of the fact that water is a life-blood of an ecosystem and securing water in a landscape creates a productive ecosystem that will be the basis for ensuring food security (for all human and animals) and other far-reaching benefits such as creating alternative livelihood basis and national economic growth.

Ethiopia is one of the best example where rain-water is the major limiting factor for the wider economy and Climate change induced water crises has been evidently demonstrated itself in causing economic challenges and social instability (Mekonnen et al., 2017). The country suffers severely from economic water scarcity due to lack of water storage infrastructures. There are some indicators that the national gross domestic product (GDP) of Ethiopia is correlated with the adequacy of seasonal rainfall. According to a study by the World Bank (World Bank, 2005, 2006), the effects of rainfall variability reduced projected rates of economic growth by 38% per year and increased projected poverty rates by 25% over a twelve year period.

The natural fresh water shortage has been exacerbated by land degradation and the adverse impacts of the climate change and the situation has become a socio-economic crises and a threat to biodiversity and the entire ecosystem functions (Shumet and Mengistu, 2016). The situation is complicated by limited water resources management interventions as demonstrated in a lack of coordination among public entities, the unclear definition of roles and responsibilities, and a lack of harmonization of regulations and policies on water management.

The most potential solution for an ultimate prevention of the problem of water scarcity for the livelihood of the people and Agricultural development activities is, therefore, to effectively utilize the existing water

resources (rainwater, surface water, and groundwater), at the same time ensuring their sustainability through enhancing their supply. The nature of the rainfall is very intense and of short duration which runs-off the catchment within short period of time in a given season. These require interventions such as investing on water harvesting and abstraction infrastructures, the uses of efficient water use technologies, proper agronomic practices that involve the use of high value, early maturing & water efficient crops, and establishment of institutions for water users and watershed management practices. Such a strategic planning and its implementation for an effective preparedness will be helpful to withstand such climate anomalies from shocking the livelihood of the community and the economic development of the region.

The paper presents a concise summary of the existing problems, a road map for interventions to be undertaken to reverse the existing trend of water crises in the target area. It tries to discuss the practical condition of mismanagement of the inherently intertwined earth's vital goods (water and land) and the consequent situation of water crises, food insecurity and its linkage with climate change in the case of Southern Ethiopia. The proposed intervention are mainly focused on the most implementable that will enable the immediate utilization of the water resources to secure the need of water supply for the people livestock, irrigation and other development activities. The aim of this paper is mainly to seek ways to increase the production & productivity in a diversified livelihood income as an ultimate means of preventing the problems of the recurrent drought conditions and to transform the agricultural sector in a sustainable manner. These proposed interventions are based on theoretical relevance, personal experiences and proven success indicators (that can be scaled up) in some pockets areas of the locality. It is believed that the interventions are locally suitable and will help for an immediate utilization of the water resources so as to offset the current water crises that in turn would enhance the resiliency against the shocks due to uncertain and recurrent climate changes.

2.0 METHODS, TECHNIQUES, STUDIED MATERIAL AND AREA DESCRIPTIONS

2.1 Methods, Techniques and materials

- Based on agro-ecologic conditions, areal proximity, and the local people's way of life, the target area was sub-divided in to three clusters, namely Boran-Guji, Bale-Arsi, and Hararge Clusters. This was mainly for the sake of effective planning and implementations of the proposed activities.
- The necessary data used in the preparation of this material were obtained from the existing watershed management study documents of the project in respective zones of the clusters and the data generated by using GIS 10.4 software at desk level.
- We followed watershed-based approach for the planning and implementation of the proposed watershed development activities.
- For effective implementation of the plan, the entire watershed area is cascaded into their respective administrative kebeles.
- Within each kebele, land use/land cover classes and slope categories were identified and proper management plans were recommended accordingly.
- The recommendations of watershed management activities were based on the existing practices and national guideline for watershed development works.

2.2 Area description

The target area for this study is found in Southern part of Ethiopia comprising the Ten administrative zones in the Southeastern part the Oromia Regional State. It covers the whole Borana, West Guji and Hararge zones, and parts of Guji, Bale, West Arsi, and East Showa zones. Geographically, it located between 36º30'0''- 43º0'0''E and 3º30'0'' 9º30'0'' N longitudes and latitudes, respectively (Fig. 3).

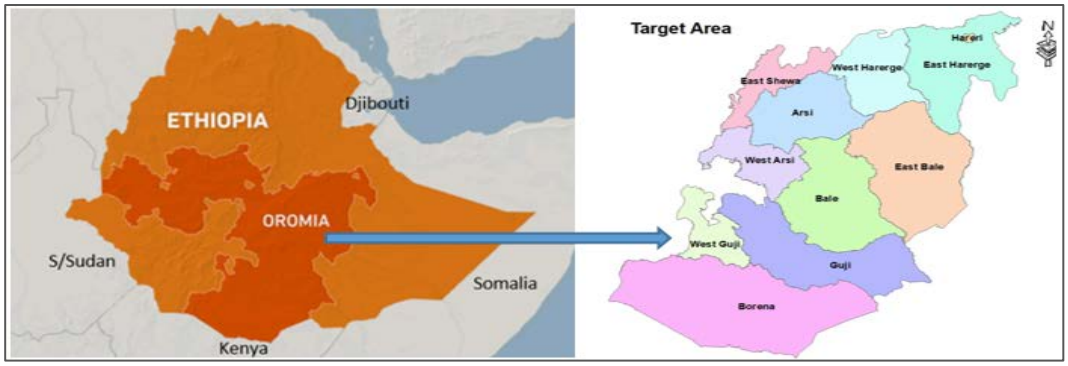

Fig. 1 Geographic location and map of the study area

2.3. Climate, Topography and Agro-ecology

The target area is characterized by arid and semi-arid climatic conditions that are highly influenced by topography (low altitude in its major parts, Fig.4). As depicted in the isohyet map of rainfall and thermal regimes of the area, the lowland area has higher mean annual temperature and lower mean annual rainfall. The rainfall is characterized by high spatial and temporal variability in quantity and distribution. Warmer mean annul temperature causes higher amount of evaporative water losses from the catchment (causing the moisture unavailable for human use).

