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Review

Review on participatory small-scale irrigation schemes and small-scale rainwater harvesting technology development and its contribution to household food security in Ethiopia

Tadesse Mosissa* and Baihilu Bezabih

Department of Natural Resource Management, College of Agriculture and Veterinary Medicine, Jimma University, Jimma, Ethiopia.

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This review aims to compile the past, present and future trends of participatory small-scale irrigation schemes (PSSIS) and small-scale rainwater harvesting technology (SSRWHT) development to ensure household food security in Ethiopia. It discusses the Ethiopian PSSIS and SSRWHT development based on the historical backgrounds, current conditions of development and its contributions to the national economy, challenges and opportunities, and future development perspectives. PSSIS and SSRWHT development *has been suggested to be a central key part in curbing food scarcity and alleviating poverty not only* in water scarce regions of the Ethiopia *but also in many other developing countries.* Government, donors and NGOs are investing in developing irrigation systems, especially on PSSIS and SSRWHT. Still irrigated land is 5 to 10% of 5.3 million hectares of irrigated potential area of country. This review indicates that, the existing current performance of PSSIS and SSRWHT development in Ethiopia is not significantly contributing to national economy of the country, when compared to rain-fed agriculture. Accordingly, irrigation sub-sector is not contributing its share based on the resources potential of the country. There is no consistent and reliable inventory data, lacks agreed reports in common consensus and well-studied and documented with regards to water and irrigations related potentials and implementations of PSSIS and SSRWHT development in the country.

Key words: Eco-efficient schemes practices, irrigation users' cooperative, smallholder farmers.

INTRODUCTION

The population of the arid and semi-arid land in sub-Saharan Africa is amongst the poorest and most vulnerable people in the world. With a population of about 100.8 million which increases annually at about 2.7%. Ethiopia is the second most populous country in Sub-Saharan Africa only after Nigeria. Sub-Saharan Africa is water abundant, but uses less than 2% of its total renewable water resources. Ethiopia's geographical and

*Corresponding author. E-mail: tadesse88@gmail.com.

climatic attributes provide a greater amount of rainfall than the rest of Africa on average (Amede, 2014). High population growth increases pressure on limited and fragile land resources and leads to unsustainable resource exploitation, resulting in environmental damage. If crops fail, subsistence farmers have few or no alternative means to provide food for their families. When they run out of alternatives, the poor are forced to exploit land resources, including fragile ones for survival, and inevitably, they become both the victims and willing agents of environmental degradation and desertification. In general, high level of chronic poverty contributes to low adaptive capacity to drought and threatens the lives and livelihoods of the poor more than other social groups. An increase in vulnerability to drought hazard may result from an increased frequency and severity of drought, increased societal vulnerability, or a combination of the two. Currently, the ongoing recurrent effects of drought, water scarcity, stress, vulnerability and erratic rainfall are the most urgent food security aid facing in the arid and semi-arid land regions of Ethiopia as compared to Africa is shown in Figure 1 (Bekele Shiferaw et al., 2014).

The majority of population directly or indirectly engaged in agriculture where around 95% of the country's agricultural output is produced by smallholder farmers (FAO and IFC, 2015). The vast majority of these farmers are smallholders. In that regard, smallholder farmers are that holding land not more than 1ha. These idiosyncratic shocks to agricultural production are closely linked to the persistence of poverty in the all rural of Ethiopia (FAO and IFC, 2015). Consequently at this time the Ethiopian government is trying to transform from traditional and manual, rain-fed, supply driven and production oriented agriculture to technology intensive and mechanized, irrigated, market oriented agriculture, via full packages of value addition and postharvest technologies (Gebremariam and Ghosal, 2016). The Ethiopian government considers irrigated agriculture as a primary engine of economic growth and plans to increase the current level of irrigation infrastructure three fold by the end of 2020 (Gebremeskel Haile and Kebede Kasa, 2015).

Ethiopian government has made a huge investment to developing participatory small-scale rainwater harvesting and small-scale irrigation schemes (SSWHT and PSSIS) program as a strategy to solve the household food insecurity problem of smallholder farmers. SSWHT and PSSIS program is a policy priority in Ethiopia for rural poverty alleviation and transformation growth (Gebremariam and Ghosal, 2016; Gebremeskel Haile and Kebede Kasa, 2015). Currently, SSWHT and PSSIS program is being prioritized recently as one of the best alternatives for reliable and sustainable food security, income generation, livelihood improvement, adapting to climate change and development as a whole (Mesfin and Nahusenay Teamer Gebrehiwot, 2015). Hence, there appears to be a relatively high potential for enhancing food security and poverty reduction via revitalizing SSWHT and PSSIS program performance and productivity (Bekele and Ayana, 2011). These have enabled smallholders to diversify their farming systems and grow high value crops for urban and even international markets. Smallholder farmers are the largest group of poor people in Ethiopia. However, smallholder farmers (low-income households) typically do not have access to appropriate and affordable irrigation technologies and rely on ineffective irrigation techniques. Over half of Ethiopia's 64 million rural populations live in poverty (Gebremariam and Ghosal, 2016; Bekele and Ayana, 2011).

