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Problems and Prospects of Water Resources Management in the Somali State, Ethiopia

Abdinasir M. Abdullahi[1], Rosin, K. G.[1*], Anil Kumar Mishra[1], Neeta Dwivedi[1] and Sarvendra Kumar[1]

[1] *Water Technology Centre, ICAR-Indian Agricultural Research Institute, New Delhi -110012*
[2] *Division of Soil Science and Agricultural Chemicals, ICAR-Indian Agricultural Research Institute, New Delhi -110012*
**Corresponding author E-mail-* kgrosin@gmail.com

INTRODUCTION

Water is essential for human, animal and plant life. Without water; life is not at all possible on the earth. There is nothing more essential to life on Earth than water. It is used in various sectors like irrigation, hydropower generation, industries and institutions, domestic purposes, navigation, wildlife etc on which country's economy depends. However, this resource is limited and also not properly managed. The quality of surface and ground water is also degrading due to improper disposal of the waste in rivers. In the developing countries, about 80% of diseases are water borne and nearly 1 out of every 5 deaths under the age of 5 worldwide is due to a water-related disease. These water scarcity and degraded quality constrains have jolted the whole world to take the right steps toward managing and improving this most valuable resource for the sustainable health. Exponential growth in population and rapidly changing life styles of people are worsening the problem of Accessibility, Adequacy, Availability and Affordability of Clean and Safe Drinking Water to the People. Water scarcity problem becomes further complex in arid and semiarid regions. Yet, in Sub-Saharan Africa, and in particular Ethiopia, there is acute water crisis sinces decades resulting into unprecedented sufferings of all kinds to the people. People are struggling to access the quantity and quality of water they need for drinking, cooking, bathing, hand-washing and growing their food. As stated by (Gleick, 1993) and (Kundzewicz, 1997) freshwater scarcity is a global problem that is particularly acute in dry land, and that threatens the potential of agriculture to alleviate poverty and improve human health.

In addition to the erratic nature of rainfall in dry land areas, extended drought also results in famine. Many dry land areas are also known to have experienced unexpected excessive rainfall that can cause flash floods and consequently, loss of life and property. Dry lands (arid and semi-arid areas) are characterized not only by low annual precipitation, but also by its temporal and spatial variability. The Somali Region of Ethiopia is one of the arid and semi-arid areas where water scarcity is very common, therefore its water challenges and opportunities are needed to be investigated, although this investigation can't be enough. As a matter of fact, Ethiopia is a disaster-prone country, exposed to numerous hazards including droughts, floods, epidemics and conflict. Recurring drought and floods have the most severe impact on Ethiopia's population. The country has a long history of recurring drought, which has increased in magnitude, frequency and impact since the 1970s. Flash and seasonal river floods are becoming more frequent and widespread. Climate models indicate that in the next century there will be a 20% increase in extreme high rainfall events (NLRC & ERCS, 2018).

In this paper we have attempted to analyse the various causes and associated factors affecting

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the water avaiability in Somali region of Africa as well as also tried to articulate the problems of Accessibility, Adequacy, Availability and Affordability of Clean and Safe Drinking Water to the People of Somali region and various strategies to overcome the problem of water shortage by its prudent use and management.

PROFILE OF THE SOMALI STATE OF ETHIOPIA

Somali regional state is located in the eastern and southeastern part of Ethiopia and is one of the least developed regions in the country in particular and Africa in general. It covers almost a third of Ethiopia's land surface area, and much of it is predominantly arid and semi-arid. It lies between $4^{\circ} 11'$ N latitude and 48° E longitude. The area of the region is estimated to be 350,000 km^2. It is bounded by Kenya and Somalia to the south, the Republic of Djibouti and the Afar region to the north, Somalia to the east and southeast and Oromiya region to the west. The Region is home to some five million people, of whom about 60% practice pastoralism. About 15% are sedentary, riverine farmers and the rest practice different forms of agro-pastoralism. The altitude of the Region varies between 200 and 2,000 meters above mean sea level; mean annual rainfall is between 150 to 660 mm a year. The low annual rainfall and its uneven distribution, together with the frequent recurrence of drought, have made water the single most important element that determines the living style of the population. People, together with their herds of camels, goats, sheep, and cattle, move from place to place, continuously, in search of water and grazing. The normalized difference of vegetation index is between 0.05–0.1, which is low to moderate and typical of vegetation cover in a semi-arid environment. Altitude is the main determinant of rainfall volume, and both increase towards the northeast of the Region (SRWB, 2012).

