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Surface Water and Groundwater Resources of Rift Valley Lakes Basin of Ethiopia: A Review of Potentials, Challenges and Future Development Perspectives

Ermias Mekonnen

Department of Hydraulic and Water Resource Engineering, College of Engineering, Wolaita Sodo University, Wolaita Sodo, Ethiopia; P.O. Box: 138;

Abstract-- **In this paper, a critical review of recent studies on surface water and groundwater resources potentials as well as the challenges and future development perspectives in the rift valley lakes basin of Ethiopia was conducted. The basin is endowed with a number of rivers as well as lakes of varying size with high environmental significance. The total surface water resource of the rift valley lakes basin is estimated at just over 5.6 billion m^3/year and the estimated groundwater potential of the basin is 0.10 billion m^3/year. The potential irrigable land of the basin is only 2.64%; and the gross hydro-electric potential of the basin is found to be 800Gwh/year. The water resources of the basin have enough potential for irrigation, hydropower and domestic water supply. However, these potentials are not fully utilized and translated into development because of many factors including limited financial resources, technical challenges, climate variability and lack of good governance in the water sector. As a result, attention must be given to interventions that moderate hydrological variability, mitigate the physical impacts of hydrologic shocks on the environment and watersheds, and arrest land degradation. Therefore, this review paper attempts to explore the interventions like infrastructure investments to provide storage and regulate river flows and runoff, and land and soil management practices to enhance the natural capacity of watersheds to moderate hydrology.**

Keywords: **Surface Water, Groundwater, Rift Valley, Potential, Basin**

I. INTRODUCTION

Water is mankind's most vital and versatile natural resource [14] and has always played an essential role in Ethiopian society as it is an input to almost all production systems[12]. Ethiopia is endowed with inland aquatic ecosystems including lentic and lotic water bodies namely the Rift Valley, Abay, Awash, Baro-Akobo, Omo-Gibe, Tekeze and Wabishebele-Genale drainage basins[4][17]. Ethiopia is gifted with many lakes and rivers that comprise diverse aquatic ecosystems of great scientific interest and economic importance.

The total area of inland waters in Ethiopia is 8800km^2, representing 0.72% of the total surface area of the country Greboval *et al*. (1994) cited in [16].

According to Abebe and Geheb (2003) cited in [17], the total surface area of open waters, including wetlands, is 7444 km^2.

Ethiopia is also endowed with a substantial amount of water resources. The country is divided into 12 basins; 8 of which are river basins; 1 lake basin; and remaining 3 are dry basins, with no or insignificant flow out of the drainage system. Almost all of the basins radiate from the central plateau of the country that separate into two due to the Rift Valley. Basins drained by rivers originating from the mountains west of the Rift Valley flow toward the west into the Nile River basin system, and those originating from the Eastern Highlands flow toward the east into the Republic of Somalia. Rivers draining in the Rift Valley originate from the adjoining highlands and flow north and south of the uplift in the center of the Ethiopian Rift Valley[1].

According to Tudorancea and Taylor (2002) in [16], the Rift Valley is particularly containing a chain of permanent lakes lying in what is known as the Lakes District, located within the Main Ethiopian Rift (MER). Most of these lakes are highly productive, contain indigenous populations of edible fish, and support a variety of aquatic and terrestrial wildlife. The lakes and feeder rivers are used for irrigation, commercial fish farming and soda ash extraction. Water abstractions are often done without a basic understanding of this complex hydrological and hydrogeological system, and the fragile nature of the Rift ecosystem. The rapidly growing, and improper use of water resources has resulted in noteworthy negative environmental problems in some Rift lakes and their environments[16].

The natural resource of the Rift Valley has immense economic and cultural values.

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These lakes are considered to be centers of biodiversity, corridors of countless migratory birds as well as in ameliorating the effects of drought and protein shortage for the population in the region[19]. [8] stated that the lakes in the rift valley used for multiple purposes like irrigation, fishing, domestic water supply, transportation, recreation and supply of fresh water to Lake Abiyata (eg. Lake Ziway) through the out flowing Bulbula River.