Using these programs, smallholder farmers in arid and semi-arid land regions of Ethiopia have been producing different crops under traditional SSIS for a long time. The diversion of perennial streams using temporary structures during the dry season is the major means of irrigation. Spate irrigation of lowland valleys using runoff from upper catchments and spring development is also practiced. In Ethiopia, most of the tanks/ponds (PVC plastic) are situated in all regions, with the largest concentration found in the arid and semi-arid land regions of Ethiopia (Abraham et al., 2015).

In spite of a generally good understanding of SSWHT and PSSIS for improving food security, little is known about the detailed ways of this program development system in the Ethiopia. Although, there is no consistent, reliable inventory, well-studied and documented information with regarding to this area. This shows there is a scanty of detail study in the in the arid and semi-arid land regions of the Ethiopia. This knowledge goes important in such a way that the people and government who are living today become aware of what the people and governments in the past had done in this sector. This review is therefore important for understanding what was done in the past and what is going on now and the future in improving food security and livelihood of rural households via SSWHT and PSSISdevelopment in Ethiopia.

EVOLUTION OF SSWHT AND PSSIS DEVELOPMENT IN ETHIOPIA

The Ethiopian Government started formal PSSIS in the early 1980s following the widespread drought that affected the country. PSSIS was given little attention during the Derge regime. It was only in the second half of the 1980s as a result of devastating famine of 1984/85. According to Mesfin and Nahusenay Teamer Gebrehiwot (2015), Bekele and Ayana (2011) and Abraham et al., (2015) report, the total potential irrigable land area in Ethiopia is estimated to be around 5.3 million hectares (Mha). From this total potential irrigable land area, 3.7 Mha by gravity-fed surface water, 1.1 Mha by groundwater potential and gently sloping areas, and