LIVELIHOOD OPTIONS

Four generic livelihood types exist in the region: pastoralism, agro-pastoralism, farming (sedentary and riverine) and urban. Pastoralism is the most prevalent, comprising about

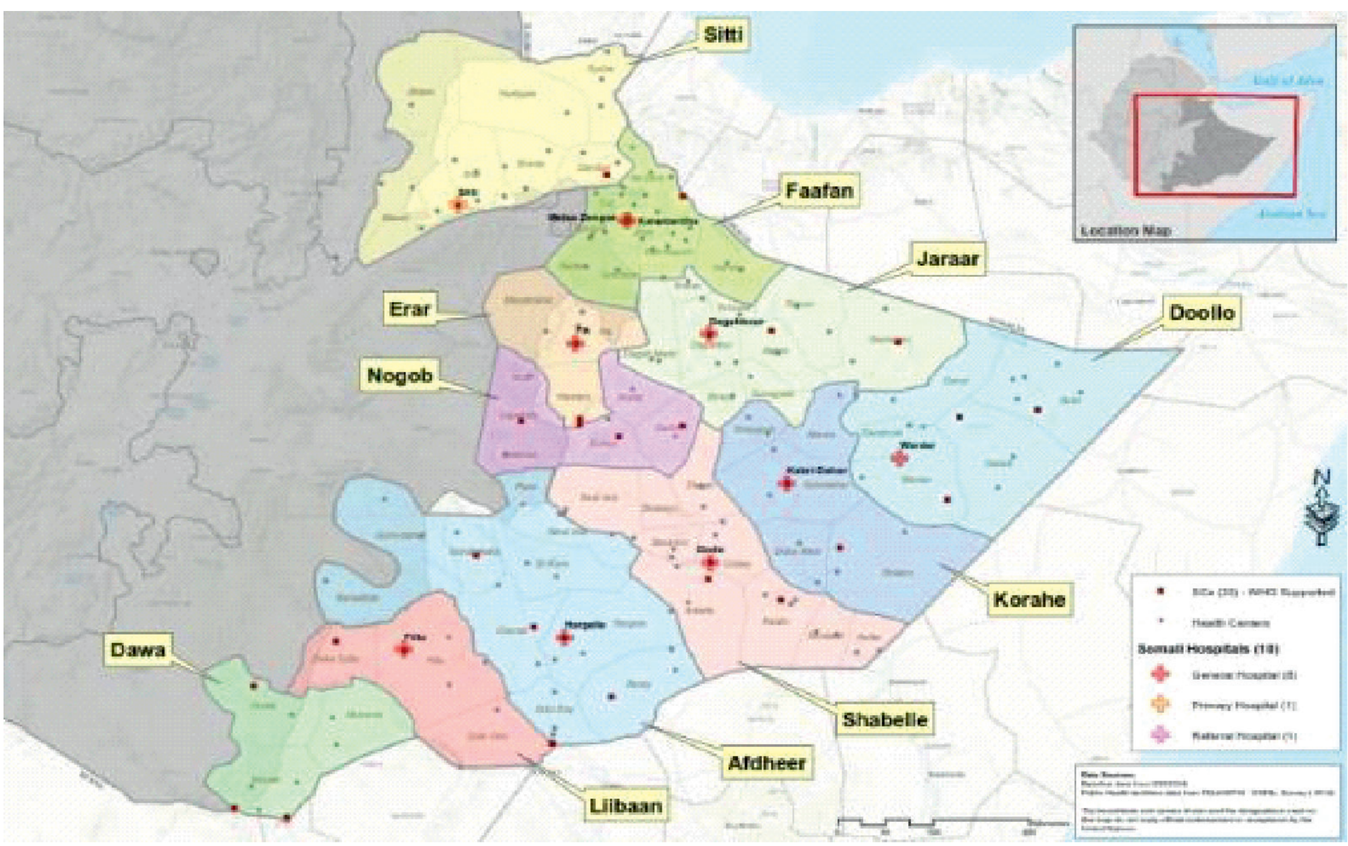

Figure 1: Map of Somali region of the Ethiopia. (Adopted from WHO office in Ethiopia, Annual report, 2018)

60% of the region's rural population. Agro-pastoralism comprises about 25% of the total rural population, and is a mixture of extensive livestock rearing and rain-fed crop production; some may be better described as pastoralists with opportunistic farming activities – as in Fik and some parts of Liban Zone. The remaining 15% of the rural population comprises sedentary (Jigjiga zone) and riverine (Shebelle and Dawa-Ganale) farmers. Both farming and agro-pastoral groups keep some livestock but farmers' herds do not migrate and are sometimes hand-fed, only migrating with other groups if there is a severe drought (CHF, 2006).