II. Literature Review

A. Water Resources Potential and Utilization

As stated by [10], the Rift Valley Lakes Basin (RVLB) is one of the eleven major river basins in Ethiopia with a total area of about 52,000 km^2. The basin is characterized by a chain of lakes varying in size as well as in hydrological and hydrogeological settings[3].

The rivers and streams distributed in the basin flow into the lakes in the middle of the valley. Therefore, the distribution of the lakes should be considered to classify the river networks in the area into the sub-basins. The main lakes (water surface of more than 100km^2) are: Ziway, Langano, Abiyata, Shalla, Awassa, Abaya, Chomo and Chew Bahir. The lakes are divided into four lake basin groups of Ziway-Langano-Abijata-Shalla basin, Awassa basin, Abaya-Chamo Basin and Chew Bahir basin based on its formation environment (basically Alluvium deposits) and their distribution. the major lake basin is divided into four major groups: Ziway-Shlla basin, Hwassa basin, Abaya – Chamo basin and Chew Bahir basin[9].

The proportion of area covered by major sub basins are: Ziway-Shalla sub basin covers 27% of the total area of the basin, Hawassa sub basin covers 2%, Abaya-Chamo sub basin comprises of 33% and Chew-Bahir sub basin covers 38% of the whole area of the rift valley lakes basin.

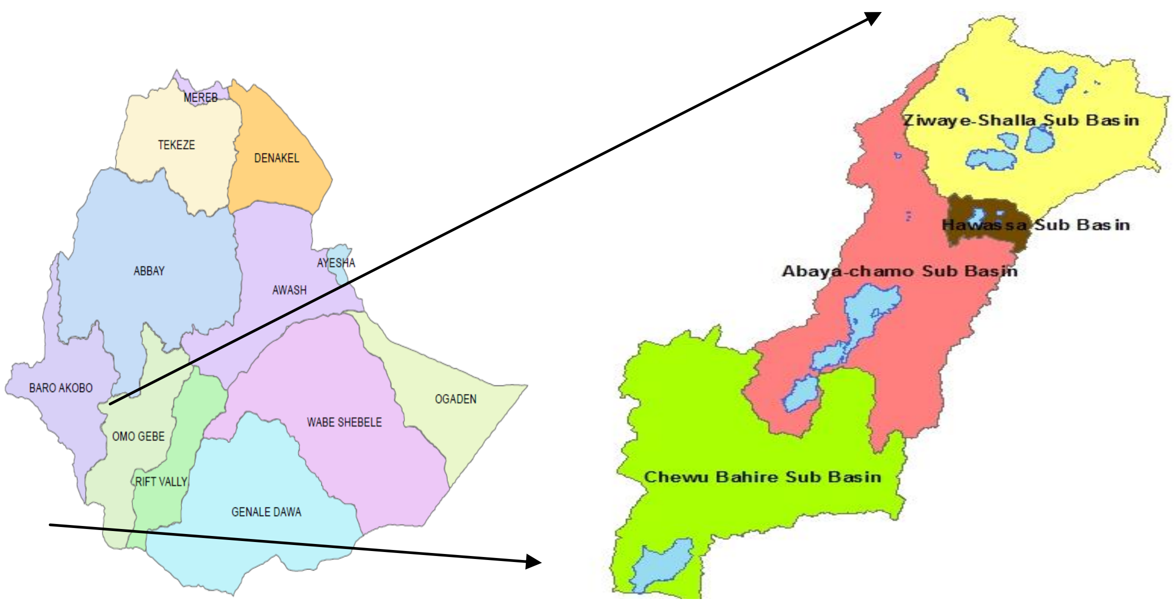

Figure 1: Rift Valley Lakes Basin with its four sub-basins

B. Surface Water Resources Potential

1) River Water

According to [9], most rivers in the rift valley lakes basin are categorized as non-perennial rivers. Even though some large rivers can be classified as perennial rivers, the amount of discharge in the dry season is quite limited.