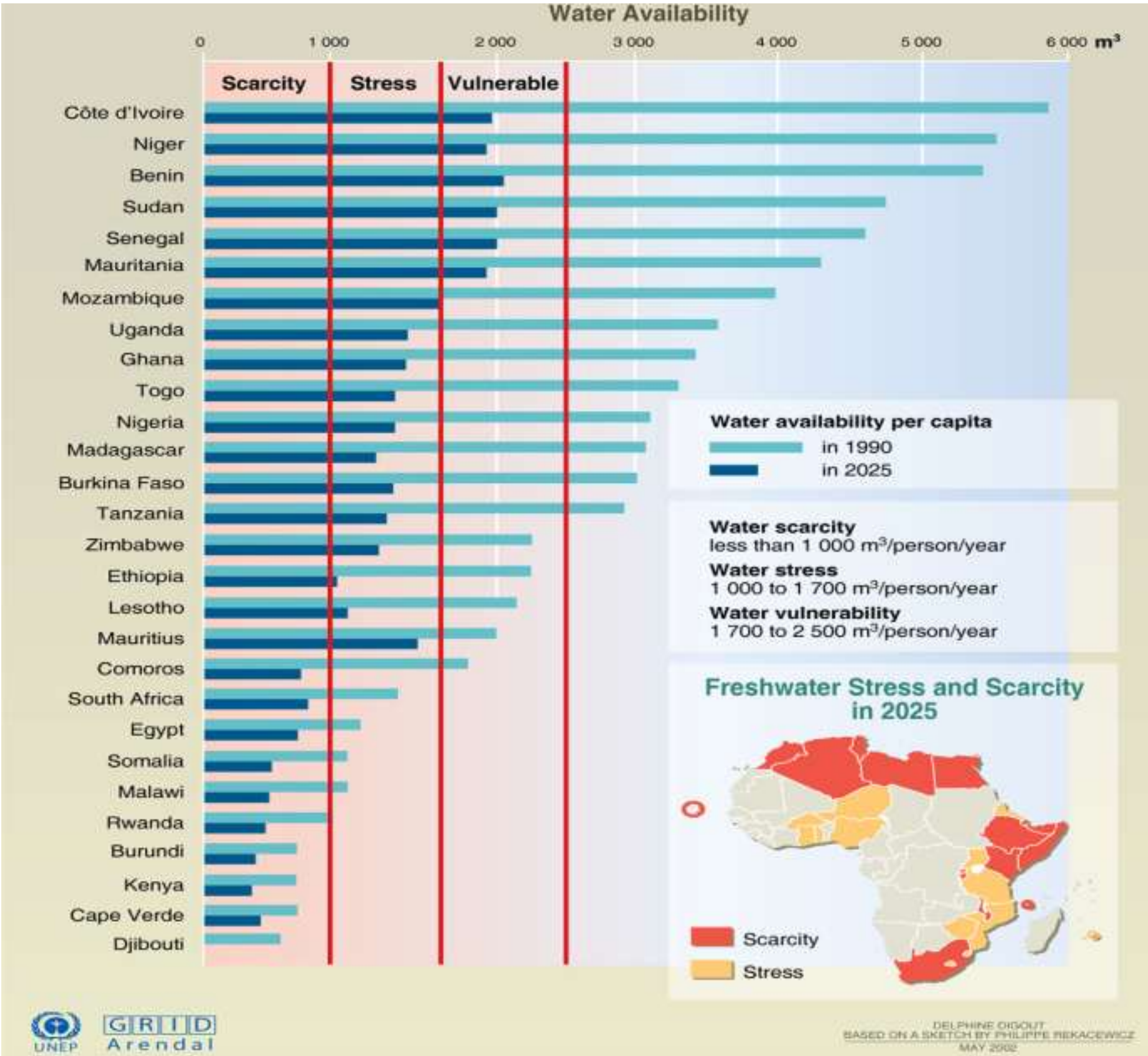

Figure 1. Per capita water availability in 1990 and 2025 in Africa (Bekele Shiferaw et al., 2014).

0.5 Mha by rain water harvesting (Awulachew et al., 2005).

According to the Ministry of Water, Irrigation and Electricity (MoWIE) set plan from 2002-2016 are 127,000 schemes identifications in the different regional states of Ethiopia. From this scheme identifications, 56% are by traditional schemes, 19% are small-modern scale schemes and 25% covered by medium to large modern scale schemes (Amede, 2014; Awulachew et al., 2005). Also from this plan is around 560 irrigation potential sites on the major 12 river basins. Similarly from this planned, around 80% are from the arid and semi-arid land regions of Ethiopia. However, the plan set for development of all irrigation schemes are 1.85 Mha (35% of the total irrigation potential), which is planned to be achieved by the end of the five years GTP of 2015 of which around 46.11% potential are SSIS. 2.2 million farmers benefiting from these at household level, of which around 20% are female headed households. Actually irrigated area/schemes has not been estimated, but in this review indicate that still used 5 to 10% of 5.3 Mha of irrigated potential area (Garbero and Songsermsawas, 2016; Beyan and Jema, 2014; Dereje Mengistie, 2016). These indicate that, the existing irrigation development in

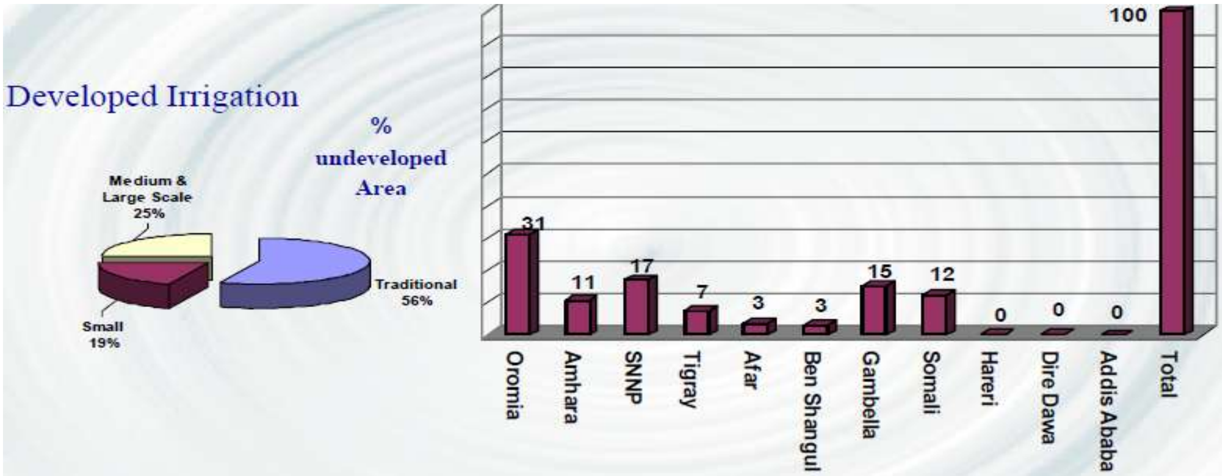

Figure 2. Proportion of undeveloped irrigation potential by region (%).