AGRICULTURE

Somali region is a huge rangeland in Eastern Ethiopia and it is the favored grazing land within the country. There is some extensive open grassland in the area often associated with cultivation. It is also the major livestock production centre in the country. The rangeland is not ecologically homogenous. The region is a plateau, which falls from 1,500 meters in the northwest to about 300 meters in the southern limits including the Wabi Shebelle basin. The higher altitude areas between 1400 and 1600 meters are characterized as semi-arid, receiving as much as 500-600 mm of rainfall annually. The landscape consists of dense shrub land, bush grassland and bare hills. The soils are Calcisol, Gypisol, Regosol, Vertisol and Fluvisol and are marginal for crop production (Ayele 1976). The dominant tree species identified in the Ogaden are *tamarixaphylla*, *calotropisprocera*, *parkinsonia aculeate*, *balanitesaegyptica*, *dodonaeaanguistifolia*, *rumexnurvosus*, acacia species and *combretummolle* (MOA 2000). The region is endowed with plant species, which produce gum arabic, *olibanum*, myrrh and *oppoponex*. It has been estimated that the region has a potential of producing 11,250 ql of gum arabic and a total of 46,000 ql gum *olibanum*, myrrh and *oppoponex* annually (Ayele & Tadesse 1990). In Afder zone in the south of the Somali region salt is exploited for commercial purposes. Some study reveals a potential for the exploitation of 15,000 ql of salt per month to exist in Afder (Ayele & Tadesse 1990).

Ethio-Somalis are traditionally nomadic pastoralists, and have been so for centuries. Life and survival revolves around livestock, with people constantly moving about in the interests of their livestock. "Where I make a living, there is my home," says a popular Somali proverb. Being a plentiful livestock owner is a show of wealth and prosperity and connotes high social status, whereas farmers have often been viewed "as inferior and poor people" (Ahmed, 2005). Pastoralists traditionally move their herds around sizable areas in search of water and grazing land, often moving with their families and clan members. Until recently there were relatively lucrative markets for livestock accessible to pastoralists, primarily in the Arabian Gulf states, which meant transporting the animals through Djibouti and Somalia. However, as discussed below, drought and regulation have substantially limited access to these markets, contributing to the gradual shift towards agro-pastoralist activities that is a focus of this report. Given the dominance of pastoralist and now agro-pastoralist activities, individuals andcommunities are extremely dependent on rainfall (CHF, 2006).

WATER RESOURCES

Major water sources used by both human and livestock in the region are Rivers, Birkas, Hand dug wells and traditional ponds and local streams. Quantity and quality of available water largely depends on the amount of rainwater received, and the seasonal water sources, which is expected to deplete within a short period of time, it is also expected that the depletion will aggravate the vulnerability of the community. In addition, the availability of functional water points is a critical challenge that compromise households access for safe drinking water. Under this situation of scarcity and limited opportunities, many communities depend on water rationing interventions to survive (SRWB, 2012).

RAINFALL DISTRIBUTION

In Eastern Africa which comprises the countries that make up the Intergovernmental Authority on Development (IGAD) trading bloc – Djibouti, Eritrea, Ethiopia, Kenya, Uganda, Sudan, South Sudan, and Somalia. It also includes Burundi and Rwanda. Its climate is complex and diverse. It ranges from hot, arid, and semi-arid in most of Djibouti, Eritrea, Somalia, and Sudan and the eastern half of Ethiopia and Kenya, to tropical rains in western Ethiopia and Kenya, South Sudan, and Uganda. Warm temperate rains are also found in the highlands of Ethiopia. Mean annual rainfall varies from over 2,000 mm in parts of southwest Ethiopia to less than 250 mm in the arid areas of Djibouti, Eritrea, Ethiopia, Kenya, Somalia, and Sudan. Kenya, Somalia, Uganda, southern and south-eastern Ethiopia, Rwanda, and Burundi have bimodal rainfall regimes. Sudan, South Sudan, most of Ethiopia, and Eritrea in contrast have one main rainfall season – from June to September with the peak intensity in July and August (GWP, 2015).

Therefore, Somali Region is among the Eastern Africa where rainfall distribution is predominantly determined by the altitude, and both (altitude and rainfall volume) increase towards the northeast of the region. Precipitation in the overall Somali Region, based on available daily rainfall measurement data from 1980–2009 as provided by the Ethiopian Meteorological Authority, averages 390 mm, with significant differences between the dry south and east and the wetter north. The climatic condition of Somali Region is mainly controlled by the seasonal migration of the Inter Tropical Convergence Zone (ITCZ), which is conditioned by the convergence of the trade winds of the northern and southern hemisphere and the associated atmospheric circulation. At local level and regional, it is also highly influenced, by the complex topography of the country. In March the ITCZ is located south of Ethiopia and moving northwards and in April it is located in southern Ethiopia. At 850mbelow level, there is strong low pressure cell over central Sudan. The anticyclone systems over Egypt and Arabia weaken; and another high pressure system develops over the Gulf of Aden and the Indian Ocean of the coast of Somalia. The Gulf of Aden-Indian Ocean high pressure system generates moist, easterly air currents over south eastern Ethiopia and southeasterly air currents along the Eritrean Red Sea Coast. The tropical easterlies have therefore two components in spring: the moist easterly and southeasterly air currents in eastern Ethiopia and the dry, northerly air currents in the north western quadrants of the country. The Gulf of Aden-Indian Ocean moist air currents form a zone of convergence with the northerly air currents along the northern half of the western escarpment of the Ethiopian rift system. The easterly and the south-easterly moist air currents ascend over the highlands in spring produce the main rainy season in south eastern Ethiopia and bring the small rains of spring to most parts of the country, including the coast, excepting the north western quadrant of the country which is under the influence of the dry country northerly tropical easterlies. Therefore, all the climatic factors inherit these aforementioned characteristics (Yohannes, Tsegay and Aklilu, 2018).