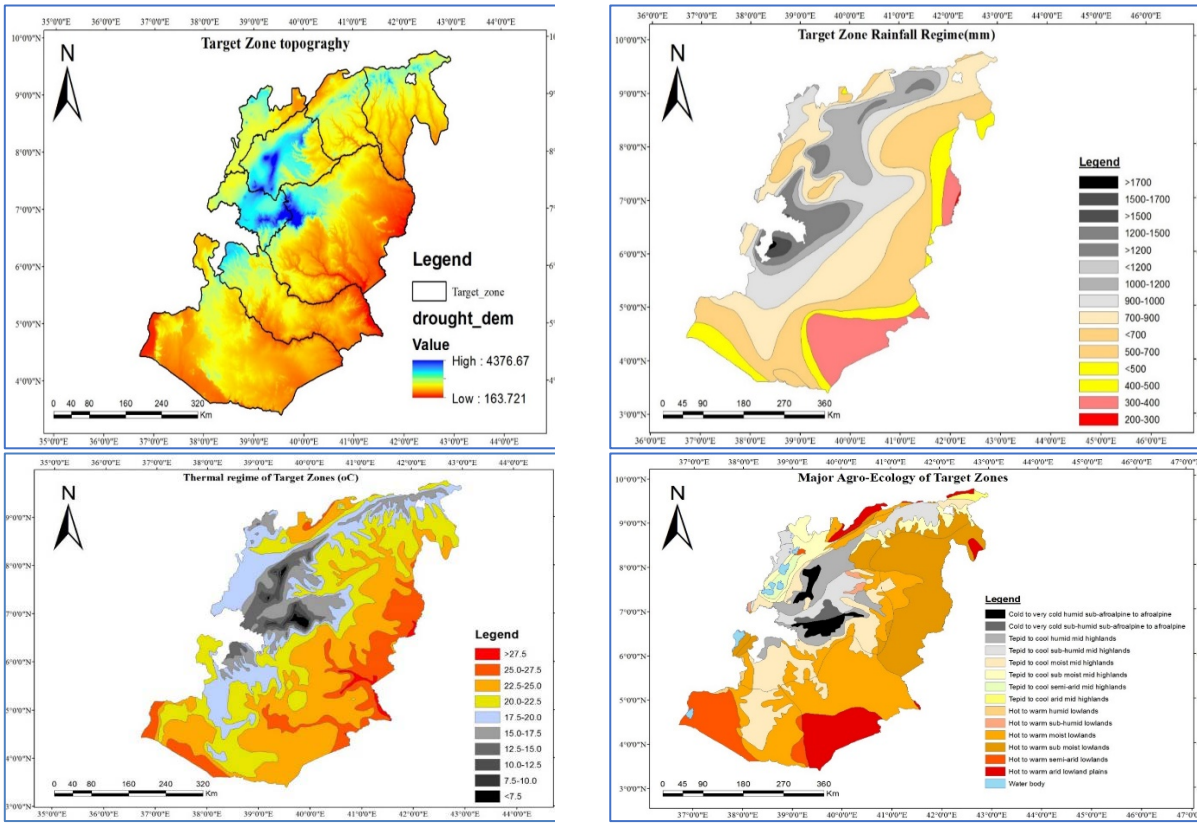

Fig. 2 Topography, Climate (rainfall & temperature) and Agro-ecology of the target area

2.4. The scale and severity of drought

The target area is among the localities in Oromiya region where water scarcity and degradation of natural resources is very severe. Both man-made and natural factors have contributed in aggravation of this natural hazards. Among man-made activities that has exacerbated this challenging situation include

unwise utilization of the natural resources through overgrazing (pastoralist areas), deforestation & land use change, overexploitation of water (west Arsi, and east Showa), poor farming practice (east and west Hararge), and over population (west Arsi, East Showa, and both Hararge zones).

As a result, most of the woredas in the target area are food insecure and some of them are supported by safety net program for several years. The following figures (Figs. 6 & 7) show the impact of the drought in 2016/17 in Borana and west Hararge zones, respectively. The effect of the drought touched not only water but resulted in the lack of forage for livestock, ultimately leading to serious economic and social crises. The situation around Haro Bake (reservoir) in Yaballo District (Fig. 6 a & b) and Chiro woreda of west Hararge (Fig.7 a & b) show an extreme demand for water and deterioration of the water body due to demand-supply mismatch. These are the only reservoirs in the area and it is facing huge pressure from the surrounding high demand.

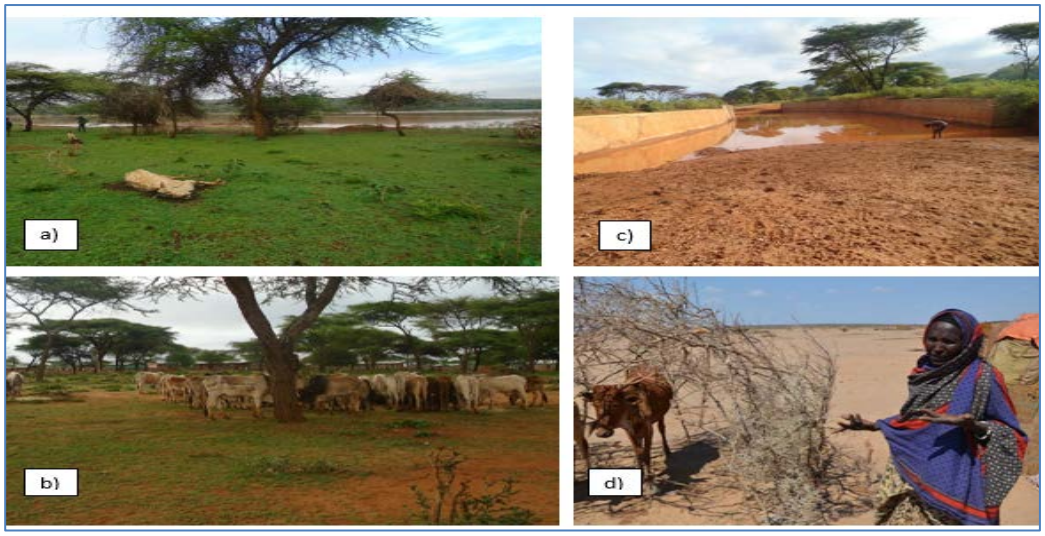

Figure 3 Effect of drought (2016/17) in Borana zone (Yabalo area- around Haro Bake -a, b. c, d) (Sources: Mekonnen et al., 2016)

The following figure (Fig. 7) demonstrates acute water crises and harvest failures due to El Nino effect in 2015/16.

Figure 4 Acute water problems and harvest failures due to drought in 2016/17 (Sources: Mekonnen et al., 2016)

The target area is naturally one of the moisture stress locality in Oromia region. It is part of the most ecologically fragile land-belts of the southeastern Ethiop in Horn of African Region where Famine Early warning System is Active (Fig.5). The natural vulnerability of the area is mostly due to topographic factor (low altitude) that essentially influenced the mean annual precipitation (below average) and temperature (high) regimes. This has caused the area very delicate and highly susceptible to climatic shocks so that most part of the area has been affected by a recurrent droughts during the past two decades.