Ethiopia, as compared to the resources potential of the country, it is not significant and the irrigation sub-sector is not contributing its share accordingly (Gebremariam and Ghosal, 2016; Beyan and Jema, 2014). Ethiopia has set itself an ambitious task to achieve an irrigation target of 1.8 millionha for irrigation development (Gebremariam and Ghosal, 2016; Belay and Bewket, 2013).

In the region-wise, about 39% of the irrigated area is in Oromia in central Ethiopia, followed by 24% in Amhara in the north, 15% in Afar in the northeast and 12% in south nation nationalities and peoples regional (SNNPR), while the remaining 10% is in the other regions as shown in Figure 2 (Awulachew et al., 2005). Most this irrigated land is supplied from surface water. Different scenarios have been developed to explore a number of issues, such as the expansion of SSWHT and irrigated agriculture, massive increases in food production from rain-fed lands, water productivity trends and public acceptance of genetically modified crops. Opinions differ among the experts as to some of the above issues. However, there is broad consensus that irrigation can contribute substantially to increasing food production. Today, most of the world's food production comes from cultivated area. Over 86% of undeveloped irrigation potential in 5 main regions showing large investment opportunities (Hagos et al., 2010).

Definition of small-scale water harvesting technologies (SSWHT)

SSWHT is a simple and low cost water supply technologies that involves the capturing, storing and convey of rainwater (in different structures or in the soil) from roof, runoff and ground catchments for domestic, agricultural, industrial and environmental purposes immediately or at a later time (Yosef and Asmamaw, 2015; Mume, 2014). SSWHT such as village ponds, sand dams and tanks have played an important role in rural life, particularly in the agricultural practices in different parts of the world including Ethiopia. Rainwater harvesting tanks: smallholder farmers are provided support to enable them to construct rainwater harvesting tanks on their land which enables them to collect and store water throughout the silt or sediment traps. If properly sited, these ponds can (i) reduce risk by supplementing rainfall in the main monsoon cropping season; or (ii) irrigate a smaller area of winter dry season crops (Titus Masila and Udoto, 2015).

Definitions of small-scale irrigation scheme (SSIS)

Irrigation is categorized as small-scale, medium and large-scale depending on the area irrigated, scale of operation and type of control or management. But the criteria for this category may vary from country to country. For example, in India the irrigation scheme of 10000 ha is classified as small while in Ghana the largest irrigation scheme is 300 ha. A single definition for 'SSIS' is not easy to derive or is globally applicable. In terms of command area, in Ethiopia, SSIS are generally considered to command areas of about 200 ha or less (Gebremariam and Ghosal, 2016; Desta Dawit, 2015). A SSIS is defined as a scheme that serves a command area less than 25 ha in the hills and less than 200 ha in the Tarai (Bekele and Ayana, 2011). SSIS is irrigation that usually practiced on small plots where small farmers have the majority controlling influence, using a level of technologies which they can operate and maintain effectively (Desta Dawit, 2015). Hence, SSIS is, therefore, farmer-managed that is farmers involved in the design process and, in specific, with decisions about boundaries, the layout of the canals, and the position of