Due to the north and south movement of the Inter-Tropical Convergence Zone (ITCZ), the Region has two distinct rainy seasons. Most of the pastoralists and agro-pastoralists depend heavily on these rains for their livelihood. Local groundwater recharge is possible due to the rains in different seasons. There are also dry seasons, which extend to very long dry seasons when the rain becomes erratic and unpredictable. Long and extended dry seasons are responsible for livelihood loss, including loss of a huge number of animals. The movement of the Inter-Tropical Convergence Zone, which passes over the country twice a year and results in two distinct short-duration rainy seasons in the east of the country, the *gu* (April to June) and *deyr* (October to November). The alternating dry seasons are known as the *jilaal* (December to March) and *haggaa* (July to September). Availability of water that falls as precipitation is then exacerbated by high evapo-transpiration rates (1,500–2,500 mm per year), which increase the fugitive nature of the resource—it is difficult to capture and store (SRWB, 2012).

During those rainy seasons mentioned above, people of the region make every effort to collect water in wells and storage containers for their family and animals to consume during the dry season. But over the past two decades

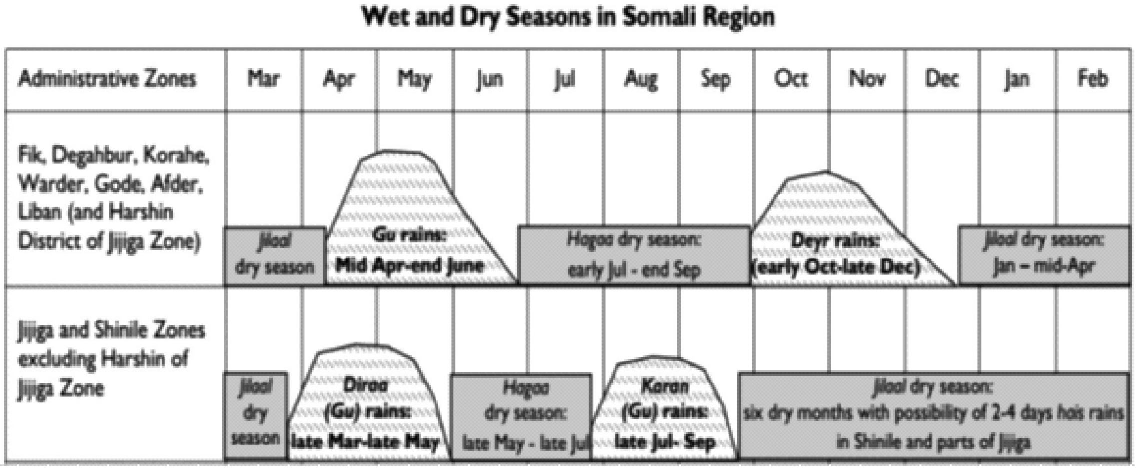

Figure 2: Seasonal rainfall patterns in the Somali State of Ethiopia. (http://www.dppc.gov.et**)**

these rains have become increasingly unreliable; there were major droughts in 1984-85 (*Dabadheer* drought in Somali, meaning 'long lasted') 1994 (*Hurgufa* drought in Somali, meaning 'the killing quickly') and 1999-2000 (*Shanqadha/Dabagunud* drought in Somali, meaning 'the loud noise') during which pastoralists claim to have lost 70-90 per cent of their cattle (Ayele, 2005). The impact of the 2015 El Niño cycle was among "the strongest on record," with effects lasting through Spring 2016. In Ethiopia, the effects of this weather phenomenon were varied, but most regions received significantly less rainfall than the 1981-2014 average (Fig. 3). This provided an opportunity to evaluate whether activities implemented under PRIME have enabled beneficiaries to recover, bounce back better, or avoid being affected completely when confronted by severe drought (Mercy corps, 2017). For large areas of the north and central regions, 2015 was the driest it has been in at least 30 years; they received less than 65 percent of normal rainfall and soil moisture, a useful proxy for crop conditions. These conditions resulted in water shortages, a lack of native forage for livestock grazing, and significant crop losses of between 50-90 percent (mercy corps, 2017).