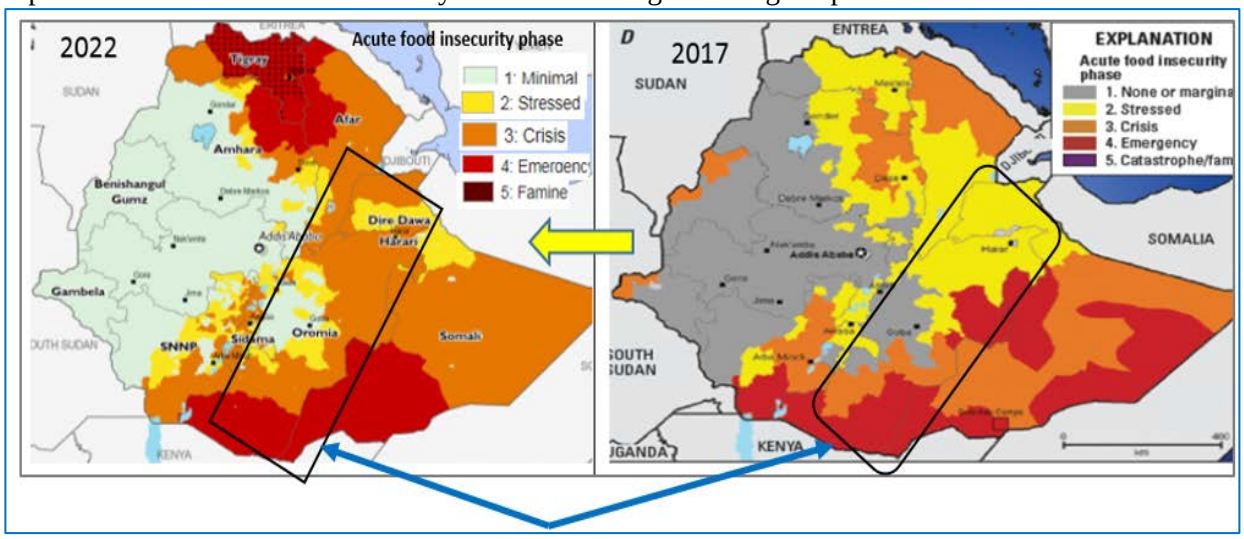

Figure 1 Acute food security map of Ethiopia. (Source: Famine Early Warning Systems Network FEWS.NET, 2017, 2022)

3.0 RESULTS

3.1 Driving Factors for Water crises and Livelihood deterioration

The major problems of the target area revolve around fresh water scarcity & land (soil) degradation, and its down-spiral effect on human livelihood deterioration. Several interconnected and supplementing issues also have contributed to a complex environmental and socio-economic challenges. Some of the issues are related to natural fragility of the area due to its, topography, geographical location and the uncertain climatic conditions. The lower altitude and its latitudinal location within drought prone areas of the Horn have made it vulnerable to the shocks by climate change. The effect of Climate change has been mainly manifested in the form of recurrent droughts and devastating floods in the target area. In addition, other multiple anthropogenic factors (limitations) have played a complicit role and exacerbated the water crises in the target area.

The lack of awareness has resulted in the failure to mobilize human, financial and technological resources. These shortcomings, in turn, have been manifested in terms of polluting the environment, failure to effectively manage water and land resources and improper utilization of forest and soil resources. Pollution and mismanagement of the water resources on one side and climate change induced evaporation water loss hugely affects both the quantity and quality of the water resources. Similarly, loss of vegetation, improper farming and inorganic fertilizers on one side and climate change caused erosive rainfall on the other side result in the deterioration of soil quality and quantity and the effect will be protracted to affect water bodies.

The chain of factors to one another and the culmination of their effects have resulted in the deterioration of natural resources and severe water scarcity. These problems ultimately enter into the chain of human livelihood. This ultimately results in to the vicious cycle of poverty, challenges for food security and reduction in national economic growth. The results of the issues gear up the level of livelihood deterioration

and challenges of national economic growth through poverty driven environmental degradation and vice versa as shown in the following flow chart (Fig.8).

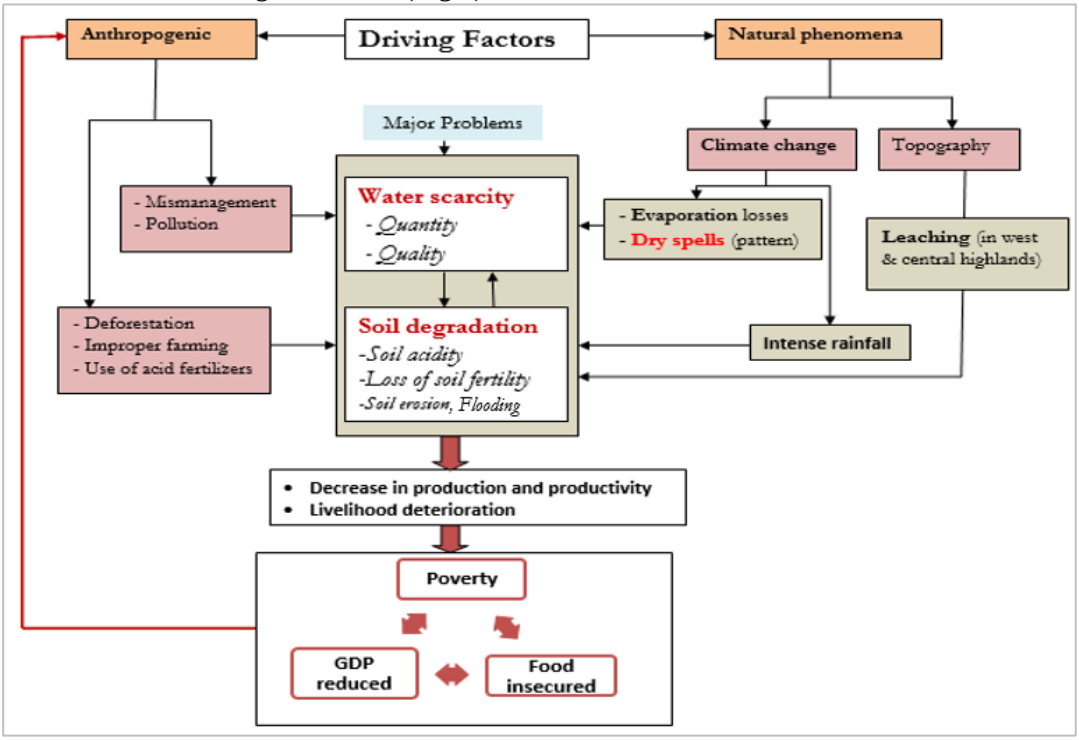

Figure 6 The major problems of the area and their main causes.
(Sources: Mekonnen et.al. 2017)

The lack of proper strategic planning, well-functioning regulatory body and prior attention towards conservation, restoration and rehabilitation works has aggravated the already fragile environment. In the following sub-sections, about ten dominant issues were identified and brief discussions were made addressing their root causes.