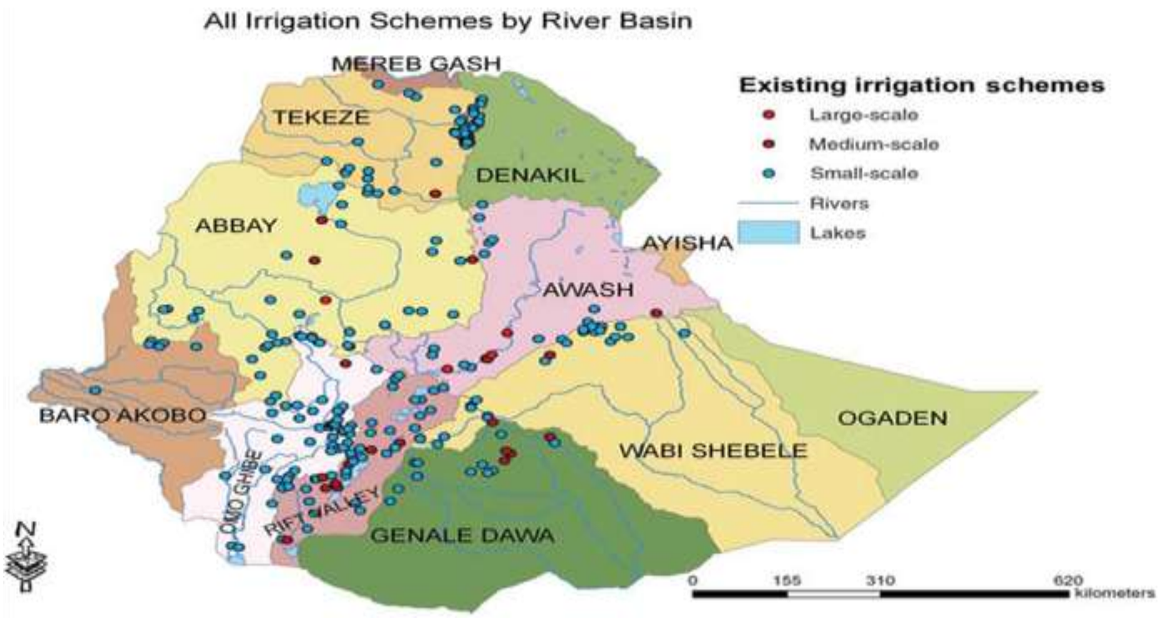

Figure 3. Existing irrigation schemes in various river basins in Ethiopia.

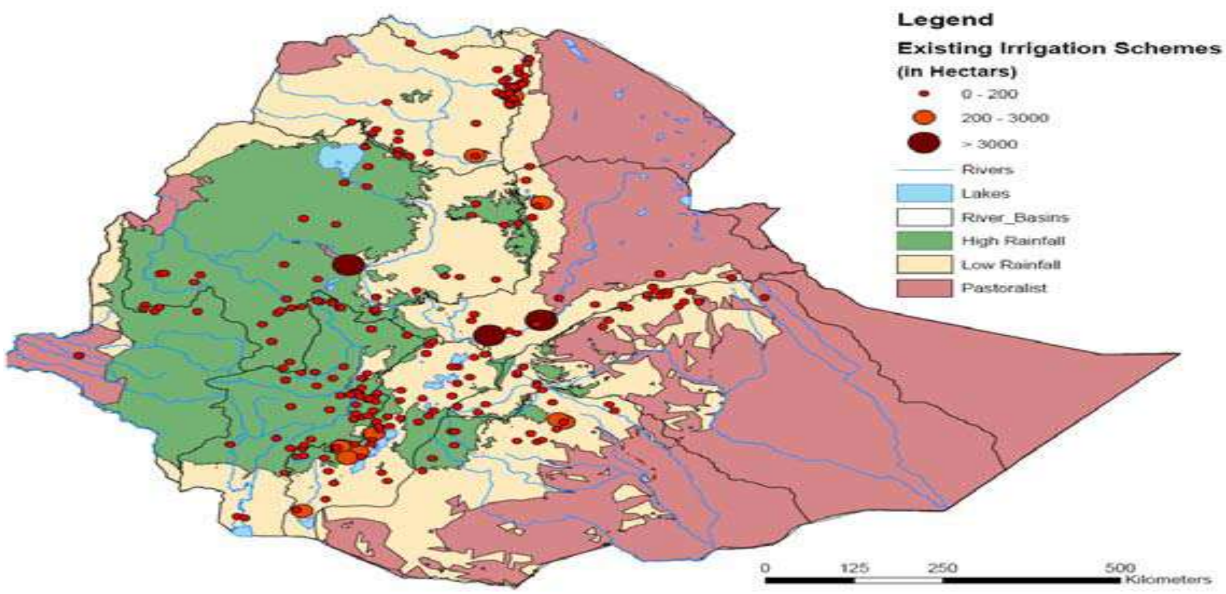

Figure 4. Existing irrigation schemes in various river basins with regional rainfall in Ethiopia.

outlets and bridges. As a result, the preference for SSIS is based on the perceived easy adaptability of the systems to local environmental and socioeconomic conditions is shown in Figures 3 and 4 (Gebremariam and Ghosal, 2016).

There are two major classifications of SSIS, the modern scheme and the traditional scheme. The development of modern SSIS started since the mid-1980s. They have relatively permanent structure and improved water control system, and are mostly constructed by either the government or NGOs. The traditional ones are constructed by the local community, commonly diverting water from rivers using local materials. There is always a need to reconstruct every year after the end of the rainy season, but it is sustainable in the water management system for a longer period of time. Both traditional and modern SSIS are farmer-managed irrigation systems with their own local