PROBLEMS OF GROUNDWATER: AVAILABILITY AND QUALITY

Ethiopia has 12 river basins. The total mean annual flow from all the 12 river basins is estimated to be 122 BMC (MoWR 1999). The Somali Regional State is endowed with four perennial rivers and a number of seasonal streams. Also, the Region has a huge potential for underground water. The total volume of underground water is not estimated in all the research conducted. As compared to surface water resources, Ethiopia has lower ground water potential. However, by many countries' standard the total exploitable groundwater potential is high. Based on the scanty knowledge available on groundwater resources, the potential is estimated to be about 2.6 BMC annually rechargeable resource (Seleshi Bekele, *et al.* 2007).

RIVER BASINS OF THE REGION

Wahit shebelle river basin comprises the drainage of the seasonal rivers of Fafan, Jerar, and Dakhato. This is the largest basin, with an elevation ranging from 2,000m to 200m above sea level, sloping towards the Wabi Shebelle River. The entire Shabelle and Nogob zones and parts of Fafan, Jarar, Koreha, and Afder Zones lie in this basin. These seasonal rivers play a significant role as a water resource of the Somali Region. Most successful boreholes are located in their sub-basins (SHAAC 2008).

Genale-Dawa-Web river basin (Juba basin) comprises three major river drainage systems. The elevation of the basin ranges from 150m to 1,600m above sea level, and the entire basin slopes southwards. The entire Liban Zone and part of Afder Zone lie in this basin (SHAAC 2008). North-Eastern-Warder Drainage Basin (Ogaden) comprises most of Dolo Zone and parts of Fafanand Jarar Zones. This Basin is characterized by a plain with a gentle slope draining towards Somalia, and on to the Indian Ocean (SHAAC 2008). Awash basin comprises the drainage areas of several seasonal rivers in Siti Zone, including Erer. It covers areas west of the Amhara Highland and entire Siti Zone. The drainage system is easterly, towards the Awash River (SHAAC 2008).

Figure 4: Major Drainage Areas of the Somali Region.
(http://creativecommons.org**)**

Groundwater flow is strongly influenced by the physical framework of the system, which is characterized by aquifers, confining units, flow barriers, and other geologic structures (Seud Amer *et al.,* 2013). Analysis of Wabi Shebelle data between 1971–1976 and 1986–1989 suggests substantial declines in flow rates. This kind of ongoing monitoring is now critical, given the possibly significant impacts of climate change. Little firm hydro-geological data is available for the SRS. Based on recent studies, the main strata and associated aquifer characteristics are as explained in the following Table 1 (SHAAC 2008). More than half the Region overlies the Ogaden-Juba multilayered aquifer, which is among the world's 37 largest aquifers, covering 1 Million m3 between Ethiopia, Kenya, and Somali. Development of this aquifer will be a future option, though subject to improvements in the overall security environment in this part of the Region (SHAAC 2008).

Table 1: Main aquifers, stratigraphy and their characteristic in the State of Somali, Ethiopia.

Zone	*Stratigraphic*	*Aquifer Characteristic*
Sitti	Recent Basalt	The upper part of the formation is highly weathered; the lower part less so and contains fresh water. A maximum thickness of more than 200 m is expected for this formation.
Fafan and Dollo	Jessoma Sandstone	Based on its characteristics, it could potentially hold significant water resources; however, there is no retaining or impervious layer at shallow depth, so recharge water percolates deep. Wells tend to be over 300 m deep, reaching 400 m in *Danot*. In some areas, wells are known to have been abandoned due to low yield.
South Korahe, Shabele, Afder	Korahe or Main Gypsum Formation	Most of the boreholes drilled in this formation are abandoned due to salinity. Drilling in this unit should reach the underlying *Kabridahar* limestone formation so as to obtain fresh water. However, even then the location matters, because the thickness of the gypsum formation increases from *Korahe* Zone towards *Shabele* and *Afder*Zones; e.g., in *Shabele,* the gypsum formation is about 800–1,000 m and in*Afder* Zone it is more than 1,000 m, making drilling uneconomical.
Partly Nogob, Partly Liban	Urandab Series	Boreholes drilled in this unit were mostly abandoned because of being dry. The lack of groundwater in this unit is due to presence of shale, which prevents vertical and lateral recharge of the formation.

GROUNDWATER QUALITY

Groundwater from the Ogaden region are noted to be dominated by sodium and sulphate with total dissolved solids concentrations in excess of 1500 mg/l (EIGS, 1993). In groundwater from the Wabe Shabele catchment of south-eastern Ethiopia, dominant dissolved constituents are reported to be sodium and chloride, with total dissolved solids in excess of 3000 mg/l (EIGS, 1993).While not directly detrimental to health, high concentrations of sodium and chloride ('salt') in groundwater used for drinking may be unacceptable to the users. Some of the saline groundwaters occur in areas of Ethiopia which are sparsely populated (e.g. the Ogaden region/ Somali region).