Furthermore, most of the perennial rivers are randomly used by the surrounding community without any rules with activities such as washing, bathing, irrigation, and cattle feeding. Most of the flow rates in the rivers are less than 2m^3/s in the dry season, except Katar, Bilate, Kulfo and Weyto rivers. The flow rate of these rivers also decreases in the dry season[11].

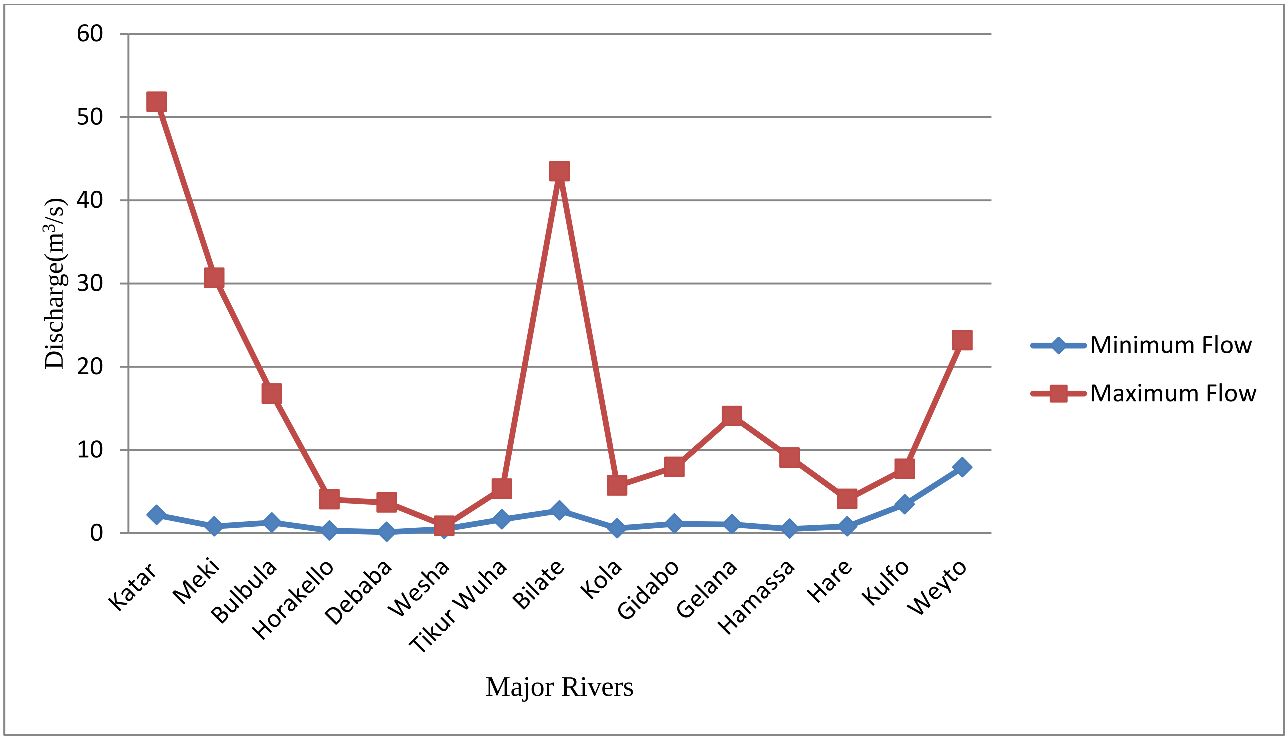

Figure 2: Mean Monthly Flow of the Major Rivers in Dry and Wet Season[11]

2) Lake Water

In the rift valley lakes basin, plenty of lakes exist in all sizes. The lakes are chiefly distributed in the center low profile of the valley and flat lands created by the rift. Dozens of lakes can be observed including small caldera lakes. The lakes found in the basin are: Ziway, Langano, Abijata, Shalla, Abaya, and Chamo. Chew Bahir is not a lake as it is a salt lake, and it has poor water quality and quantity. The largest lake in the study area is Lake Abaya, and it has the surface water of 1,160km^2, but the mean water level is only 7m which stores 8.2km^3 of water.