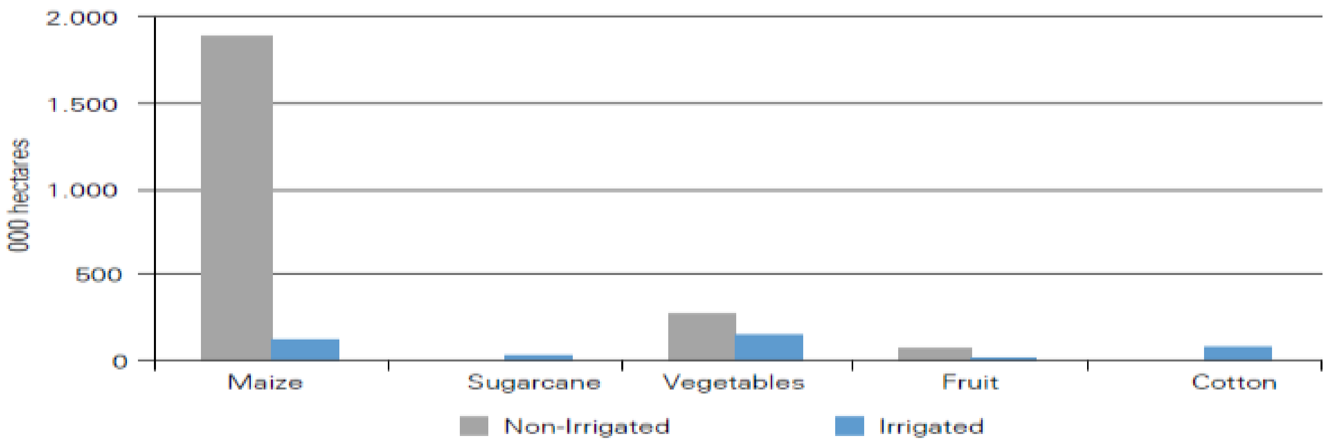

Figure 5. Area estimates for the main irrigated crops in Ethiopia – 2012 (FAO and IFC, 2015).

leadership of water users' associations or irrigation cooperatives, assisted by public extension systems (Awulachew et al., 2005). Traditional water management institutions have established with their own initiatives based on their local experience and indigenous knowledge, and perform better than modern water management institutions, such as the Water Users' Association (WUA) and irrigation users' cooperatives (IUCs) which were established through government initiatives (Hagos et al., 2010). The SSIS in Ethiopia are understood to include traditional small-scale schemes up to 100 ha and modern communal schemes up to 200 ha (Hagos et al., 2010). The canals are usually earthen and the schemes are managed by the community. A SSIS is, therefore, farmer-managed: farmers must be involved in the design process and, in particular, with decisions about boundaries, the layout of the canals, and the position of outlets and bridges. These SSIS which usually use diversion weirs made from local material and needs annual maintenance (Gebremeskel Haile and Kebede Kasa, 2015). Although some SSIS serve an individual farm household, most serve a group of farmers, typically comprising between 5 and 50 households. Examples of SSIS include household-based RWH, hand-dug wells, shallow wells, flooding (spate), individual household-based river diversions and other traditional methods. Many development organizations believe that small-scale irrigation schemes are an effective way to increase food production (Mesfin and Nahusenay Teamer Gebrehiwot, 2015; Fanadzo, 2012; Hintsa Libseka and Welde, 2015).

BENEFITS FROM SMALL-SCALE RAINWATER HARVESTING AND PARTICIPATORY SMALL-SCALE IRRIGATION SCHEMES

Comparative yields analysis by crop type could not be done because of lack of uniformity in the use of inputs and inadequate documented in the Ethiopia. However, virtually all food crops (97%) in Ethiopia come from rainfed agriculture, with the irrigation subsector accounting for only about 3% of the food crops (FAO and IFC, 2015). The major cereals (maize, sorghum, wheat, and barley) dominate crops by volume and value, followed by industrial crops such as sugarcane, vegetable, cotton, roots (potato and sweet potato) and fruits are mostly irrigated is shown in Figures 5 to 8. These crops are supported by traditional water harvesting practices, particularly in central-north, eastern, and southeastern areas of the country. The proportion of traditionally irrigated land (almost half of the total irrigated area) and the number of farmers involved indicate the significant economic and social role of traditional irrigation for rural society. Urban and peri-urban irrigation are not significant in terms of area coverage and production, but the traditional irrigation practiced around Addis Ababa plays an important role in supplying vegetables to the Addis Ababa market. The use of irrigation technology, although currently not widespread, can reduce risk and improve production (FAO and IFC, 2015).

In Figure 8, the inner (yellow) circles represent the estimated current irrigated area of crops in Ethiopia. The outer circles are proportionate to the relative total area sown with these crops: maize, sorghum, and wheat are the dominant crops. About 37% of all vegetable production is irrigated with flood irrigation, and 100% of sugar and cotton production is irrigated (FAO and IFC, 2015).