TRADITIONAL AND MODERN WATER HARVESTING

The major surface sources that the Region has developed reflect fairly recent trends (in the last half-century) in response, largely, to growth in human and livestock concentrations. It includes *birkeds,* ponds, haffirs. Birkeds are traditional rainfall-runoff water-harvesting structures that are used by human and livestock. There are estimated to be many thousands of them across the Region, most of which are privately owned. Their exact location and number is unknown and an audit of them pinpointing their concentration is now overdue. This self-supply mechanism provides water during and subsequent to the rainy season, sometime for up to three months after the end of the rainy season. Seepage is reduced through cement lining of the tanks. Some *birkeds*are covered, which helps prevent from evaporation losses. *Birkeds*provide a functional storage capacity of some 50 m^3, estimated to provide water for a family of six with 30 head of livestock for 60 days at a consumption rate of 15 Lcd. Larger, communal-scale *birkeds* have been provided by agencies, with between 3 and 30 times the capacity. Communal *birkeds* may face management challenges. Where there is private ownership, by waiting until the dry season, private owners can achieve very high profits from the sale of water to more nomadic herders. In some cases, the vested interests in these *birkeds* can block development of alternative sources. In many cases, *birked* development has led to more permanence in certain grazing areas. These are signs of the value of water across time in the Region, but also of the need for careful stakeholder engagement in the future development of schemes (SRWB, 2012).

IRRIGATION SCENARIO

The agricultural sector is also the major employer, accounting for 85% of the total employment. Crop production accounts for 60% of the sector's output, while livestock and forestry constitutes 30% and 10%, respectively, and rain-fed agriculture provides the largest proportion of the total production. However, irrigated agriculture has become more important and irrigation is one of the sub-sector development strategies dealt with in the government's water sector strategy. The principle objective is to exploit the agricultural production potential of the country to achieve food self-sufficiency at the national level, including export earnings, and to satisfy the raw material demand of local industries, but without degrading the fertility and productivity of country's land and water resources base (MoWR, 2001).

The objective of irrigation projects is to increase agricultural production and consequently to improve the economic and social wellbeing of the rural population. However, changing land use patterns may have unintended impacts on the social and economic structure of the project area. Small plots, communal land use rights, and conflicting traditional and legal land rights all create difficulties when land is converted to irrigated agriculture. Land tenure/ ownership patterns are almost certain to be disrupted by major rehabilitation works as well as new irrigation projects. Similar problems arise as a result of changes to rights to water. Increased inequity in opportunity often results from changing land or water use patterns (LCRDB, 2013). For example, owners benefit in a greater proportion than tenants or those with communal rights to land. Access improvements and changes to the infrastructure are likely to require some field layout changes and a loss of some cultivated land. Irrigation projects tend to encourage population densities to increase, either because of the increased production of the area or because they are part of a resettlement project. Impacts resulting from changes to the demographic/ethnic composition may be important and have to be considered at the project planning stage through, for example, sufficient infrastructure provision (LCRDB 2013).

Irrigation projects do not only affect economic outcomes, but may have wider socio-economic effects. A very visible effect of irrigation projects are the negative health effects associated with increases in incidence of water-related diseases such as *malaria* and *bilharzia*. When irrigation is associated with the construction of large dams, additional impacts include the displacement of large numbers of people and negative environmental effects of dam construction. According to the World Bank, forced population displacement caused by dam construction is its single most serious counter-development consequence (Horowitz, 1991). While there is no doubt that both of these effects carry heavy private and social costs, insufficient attention to the 'without irrigation scenario' in programme evaluation gives rise to a devaluation of the positive economic and social impacts of irrigation works (Blackman, 1987; Carruthers*et al.,* 1997)

Despite investments on irrigation development, various studies underline the poor performance of irrigation schemes, and note the importance of institutional problems. As such, many irrigation schemes are reported to be under-performing, with disappointing results in terms of public investment. At the federal level, it was noted that the mandates of the Ministry of Agriculture and Ministry of Water Resources in irrigation development were not clearly articulated or scrupulously tended. The setup of irrigation institutions from federal to *woreda* (district) level is frequently changing, leading to lapses in institutional memory, duplication of efforts, and accountability issues (LCRDB 2013).

The only irrigation project in the region is named "West-Godey Irrigation Project" which is under process. The Shebelle River Basin is one of the 12 major river Basins in Ethiopia, and covers an area of 202,697 km^2 with a total mean annual water flow of 3.16 billion metric cube (BMC). The irrigation potential of the Basin has been estimated at 237,905 ha, in 149 locations on 41 small, 77 medium and 31 large-scale sites. The small-scale sites are estimated to cover 10,755 ha, the medium 55,950 and the large-scale 171,200 ha (Awulachew*et al*., 2007). Along with the Shebelle river, the other three important rivers crossing the SRS are the Genale, Dawa and Weyib. The region also hosts a small perennial stream, Erer, and major seasonal streams that include Fafem and Jerer.