3.2 Major Challenges that need to be addressed

3.2.1 Poor trend of soil and water conservation

Most part of the target area is characterized by various degrees of arid and semi-arid agro-ecological regimes. The soils of these arid-and semi-arid areas are very susceptible to erosion as they are fragmented and easily detachable. Enhanced by land use change and over grazing, erosion by wind and water is the most important phenomena. The intensive rainfalls of short duration in those arid and semi-arid areas of barren extensive land mass usually result in huge soil erosion problems. The two main components of land degradation, damage to plant communities and deterioration of soil, has interacted to cause a downward spiral of accelerating ecosystem damage and human poverty.

In central Rift Valley of the target area, particularly, the severity of environmental challenges has become a critical issue because of over population, land use change and over abstraction of water for various needs. Regardless of some efforts towards soil and water conservation practices by the local government and NGOs, the level of natural resources degradation is still very serious. The major vital ecosystem goods of such as water bodies, fertile soils and vegetation cover have been degraded and the quality of their services are continuously declining. The pressure on the water bodies, particularly, have resulted in severe water scarcity in the sub basin and shrinkage of lacustrine conditions as demonstrated in the case of Abijata Lake and the subsequent threats on biodiversity in Abijata-Shala National Park (Meshesha et al., 2012; Shumet and Mengistu, 2016).

3.2.2 Weak attitude towards water harvesting

Despite the myth that Ethiopia is the '*roof*' of Africa, the *water tower* of Africa, etc., the storage per capital of the region is among the lowest in the world. On one hand, it is an existing fact that the high-altitude localities of the country get a considerable amount of annual precipitation that becomes the sources of a few Trans-boundary Rivers that radiate in the southern, south-western and western directions. On the contrary, the country is among the economical water scarce regions of the world due to lack of water storage infrastructures.

As a result, the usual approach of water resources management and utilization in the region has mainly been focused on the surface and groundwater sources. However, the practical condition of the area and the experience gained so far indicate that these two sources of water are becoming limited and under threat in those parts of the region since the last few decades. The nature of precipitation and the condition of land degradation, without proper soil and water conservation practices, has aggravated the escape of the limited rainfall out of the accessible environment for the users. It either runs-off the catchment or lost to the atmosphere through evaporation. Therefor there is a grave need to work with the rainfall and a mechanism should be devised so as to retain such rainfall in accessible condition to the immediate users and for future generation.

3.2.3 Limited trends of water exploitation

In addition to the water scarcity, there are two major categories of water exploitation trends in the target area. There are poor water use trends in Borana, Bale, Guji and Arsi parts of the target area. This part of the target area is characterized by arid and semi-arid conditions and have some level of underground water potential at some limited pocket areas that can be wisely utilized for economic and social benefits of the community. But it needs huge financial and technological capacity for their abstraction and efficient utilization. A limited number of large rivers that cross these drought prone areas also need systematic abstraction and efficient utilization technologies that involve water storage infrastructures and water saving and recycling technologies for their efficient utilization.

In central Rift valley, Hararge zones and part of east Showa, there is intensive both surface and groundwater exploitation trends. The people of these areas have understood the value of water for crop production and the remaining challenge is to create awareness and capacity building on proper water allocation, efficient water use and seeking means of generating water so as to avoid a potential social crisis on water share and possible damage on ecosystem.

It should also be understood that groundwater resources are like a fossil oil that is barely renewable in human time scale. So, the balance between the abstraction and recharge should be kept at manageable level so that watershed management for groundwater recharging purpose should be enhanced.

3.2.4 Settlement pattern of the community

The pattern of settlement in the target area is among the factors that have made the area exposable to the socks from the climate change. In some pocket areas (Central Rift alley and some parts of Hararge zones), there is extremely dense population putting pressure on the natural resources base. In most parts of the target area (especially remote lowland areas), the settlement of the people is very scattered. This is mostly related with the pastoralist economic activities that influence their settlement based on the availability of water sources. Interventions to make water available might positively influence the livelihood of the community through diversifying their economic activities and making suitable conditions for development of other services infrastructures.

3.2.5 Limited attention from concerned bodies

The semi-arid and arid localities of the target area have huge potential for transforming the agricultural sector that has considerable positive impact on the livelihood the community and economic growth of the region. However, the practical attention given to this resource potential is very limited from public, private and other development assisting partners. A progressive strategy based on sustainable alternative water supply for development and ecosystem functions is a prior urgency for all concerned bodies.

3.2.6 Weak participation, coordination and integration among stakeholders

There are some initiatives by the federal and regional governments through different sectorial offices and other few development partners. The participation is limited in extent and there is an understandable lack of integration and coordination among the sectorial offices and the development partners. Each of them acts independently without synchronizing their activities. A well-defined and integrated action plan in their approach of solving the water related problems in the area may have a significant positive contribution towards the sustainable water supply of the areas.

3.2.7 Limitations on budget use to the intended target

Due to lack of strategic plan and well-defined coordination in various approaches to end the problem of water scarcity and the recurrent drought conditions, there is some level of limitations to use the budgets for addressing the intended target. This issue concerns the activities of both development partners and sectoral offices of regional and federal governments. In addition, most of the budgets are aimed at temporarily addressing the problems for a short time relief rather than systematically investing on the core issues of water problems that have a potential to reverse the recurrent trend of the livelihood shocks by the climate change.

3.2.8 Weak institutional capacity for water management

The development of water resources involves investments on water abstraction and storage infrastructures which require huge financial, technological, and human resources. The institutions that are mandated to manage and regulate the water resources of such drought prone areas are very weak in terms of financial capacity and skilled manpower. The required work is very vast, interrelated and complex that needs strong institutional capacities for effective planning and mobilization of available resources.

3.2.9 Limited water supply infrastructure

The development of water related infrastructures are very limited in those drought prone areas. Only very few endeavors were made focused on drinking water supply for humans around the towns. Development of some ponds and reservoirs were attempted in a fragmented manner and currently under treat due to the combined effects over exploitation, evaporation loss and siltation problems. Intensive and extensive intervention in the development of water storage and supplying infrastructures is a critical issue that needs agency and relevant priority.

3.2.10. Vulnerability to extreme effects of climate change

Since the last two decades, the target area has repeatedly experienced extreme hydrologic events such as recurrent droughts and floods of deleterious effects that are caused by the global climate change. Although some events of floods have been observed, the target area is highly vulnerable to recurrent droughts of various extent. Two major factors might have contributed to the vulnerability to the recurrent drought condition as an extreme effects of climate change.

The first factor is related to the natural fragile climatic conditions of the area (mostly arid and semi-arid climatic zone) as demonstrated in terms of lower average annual precipitation and higher mean annual temperature leading to higher evaporation rates. As a result, the terrestrial water balance of the ecological region is mostly negative as the natural condition enhances the outgoing moisture rather than the incoming one in the form of precipitation (dominantly rainfall).