When comparing between irrigators and non-irrigators, irrigators have small household size, higher level of education, large livestock holding size, and better quality (fertility) cultivable land. The irrigators had also better access to extension and credit services (Figure 9). In conclusion, irrigators are better in terms of food security status and other welfare indicators (Dereje Bacha et al., 2011).

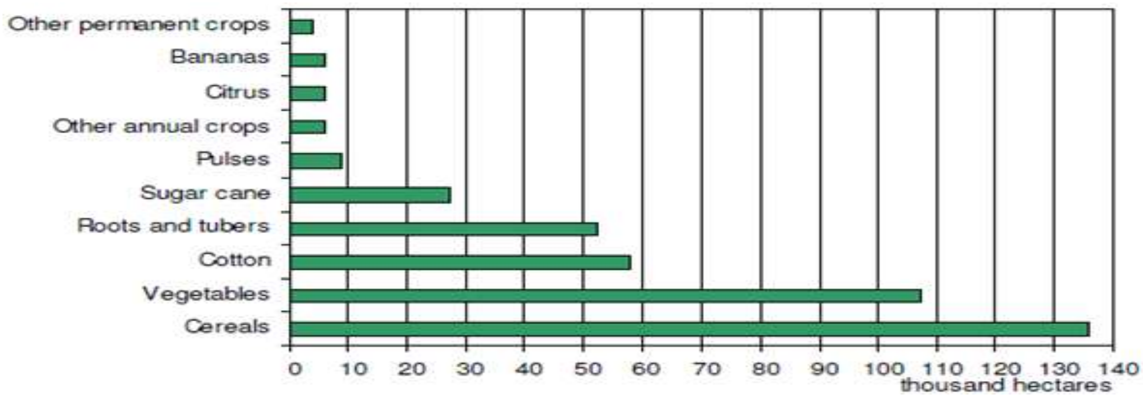

Figure 6. Irrigated crops in ha in 2016 in Ethiopia.

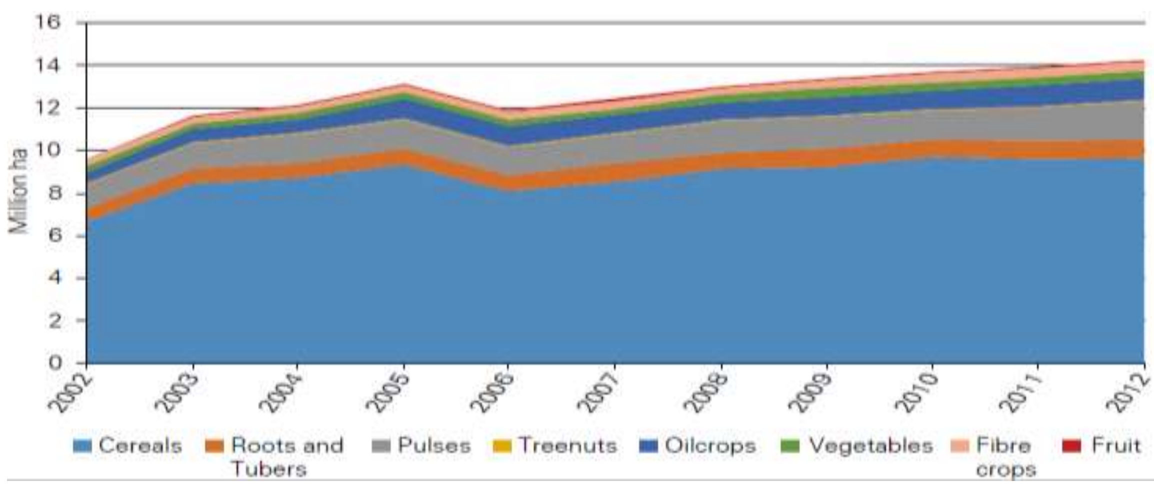

Figure 7. Harvested area by crop group in Ethiopia, 2002–2012 (FAO and IFC, 2015).