On the other hand, Lake Shalla has only 409km^2 surface area (which is one third of Lake Abaya) but it has a maximum depth of 266m, and average depth falls to 87m which reserves 36.7km^3, four times more than Lake Abaya[9].

The majority of the rift valley lakes are rich in fish. Lakes Ziway, Langano, Abbaya and Chamo have surface water outlets; the remaining lakes have no surface outlets, i.e., they are endhoric. Lakes Shala and Abiyata have high concentrations of chemicals and Abiyata is currently exploited for production of soda ash[6].

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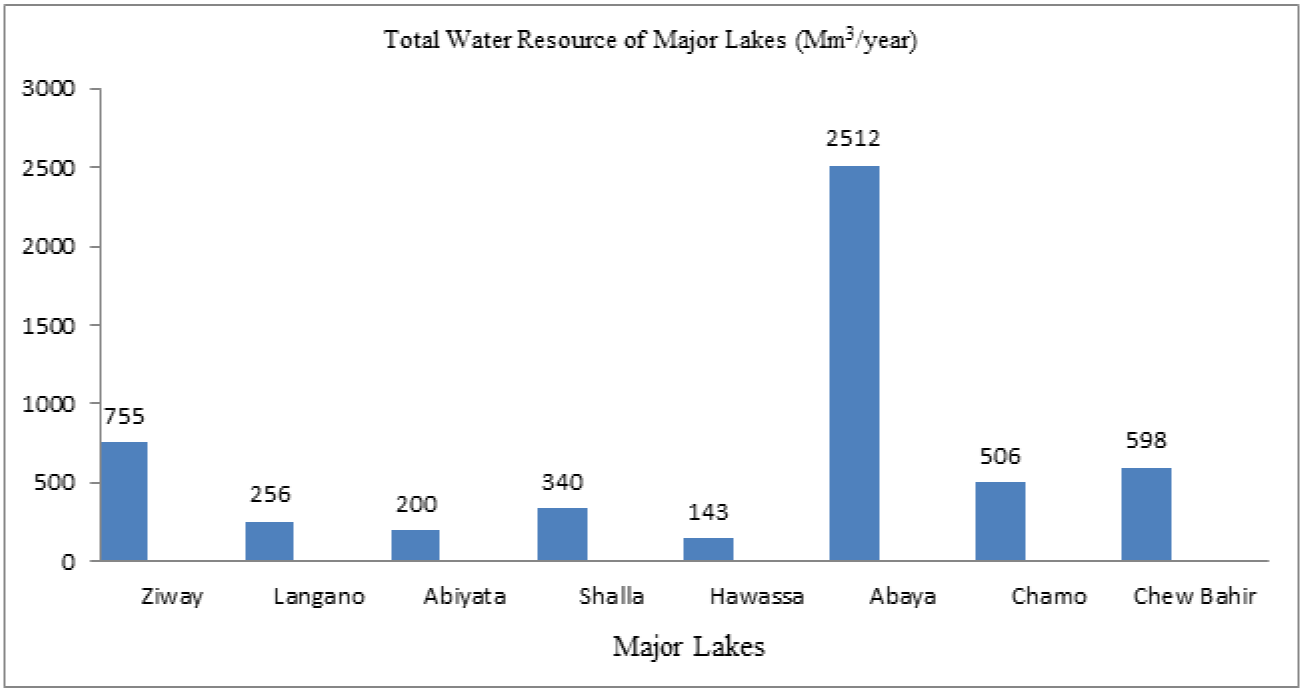

Figure 3: Total Water Resource of Major Lakes[6][9][15][13][7]