The second factor is related to the way of life of the community and their adverse activities on the natural resources. One of the peculiar nature of arid and semi-arid agro-ecologic zones of the region is the livelihood of the communities which is highly dependent on livestock production. The productivity of such pastoralist, or semi-pastoralist activities are correlated with availability of water sources of which rainfall and surface water play a significant role. When there is occurrence of any hydrologic event such as drought, the effect directly shocks the livelihood of the communities. This has been frequently observed during the

last few decades when several drought incidents were occurred. In some cases, the shock is so significant and resulted in loss of lives of animals and exposed the people to be depended on external reliefs.

The customarily approaches by which the community use the exiting natural (water) resources has also made the target area vulnerable to climatic shocks. In central Rift Valley area, overutilization of both surface and groundwater resources and population growth at alarming rate has made the locality very fragile and irresistible to climate changes.

4.0 DISCUSSION

Various strategic intervention mechanisms need to be devised so as to overcome the aforementioned issues in the target area before the adverse impacts get to a point where reversing is very costly or even impossible. In order to reverse the existing critical problems and ensure fast and sustainable development in the region, four major areas of interventions have been identified. These interventions are water harvesting, efficient water abstraction, efficient water use, rehabilitation of degraded soils (acidic soil, soil fertility), and capacity building.

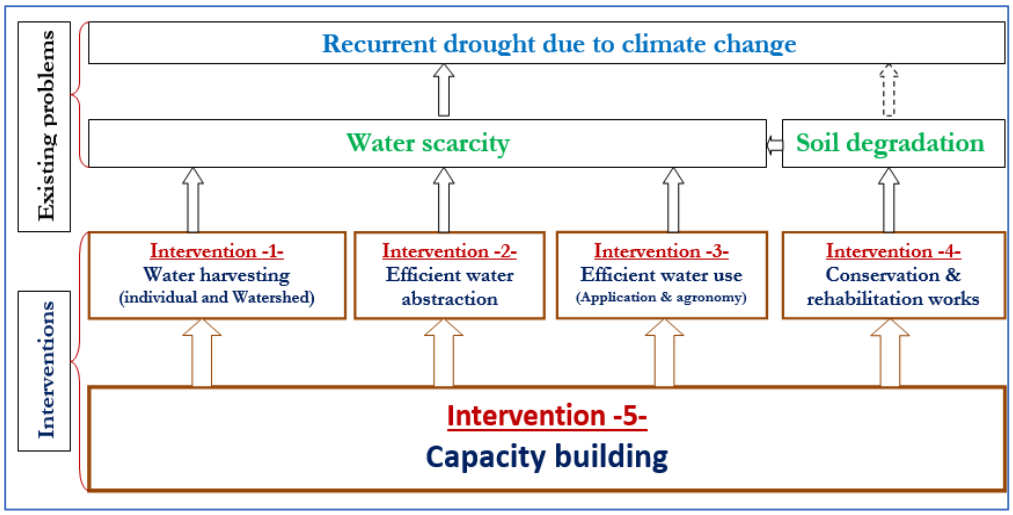

Figure 7 Relationships of the existing problems and the devised interventions.
(Sources: Mekonnen et al., 2017)

As shown in the figure above, capacity building is the basis for all interventions. One intervention functions as an input for the other one and ultimately all the five interventions systematically address the identified issues. Although it is impossible to prevent the recurrent drought from happening, it is possible to prevent it from translating into hunger and other forms of livelihood deterioration by using the indicated adaptation and mitigations tools.

All the adaptation and mitigation tools aid to ensure water security. Ecosystem conservation has a beneficial value for the storage of water and sustainability of the water infrastructures. This will have a positive contribution for enhancing production and productivity that enables to ensure food security and alleviate poverty while maintaining healthy ecosystem functions at the same time, resulting in the attainment of sustainable development as shown in the following conceptual framework. Relevant activities within these water focused development tracks are the following.

4.1. Intervention 1- Water Harvesting

Water harvesting is one of the key water-related interventions to overcome water crises. It essentially addresses the issue of economic water scarcity as it involves the process of storing water when it is plentiful to make it available during the time of shortage. It has the potential to contribute to rapid improvements in the livelihood of the small holder communities, the national economy and ecosystem functions of an area. By integrating water harvesting and storage structures in landscapes (including groundwater recharge) in a planned and systematic manner, it is possible to create a water buffer that helps reduce vulnerability to the

adverse impacts of climate change such as seasonal variations in rainfall the and the subsequent recurrent droughts and flooding effects.

4.1.1 Water harvesting is a mechanism of making water accessible

Despite the temporal and spatial variability, the target area gets significant amount of annual rainfall resulting in to run off which is usually inaccessible for various water users. This is mostly related to the type of precipitation in the geographical locality and the nature of its intensity & distribution. Like most tropical and subtropical regions, rainfall is the typical precipitation type in the area. Inherently, this precipitation has a tendency of running-off the watershed within a limited time. The spatial and temporal distribution of this rainfall is highly variable as some parts of the region get abundant annual rainfall whereas the rest gets a limited amount. Temporally, only few months get this rainfall and the rest of the year stays dry.

As rainfall escapes the watershed within short period of time in the form of run off, it will have limited time to infiltrated in the soil and enrich ground water table that ultimately contributes to flushing of springs. It is this springs that make networks and develop to streams and larger rivers. Basically, this run off escapes off the watershed by two major processes: to the atmosphere via evaporation/evapotranspiration and to the downstream side through stream flow. Unless there is a systematic intervention in such interconnected components of the hydrologic cycle through making the run-off delayed within the watershed, the water will not be accessible to immediate users and to the forthcoming future generation. So, water harvesting systematically helps the nature to keep its water-share where is rains and provide (make accessible) this water to the users and the wider environmental functions.

4.1.2 Water harvesting should be done for various categories of users

Water is among the most important ecosystem goods and needed for drinking, various development activities and healthy ecosystem functions. Therefore, the major water users are humans, other living things including livestock, and the general environment for its proper functions. In a special case humans need water for socio-economic development such as for producing of food, feed and fibers through (mainly) irrigated agriculture, fishery, animal husbandry, and other service based economic activities such as tourism and navigation. In addition, water should be harvested to enhance groundwater recharge. The plan of water harvesting, therefore, should consider all these multipurpose objectives and systematically integrate the activities for a sustainable output.

4.1.3 Resource identification for water harvesting

The usual notion that only surface water (springs, rivers, lakes etc.) and groundwater are considered as the only utilizable water for various uses should be override by a broader consideration of the components of the hydrologic cycle. The focus only on these sources of water has been a limitation for maximizing command areas for irrigated agriculture and an obstacle for a progressively thinking of storing and using moisture that comes from the sky.