PROSPECTS OF WATER RESOURCE DEVELOPMENT AND MANAGEMENT

A first step in better management and development of water is knowing where it is and how it behaves under different conditions; in addition, how much of it is demanded when, where, and by whom, and how better management can support changing patterns of demand. At present, Somali region suffers from a huge gap in such information, the bridging of which must be a starting point in achieving greater regional water security.

UNDERSTANDING THE RESOURCE: ASSESSMENT AND QUANTIFICATION

Variability between seasons and years is the norm. Combined with changes in policy and wider socio-economic changes, a specific pattern of agro-ecological and livelihoods zones has emerged. Future water security for this variegated landscape requires a range of approaches. Central to achieving security in such a context is the need to address two elements of this variability: first is the capacity to absorb the extremes of variability without seriously damaging livelihoods and to improve the way in which local and regional systems are capable of responding; the second is to strengthen the capacity to predict so that variability becomes less of an unknown, reduces risk, and supports greater decision-making certainty (SHAAC, 2008). As part of this exercise, the Region should establish an effective rainfall, streamflow, and groundwater monitoring system, based on simple physical measurements. This will ground-truth other remote sensing data provided by central government authorities and external agencies to help build up a more sophisticated resource management picture. (SRWB, 2012).

DEALING WITH VARIABILITY

Variability is hard-wired into the region's hydro-climatic system. This variability may be changing over time as global climate systems respond to warming of the atmosphere. At the present time, however, the granularity of Global Climate Models is such that their resolution will not support prediction at the scale of a region within Ethiopia, such as SRS. Dealing with variability therefore needs to address practical concerns, described below, in anticipation of future shocks (SRWB, 2012).

Table 2: Water resources assessment and monitoring physical measurement, instrumentation and field activities.

Resource	*Activity and Measurement*
Rainfall	- Ensuring functionality of currently available rain gauge stations, where possible install new gauging stations. - Use of traditional and location-specific categorization of rain; "below," "normal," and "above." This will need to be defined in terms of annual rainfall quantities based on local knowledge and expert interpretation.
River flow	- Ensuring functionality of currently available river gauges, where possible install new ones, including on major ephemeral rivers. - Use of traditional and location-specific categorization of riverflow; "below," "normal," "above," and "flood." This will need to be defined in terms of annual riverflow quantities based on local knowledge and expert interpretation.
Underground water	- Mandatory installation of observation pipes on new boreholes by all implementers, capacitating woreda water offices to conduct groundwater monitoring on existing boreholes. - Mandatory submission of drilling reports (with water quality tests) to RWRDB and WWOs by drillers and implementing agencies. - Regular groundwater sampling and testing from strategic boreholes (existing) by RWRDB and agencies with water quality testing capacity. - Where possible, installation of groundwater observation boreholes in strategic zones.

BUFFERING WATER STOCKS

At present the Region has low levels of storage capacity and poor ability to manage effectively the storage capacity that it does have. Buffering should take two forms—surface and subsurface water storage to mitigate the peaks and troughs of extreme variability (SRWB, 2012).

MEASURING THE AQUIFER DISCHARGE FOR ENSURING THE ADEQUACY:

In parallel with the need to increase regional storage, greater effort is required in understanding the behavior of the river basins and aquifers within the Region. Analysis of Wabi Shebelle data between 1971–1976 and 1986–1989 suggests substantial declines in flow rates. This kind of ongoing monitoring is now critical, given the possibly significant impacts of climate change. Little firm hydro-geological data is available for the SRSE (SHAAC, 2008).

ENSURING THE AVAILABILITY OF WATER

Water availability is both ecologically and human controlled. The water resources of the Region occur as precipitation (rainfall), surface runoff, and groundwater. Ensuring availability in space and time and for whatever uses (human, livestock, and agriculture) involves harnessing of the resource when and where it's needed for use. Traditionally, water has been made available by construction of ponds, hand-dug wells, *birkeds*,

Table 3: Technology Choices for Buffering Water Stock for Different Settings

Setting/Ecological Zone	*Normal Supply Choice*	*Buffering Supply Choice*
Urban settlement in riverine areas	River intake with treatment; individual roof harvesting; truck/cart delivery	Large offshore flood storage dams
Urban settlement in other areas	Motorized borehole-based, individual roof harvesting systems; truck/cart delivery	Large surface water storage dams
Agro-pastoral (settled) areas	Borehole-based systems (motorized and hand pump); Hand-dug wells; *birkeds*; ponds; haffir dams	Large surface water harvesting dams; subsurface sand dams (seasonal river belts)
Pure pastoral areas	Large haffir dams, *birkeds*, ponds	Strategically positioned boreholes; safe distance could be not less than 20–30km to reduce impact of permanent water sources to pastoral land
Irrigated agriculture areas	River offtakes with gravity weir or surface pumps; large storage surface dams; rainfed	Large offshore flood storage dams

Source: (SRWB, 2012).