Table 1.
Major Lake Water Resources of Rift Valley Lakes Basin

Name	Location		Elevation (m.a.s.l)	Drainage Area (km^2)	Surface Area (km^2)	Maximum Depth (m)	Average Depth (m)
	Longitude	Latitude					
Ziway	38^{0}45’	07^{0}54’	1,636	7,380	440	9	2.5
Langano	38^{0}31’	07^{0}32’	1,585	2,000	241	46	17
Abiyata	38^{0}35’	07^{0}33’	1,580	10,740	176	14	7.6
Shalla	38^{0}35’	07^{0}03’	1,550	2,300	329	266	87
Hawassa	38^{0}27’	07^{0}07’	1,680	1,300	90	22	11
Abaya	37^{0}50’	06^{0}15’	1,169	16,342	1,162	24.5	7.1
Chamo	37^{0}38’	05^{0}50’	1,110	18,575	551	14.2	6
Chew Bahir	36^{0}56’	04^{0}45’	500	-	308	-	-

Source: [6][9][15][13][7]

The water level of the major lakes has been recorded since the early 1970s. The variations by year and by lake are obvious; however, the water level change of the lakes is not large in the long term. The water balance of the lakes, recharge and outflow (evaporation, groundwater outflow) seems to be well balanced [2].

The total surface water resources of the rift valley lakes basin is estimated at about 5,183 million m^3/year. This is calculated from total average river flow into the lake system under ‘existing’ conditions with abstractions for irrigation and water supplies for domestic and industrial use. Other water use, as it grows and develops, takes away from this total resource.

The total surface water resource of the river basin is also estimated at just over 5,300 million m^3/year under 'natural' conditions without human abstractions. This amounts to a per capita water availability of 597m^3 per annum which is well below the threshold of 'water scarcity' of 1000m^3/capita/annum[11].

III. Groundwater Potential

According to [6], Ethiopia has lower ground water potential as compared to surface water resources. However, by many countries' standard, the total exploitable groundwater potential is high. Based on the scanty knowledge available on groundwater resources, the annual rechargeable resource potential is estimated to be about 2.6 BMC (Billion Metric Cube). The rift valley basin covering a total area of 52,739km^2 has an estimated groundwater potential of 0.10BMC representing about 20% of the surface water resource of the basin); the estimated annual direct groundwater recharge of the basin is 1,080 million m^3/year while the estimated groundwater resource availability of the basin is found to be 53 million m^3/year. Thus, if groundwater demand reaches 5% of the calculated recharge, the resources must be considered under pressure and more detailed investigations must take place to re-evaluate the available resource to ensure that the resource is not over utilised. Locally within the basin catchment, different elements of the groundwater balance may be more prominent, especially given the variability in rainfall, topography, hydrogeology (particularly storage) and hydrology. Site specific understanding local to a particular area will be needed for an appreciation of the available local groundwater resource. The local effects of abstraction must in particular be considered (e.g. will an abstraction effect surface water resources, spring flows, groundwater transfers out of the catchment etc.). Each water source should be developed with this in mind and should be used to help further understand the groundwater regime within the basin[6][11][7].

IV. Water Resources Utilization

As stated by [6], little has been developed for drinking water supply, hydropower, agriculture and other purposes though the country possesses a substantial amount of water resources. The great majority of the rural Ethiopian population community water supply relies on groundwater. The safe supply of water in rural areas is usually derived from shallow wells, spring development and deep wells. People who have no access to improved supply usually obtain water from rivers, unprotected springs, hand-dug wells and rainwater harvesting.

Despite its immense relevance and importance, the groundwater sector has been given less attention until recently.

Understanding of the groundwater occurrence and distribution in space and time, proper management and efficient exploitation is necessary to utilize the ground water resource properly. The available studies on the groundwater resources of the country are very limited, in that, the delineation of aquifer systems, the water balance and determination of the aquifer characteristics has not been conducted. Any sustainable utilization of groundwater resources demands systematic study and raising the technical and manpower capability. In this regard, the country has a long way to go, yet[6].

The Rift Valley basin has an area of 52,739 Km^2, covering parts of the Oromia, SNNPR regions. The total mean annual flow from the river basins is estimated at about 5.6 BMC. Large-scale irrigation potential is estimated at 45,700 hectares with an estimated total irrigable area of 139,300 hectares. The basin is endowed with a number of lakes of varying size with high environmental significance[6].