The main principle of water harvesting is to work with nature for making optimum use of available water resources and enhance storage of water using different harvesting technologies. Thus, identification of water sources and suitable water harvesting technologies to collect that source are crucial. Accordingly, the concept of water harvesting in this plan of intervention focus on the three sources of water for which further technologies and development interventions are considered. These sources of water are rainfall, surface water and groundwater.

Harvesting water from the direct rainfall in a specific area (be it on roof top or land area) is seen in two ways based on the nature of the catchment. It can be direct rainfall catching within the catchment such as roof top and runoff water harvesting or collecting of flood water that comes from other catchment/s following roads side flood water ways or ephemeral streams. The development of groundwater, with various accessing technologies (shallow well and deep well), and surface water sources with interventions such as spring development and traditional diversions for household micro irrigation development are also considered.

4.1.4 Efficient water harvesting strategy

Efficient water harvesting activity involves the integration of stakeholders and technologies. The integrated action should focus on a concerted manner at individual and watershed level. The individual water harvesting will enhance the ownership of farmers their own water bank and the watershed approach will maximize storage in the watershed. In a watershed, there might be several individual households. Within both levels of spatial considerations (household and watershed), there shall be integration of technologies, activities and stakeholders for water harvesting and management of other natural resources. The engagement of various stakeholders helps to strengthen the capacity of each activity towards the attainment of its intended objectives.

Similarly, effective water harvesting should be carried out in a consortium approach with various role players who have stakes in the target area. Various aspects of socio-economic, cultural and political components in the watershed shall take part and play their respective roles towards watershed management in a holistic manner. The category of these stakeholders may include government (public institutions, communities, etc.), NGOs, Development partners and Private sectors in the manner that all are actively involved at household and watershed level as shown in the following figure.

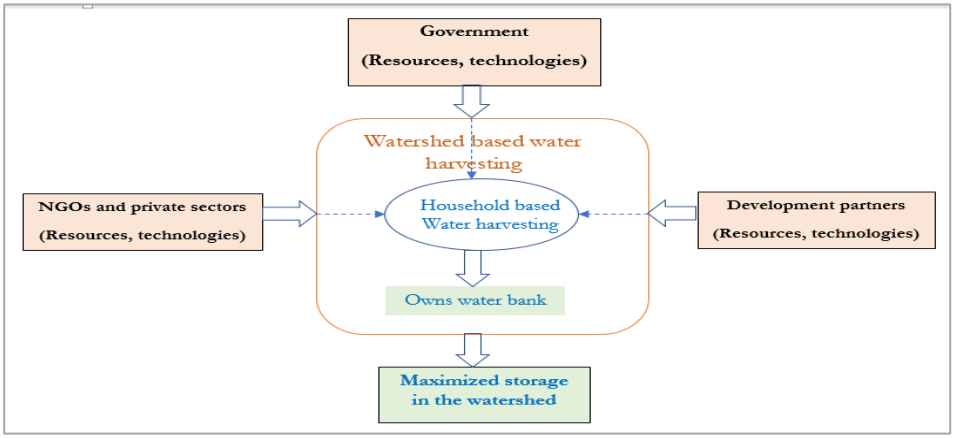

Figure 8 Concept of effective water harvesting approach and form of stakeholder engagement. (Sources: Mekonnen, 2016)

About integration of activities, efficient water harvesting should be done in combination with efficient water abstraction and use. This helps to maximize the intended benefit of the harvested water. Integrating the work of water harvesting with soil and water conservation activities is crucial for enhancement of water generation, efficient resources mobilization for the target work and to ensure the sustainability of water storage infrastructures.

By integrating water harvesting and storage structures in landscapes in a planned and systematic manner, it is possible to create a water buffer that helps reduce vulnerability to the recurrent droughts, problem of seasonal variations in rainfall and transform the agricultural and other development activities of the target area by ensuring the continuous availability of water.

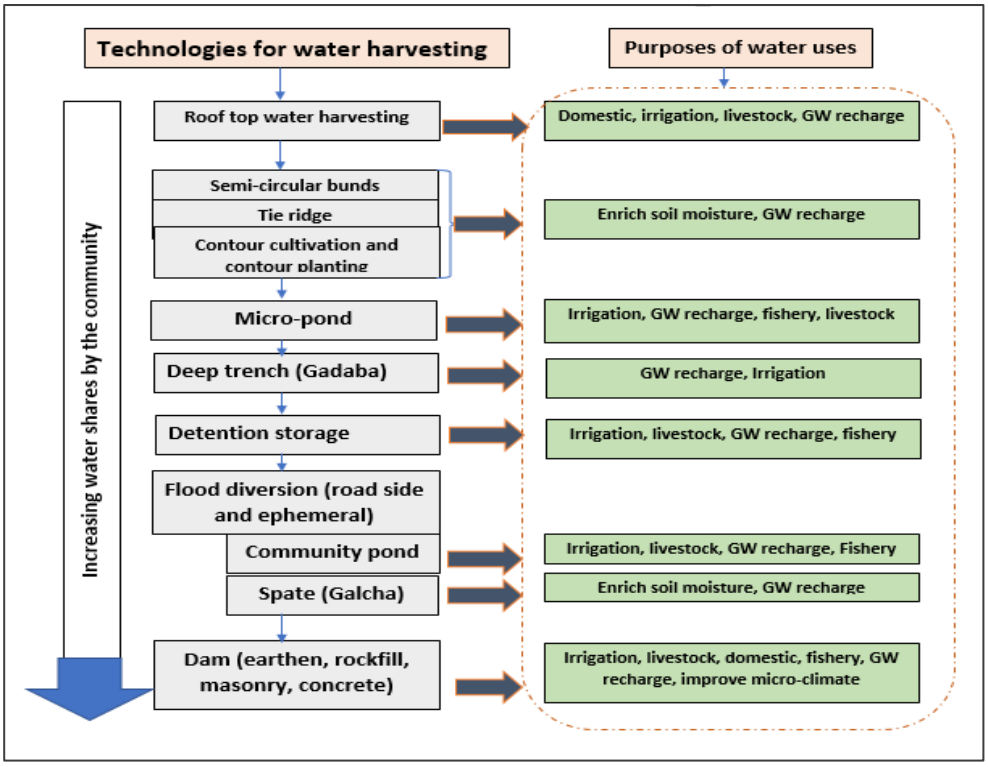

Figure 9 Flow chart for the major sources of freshwater and identified water harvesting technologies for various purposes.

In this context, water harvesting is considered as interconnected activities that involve systematically storing all the available water resources in accessible environment for various users and healthy ecosystem functions. This involves the use of various water harvesting technologies in an integrated manner. When we consider efficient and sustainable water harvesting interventions, there is no such a condition that only one water harvesting technology is perfect by itself. This is because of the fact that water scarcity is the result of multifaceted environmental problems and there will never be a single solution to address such complex and interrelated issues.