Table 4: Technology Choices for Different Settings in the Region

Technology Type	*Settings for Application*	*Management Options*
Safe water sources		
Motorized borehole	- Areas has groundwater. Well depth exceeds 60 m and supplies large population (people) or industry.	- Managed by WMC on behalf of community, aim at O&M cost recovery. - If pump is to be installed at less than 70 m, consider using solar power.
Borehole with hand pump	- Area has groundwater. Well depth less than 60 m and supplies small population (people).	- Managed by WMC on behalf of community, aim at O&M cost recovery.
Sealed hand-dug well installed with hand pump/ subsurface sand dams	- Area has shallow groundwater, usually near perennial or seasonal river beds. - Improving storability in seasonal river bed.	- If public will be managed by WMC, aim at O&M cost recovery. - If yield is good and population is large, pumping with solar power should be considered.
River intake with treatment facility	- Riverine communities and towns where large population (people) to be served or industrial activity justify the heavy investment.	- Centrally managed by a technical team employed by the responsible authority. Public-private partnership is a likely better option. aim at full cost overtime and O&M recovery.
Unsafe water sources		
Household or group *birkeds*	- Areas with sufficient rain to fill tank and household have interest for self supply for human and livestock.	- Private. - Owners can be supported to improve water quality through filtration and SODIS.
Communal "super" *birkeds*	- Areas with sufficient rain to fill the tank +200 mm ARF. - A consideration for human use only if area is not feasible for borehole, otherwise meant for livestock in pastoral and agro-pastoral areas, parallel to borehole for human use.	- Managed by WMC on behalf of community. - Where human consumption is a consideration, installation of simple treatment facility and well with hand pump is necessary. - Solar/wind powered pumping of raw water for livestock is recommended.
Haffir dams	- Areas with sufficient rain to fill the tank +200 mm ARF. - A consideration for human and livestock use where borehole is completely not feasible in pastoral and agro-pastoral areas. Also for irrigation potential and buffering near urban settlements.	- Managed by WMC on behalf of community. - Treatment facility and well with hand pump for human use. - Solar/wind powered pumping of raw water for livestock.
Roof harvesting	- In institutions and towns with feasible roof surfaces; very few homes in rural Somali have feasible roofs.	- Private. - Quality can be improved by installation of simple first flush separators and teaching people on application of SODIS.

water holes in seasonal river beds, and surface runoff or river diversion ditches. Non-traditional methods include: motorized and hand pump-fitted boreholes, hand-dug wells improved with hand pump, including those installed on subsurface sand dams, haffir dams, river intakes (with treatment for human supply and raw for irrigation) and roof harvesting (SRWB, 2012). The table 4 below shows recommended scenarios for choice, applicability, and management options for the above technology types.

CONCLUSION

Being the most essential element for life on earth, water plays an important role in the ecosystem functioning and equilibrium. It plays a pivotal role in any country's economy as it is directly linked to different sectors like irrigation, hydropower generation, industries and institutions, domestic purposes, navigation, wildlife etc. The region has a troubled history of poverty and strife. Two wars have been fought between Ethiopia and Somalia over the land, in 1964 and 1977-78. Somali region is a huge rangeland in Eastern Ethiopia and it is the favored grazing land within the country. There is some extensive open grassland in the area often associated with cultivation. It is also the major livestock production Centre in the country. The dominant tree species identified in the garden are *tamarixaphylla*, *calotropis procera*, *parkinsonia aculeate*, *balanitesa egyptica*, *dodonae aanguistifolia*, *rumex nurvosus*, acacia species and *combretum molle*(MOA 2000). Ethio-Somalis are traditionally nomadic pastoralists, and have been so for centuries. The climatic condition of Somali Region is mainly controlled by the seasonal migration of the Inter Tropical Convergence Zone (ITCZ), which is conditioned by the convergence of the trade winds of the northern and southern hemisphere and the associated atmospheric circulation. The movement of the Inter-Tropical Convergence Zone, which passes over the country twice a year and results in two distinct short-duration rainy seasons in the east of the country, the *gu*(April to June) and *deyr*(October to November). The alternating dry seasons are known as the *jilaal* (December to March) and *haggaa*(July to September). The Somali Regional State is endowed with four perennial rivers and a number of seasonal streams. Variability is hard-wired into the region's hydro-climatic system. This variability may be changing over time as global climate systems respond to warming of the atmosphere. Water availability is both ecologically and human controlled. The water resources of the Region occur as precipitation (rainfall), surface runoff, and groundwater.

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