V. Challenges Of Water Resources Development And Utilization

According to [7][6], the total surface water resource of the rift valley lakes basin is estimated at just over 5.6BCM/year and estimated groundwater potential of the basin is 0.10BCM/year. Out of its total area, potential irrigable land is only 2.64%, i.e, about 139,300ha; and the gross hydro-electric potential of the basin is found to be 800Gwh/year. However, the utilization status of available water resource potentials in the basin for irrigation, hydropower and domestic water uses is in infant stage.

According to [18], the primary water resource management challenges of the rift valley lakes basin in particular and Ethiopia in general are its extreme hydrological variability and seasonality and the international nature of its most significant surface water resources. Moreover, World Bank (2006) stated land degradation, sedimentation, drought and floods as the major challenges of water resources development in the rift valley lakes basin of Ethiopia. The major constraints of Water Resources Development in the rift valley lakes basin as one of the river basins in Ethiopia are numerous. They fall in one of the general categories of legal, political, social, institutional or technical[6].

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As indicated by [5], that climate variability, including droughts and flooding, is a major constraint of water resource development in the rift valley lakes basin of Ethiopia which is expected to increase the occurrence and the severity of extreme events (flood and drought) and related shocks. [5] also stated costly development and operations, lack of a comprehensive understanding of Ethiopia's groundwater resources, and difficulties and costs related to the need for specialized equipment (e.g., deep drilling rigs) and specialized and well-trained staff (e.g., well drillers) as the major constraints of groundwater development in Ethiopia. [7] stated six challenges of water resources development in Ethiopia namely: hydro politics challenges, uneven spatial and seasonal distribution of rainfall, uneven temporal and spatial distribution of major rivers, technical challenges, topographic features of the country and economic challenges.

VI. Future Opportunities For Water Resources Development And Utilization

According to [7], Ethiopia has a great future opportunity to develop and utilize water resources. Among many opportunities, some of them are: i) enough water sources potential, ii) the government of the country turn the face and focus on water resources development and utilization, iii) different funders are promised to support the water sector development, iv) a probability to apply multipurpose use of those water resources like for irrigation and hydropower generation, v) an opportunities to produce qualified expertise in different higher institutions to fill the gap of knowledge barrier and distributed throughout the country being expertise and train the low level expertise which works in different sectors in the form of training, experience sharing, give technical support if required and vi) the opportunity to gender mainstreaming in all levels of water development projects starting from the beginning of the project to the end of it.

According to [5], there are major opportunities for the development and protection of groundwater, including: (i) exploiting shallow groundwater; (ii) enhancing water recharge in aquifers, including forestation in hilly areas, infiltration galleries, and subsurface dams to increase the available water in the sub-surface; and (iii) using a watershed-based approach to enhance soil and water conservation and increase the groundwater level in the valley bottoms for easy access to groundwater.

VII. Recommended Actions

As stated by [18], opportunities exist to significantly strengthen water resources development and management practices. Attention must be given to interventions that moderate hydrological variability, mitigate the physical impacts of hydrologic shocks on the environment and watersheds, and arrest land degradation. Such interventions will include infrastructure investments to provide storage and regulate river flows and runoff, and land and soil management practices to enhance the natural capacity of watersheds to moderate hydrology.

VIII. Conclusion

The rift valley lakes basin is endowed with a number of rivers and lakes of all sizes. Although the basin possesses a significant amount of water resources, little has been developed for drinking water supply, hydropower, agriculture and other purposes. The rift valley lakes basin has an annual runoff volume of 5.6 billion m^3 of water and an estimated 0.10 billion m^3 of groundwater potential. Conversely, due to lack of water storage infrastructure and large spatial and temporal variations in rainfall, and poor water governance system, there is insufficient water for agriculture, water supply, hydropower and other intended uses. As a result, attention must be given to interventions that moderate hydrological variability, mitigate the physical impacts of hydrologic shocks on the environment and watersheds, and arrest land degradation. Therefore, this review paper attempts to explore the interventions like infrastructure investments to provide storage and regulate river flows and runoff, and land and soil management practices to enhance the natural capacity of watersheds to moderate hydrology.

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