Various technologies shall be identified and systematically utilized in an integrated manner. There are several factors in choosing suitable technologies for different types of agro-ecology and topographic conditions. Technologies to store water on the land surface and/or underground using various physical structures and equipment exist from rooftop water harvesting to storing water in large reservoirs such as ponds, detention storages and dams. Some of the identified technologies of water harvesting that are deemed suitable for the various physiographic and climatic condition of the target area with their multipurpose benefits are presented in the following flow chart.

4.2 Intervention 2- Promotion of efficient water abstraction

Efficient water abstraction is important to effectively use either the **harvested water** or naturally occurring **surface** and **groundwater** resources. Promotion and utilization of economically efficient and environmental friendly water abstraction methods is crucial for both water saving and minimizing adverse impacts on the environment. The indigenous knowledge of the local community shall be considered and supported with efficient technologies in approaches of groundwater abstraction, stream diversion, and spate irrigation. Gravity based abstraction methods needs to be promoted for the water stored in on-surface infrastructures. It can also be abstracted using simple mechanical pumps such as rope and washer and treadle pumps without polluting the environment and in reasonable cost at household level.

4.3 Intervention 3- Efficient water use

Economically efficient and environmental friendly use of water in various scales of irrigation usually depends on the use of water saving technologies during application and water efficient agronomic practices.

Figure 20 Efficient water abstraction and application technologies (Source: Mekonnen et al., 2017)

Water application technologies such as drip irrigation, sprinkler irrigation, and furrow irrigation are considered to be the most water saving methods in irrigated agriculture. At household level, water can be applied to crops either by manually sprinkling or using local material such as cans and buckets. The following figure shows that after storing the water in structures at higher elevation, the water can be distributed by gravity and efficiently applied by dripping method. Alternatively, other suitable water application and maximum water saving such as manual (can or bucket), drip, or manual sprinkling methods can be used in order to maximize water saving.

Simple motor pump, treadle pump or rope and washer can be used to lift the water to the above ground storage water distribution by gravity for drip, or manual sprinkling irrigation (photo: taken at Melkasa research institute).

Water efficient agronomic practices

Water optimization, crop selection, cropping calendar and conservation farming are agronomic practices that are intended to be implemented so as to maximize the benefit of the harvested or abstracted water resource. Water optimization may refer to the application of the right amount of water at the right time of the plant's growing period. Whereas selection of crops (forage) refers to the use of crops (forage) that are early maturing, high value and water efficient. Proper cropping calendar shall be promoted for supplementary irrigation that enables to complement rain fed agriculture by irrigation and vice versa using supplementary irrigation practices. Conservation farming is important to reduce the loss of water from the watershed by evaporation and/or runoff.

Innovative technologies derived from applied research, combined with appropriate policies and strategies, are necessary for the success of these practices.

4.3 Intervention 4- Watershed based soil and water conservation

Water harvesting activities at micro level on the farm can be carried out in coordination with soil and water conservation practices. Within each micro-watershed, the practices of water harvesting activity in combination with conservation works should start from individual farmer.

Watershed based soil and water conservation practices have significant positive contribution towards storing water (on the surface or underground in the aquifer system) and ensuring sustainability of the water harvesting infrastructures by minimize siltation problems. By doing so, it also helps to prevent the loss of top soil by erosion.

The main principle of conserving water by this intervention (conservation works) is to minimize the losses of water by runoff and/or evaporation processes. Losses of soil and water by runoff can be minimized by increasing the roughness of the surface that reduces the speed of runoff. It also involves the creation of spongy type landscape that enhances soaking of precipitation. Loses by evaporation can be minimized by protecting the moisture in the soil either by covering the land surface or enhancing infiltration in to soil and reducing the hydraulic conductivity to prevent upward movement of soil moisture.

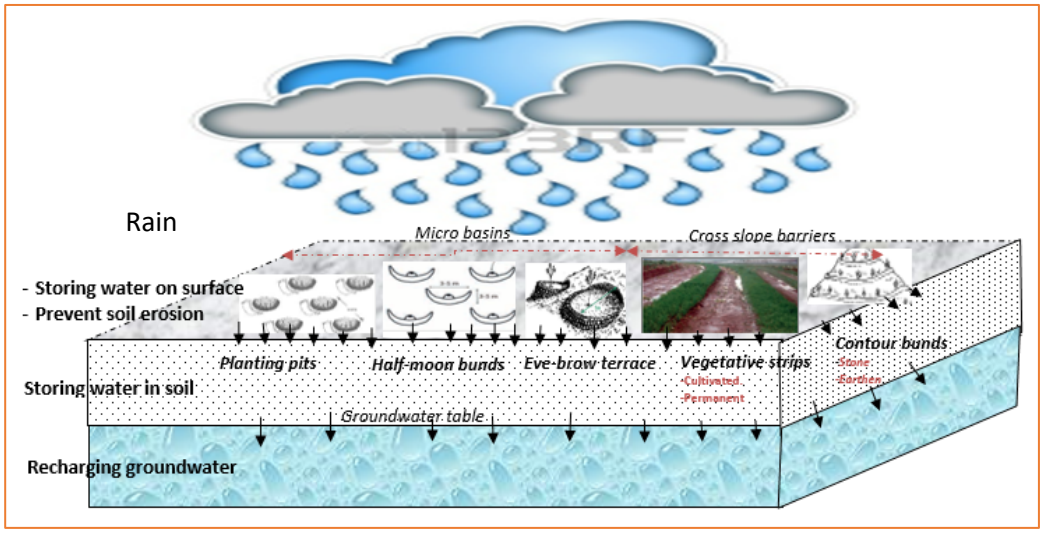

Figure 11 The scheme representing multipurpose soil and water conservation technologies (Sources: Mekonnen et al., 2016).

Soil and water conservation practices, therefore, help to effectively prevent siltation problem by reducing the erosive force of overland flow. When conservation practices are strengthened by reforestation and other biological soil and water conservation technologies, the entire area acts as natural sponge and enhance the recharge of runoff water to the groundwater table. This process helps to improve the quality and quantity of the reservoirs due to prevention of sediment load and increased base flow to the reservoir.

When the conservation technologies are implemented in an integrated manner, it will have three noticeable advantages from ecosystem conservation points of view:

(1) the water is stored in the soil and enhances water availability in the root zone,
(2) it reduces soil erosion by preventing aggressive overland flow, and
(3) it may percolate through the sub-soil and recharges the groundwater. The recharged groundwater usually improves a continuous base flow in the nearby streams.

4.4 Intervention 5- Capacity Building

A holistic approach for strengthening the capacity of the target area for planning and implementation of focused water and land resources management is crucial. The major areas of capacity building may include establishing effective institutions with well-functioning structural arrangements, strengthening manpower

and provision of materials and technologies. This can be categorized into human capacity building and physical capacity building as briefly discussed in the following.

4.4.1 Human capacity building

The main aspect of human capacity building is through training and mentoring at an individual or group level. In either case, knowledge production and disseminating to the community requires linking livelihoods and indigenous knowledge of the communities' in a social acceptable manner. Recognizing social values, norms and even religions of the community essential to get acceptance of new ideas by the local people. The form of engagement can be raining and/or demonstration on innovative and traditional best practices.

4.4.2 Physical capacity building

Provision and introducing farming community to the state-of-the-art technologies and materials will have an irreplaceable importance in effective implementation of this management interventions. Capacity building intervention of this area may include but not limited to:

- Integration of technology for natural resources management,
- Provision of alternative clean energy sources for rural community, e.g. solar panels and energy saving materials for fuel, consumption at household level, water abstraction, and house hold services.
- Provision of technologies for groundwater exploration, water saving technologies, and other agronomic practice.

5.0 CONCLUSION

Freshwater is the most vital resource for supporting life, transforming human livelihood and maintaining healthy ecosystem functions. But this valuable resource is under threat due to an ever increasing demand and the uncertain climatic conditions.

With the current trend of water utilization, the mismatch between demand and supply of water will be wider and ever aggravate the water crises to the point of no-return. This situation highly damages developing countries like Ethiopia whose per capital water storage is limited and major economic basis is dependent on natural rainfall.

Climate change is real and its impact on water resources is evident. It further exacerbated the water crises in terms of water threats, drought and flooding, that have devastating effect on lives and economy. It is impossible to avoid these impacts, but we can prevent it from translating in to famine and loss of life. It is possible to build social and economic resilience to the uncertain shocks from the climate change impacts. Investment on early warning system and preparedness are inexpensive to relief activities after the damage happens to the community.

Advocacy works for awareness creation, focused investment on water infrastructures in a coordinated, integrated effort and proper regulation of water use habits will be helpful for preventing future impacts and reversing the current water crises. Integration in its triple state: Integration of technology, integration of stakeholders and integration of activities are of supreme importance so as to effectively mobilize resources and to attain the intended goal.

The dire condition of water crises in Southeastern Oromia region of Ethiopia requires a consortium and multifaceted interventions. Strategically planned and properly scheduled action plans for water demand management and treating the entire watershed to enhance its water holding and generating capacity are the current urgent priorities.

6.0 REFERENCES

Chow, V. T., Maidment, D. R., Mays, L. W., 1988. Applied Hydrology. McGraw-Hill, Inc. NY, USA ISBN 0-07-010810-2.

FAO, IFAD, UNICEF, WFP and WHO, 2017. The State of Food Security and Nutrition in the World 2017. Building resilience for peace and food security. Rome, FAO.

FAO, 2016. AQUASTAT database. http://www.fao.org/nr/water/aquastat/data/query/index.html?lang=en

FAO, 2016. Coping with water scarcity in agriculture: a global framework for action in a changing climate. Marrakach, Moroco.

FAO, 2014. Water in the Cloud. AQUASTAT, FAO's global water information system. http://www.fao.org/nr/aquastat.

FEWS.NET, 2017. Extreme levels of acute food insecurity to persist in southeastern pastoral areas.

Mekonnen, G.B., T. Chibsa, E. Ararso, D. Tadele, G. Ayala, J. Mume, Z. Shelemew, T. Beyana, A. Birhanu, 2020. Utilization of Water Harvesting Technologies as Copping Mechanisms to Mitigate Probable Impact of COVID-19 Pandemic on Food Security in Oromiya Region: A Quick Strategic Plan (*unpublished*). Unpublished. Ormia Bureau of Agriculture and Natural Resources. Finfinnee, Ethiopia.

Mekonnen, G.B., Tesfaye, K., Runda, T., 2017. A five Year Strategic Plan of Sustainable Alternative Water Supply for Irrigation Development in Drought Prone Areas of Oromia. Unpublished. Oromia Irrigation Development Authority. Finfinnee, Ethiopia.

Mekonnen, G.B., Birhanu, B., Afrasa, A., 2017. Action Plan Development for the Water Allocation Plan in Ziway-Shalla sub Basin. Unpublished. Rift-Valley Lakes Basin Authority. Hawassa, Ethiopia.

Mekonnen, G.B., 2016. Manuals on the self-supply water harvesting technologies for small holder farmers in Oromiya: an approach towards sustainable solution to economic water scarcity in the Region. Unpublished. Oromia Irrigation Development Authority. Finfinnee, Ethiopia.

Mekonnen, G.B., Tesfaye, K., Abdi, A., 2016. Assessment Report for Irrigation Potential Identification in Some Districts of West and East Hararge Zones: An Argent Response for the Recurrent Drought Preventions. Unpublished. Oromia Irrigation Development Authority. Finfinnee, Ethiopia.

Mekonnen. G.B., Dula, B. Ibsa, U., Wari, T. A., 2016. A Proposal for the Development of Potable Water Supply, Irrigation, and Livestock Production in Borana-Guji and Hararge Corridors: An Urgent Response for the Preventions of the Existing and Recurrent Drought Problems. Unpublished. Oromia irrigation Development Authority, Oromia Water, Mineral and Energy Bureau, Oromia Pastoral area Development Commission. Finfinnee, Ethiopia.

Meshesha, D.T., Tsunekawa, A., Tsubo, M., 2012.Continuing land degradation: Cause–Effect in Ethiopia's central rift valley. Land Degradation & Development, 23, 130–143. doi:10.1002/ldr.1061.

Ojha, C.S.P., Berndtsson, R., Bhunya, P., 2008. Engineering Hydrology. Oxford University Press. **I S B N:** 978-0-19-569461-1.

OECD, 2012. Development Co-operation Report 2012: Lessons in linking sustainability and development.

Reaugh-Flower, K., 2011. Abijata-Shalla Lakes National Park. Assessment of Factors Driving Environmental Change for Management Decision-Making. Report to the Ethiopian Wildlife Protection Authority's Sustainable Development of the Protected Area System of Ethiopia Program.

Shumet AG, Mengistu, K.T., 2016. Assessing the Impact of Existing and Future Water Demand on Economic and Environmental Aspects (Case Study from Rift Valley Lake Basin: Meki-Ziway Sub Basin), Ethiopia. Int J Waste Resour 6: 223. doi:10.4172/2252-5211.1000223.

World Bank, 2006. "Managing Water Resources to Maximize Sustainable Growth: A World Bank Water Resources Assistance Strategy for Ethiopia" A Country Water Resources Assistance Strategy, World Bank, Washington, DC.

World Bank, 2005. "A Strategy to Stimulate and Balance Growth in Ethiopia." A Country Economic Memorandum Report 29383-ET, World Bank, Washington, DC.

WWF, 1986. Living Waters: Conserving the source of life. Netherlands.