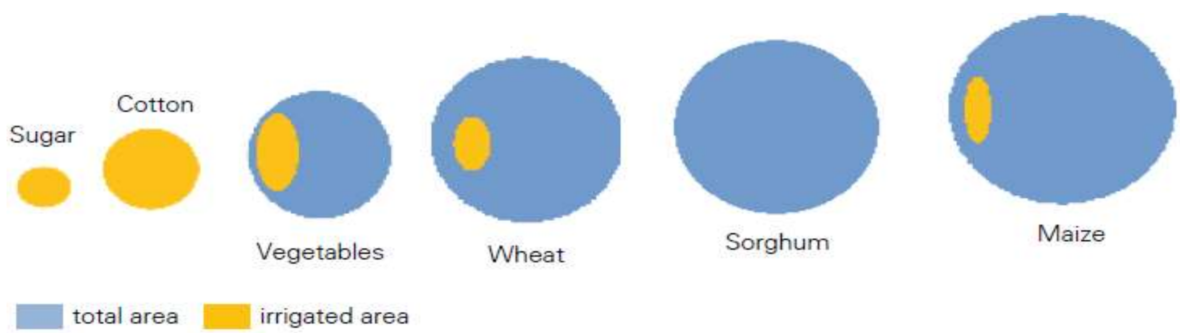

Figure 8. Estimates of the relative size of irrigated area by crop in Ethiopia (FAO and IFC, 2015).

CONSTRAINTS AND FUTURE OPPORTUNITIES OF PSSIS AND SSWHT DEVELOPMENT IN THE ETHIOPIA

Constraints of SSWHT and SSIS in the Ethiopia

Inefficient SSWHT and PSSIS system management has become one of the bottlenecks in the implementation of irrigation development in the Ethiopia (Gebremariam and Ghosal, 2016). Insufficient external/internal support from relevant stakeholders and low level of efficiency of the irrigation users' cooperative (IUC) were the major reasons for the poor performance of the IUC, which is unable to undertake its day to day activities (Abraham

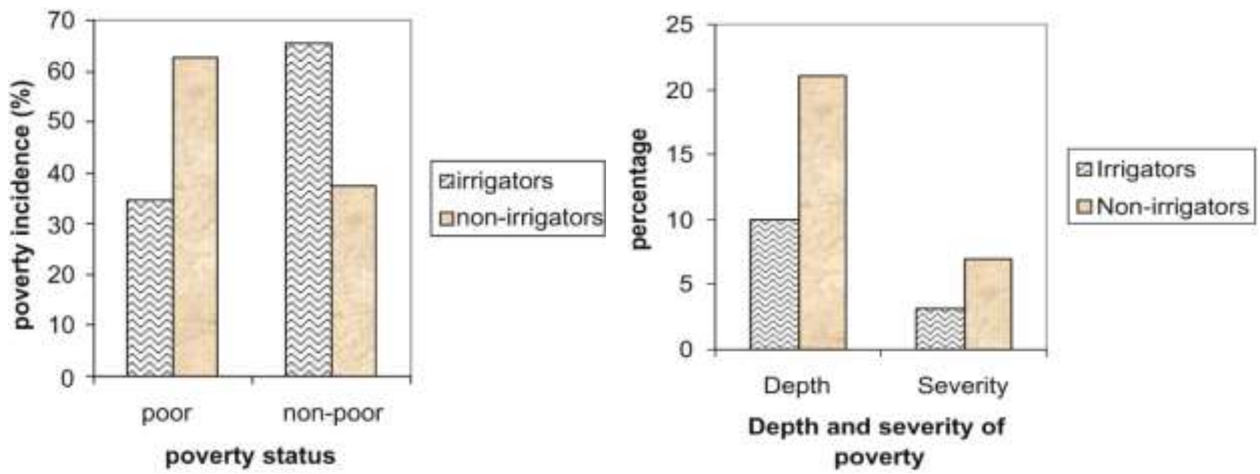

Figure 9. Household food security status differentiated among irrigators and non-irrigators (Bekele and Ayana, 2011; Gebremeskel Teklay, 2014).

Gebrehiwot Yihdego and Addis Adera, 2015). Irrigation management transfer as a policy instrument has started to be practiced in the water scarce regions of the Ethiopia to make SSIS management effective through the establishment of a locally created farmers' organization, specifically establishing an irrigation users' cooperatives (IUCs). However, the challenges faced by the IUCs for the management of SSIS have not been studied well (Abraham et al., 2015; Gardachew and Hanaraj (2013).

There is no effective enforcement of the rules and regulations of the IUC due to inefficient service delivery of the kebeles social courts, especially in addressing cases and forwarding timely decision for non-member offenders (Abraham et al., 2015). The kebeles administration would also not put in effect the decision made by the social court. Since most members of the kebeles administration are from different village that does not have irrigable land within the command area, they are not interested in being involved in the irrigation activities (Gebremariam and Ghosal, 2016).

The existing executive committee of the IUC is also not committed in identifying offenders and bringing them to social courts to get appropriate penalties against their illegal activities. One basic problem with regard to enforcement of rules and regulation in the bylaws is that, it could not be acceptable to a court if not endorsed by all water users (Gardachew and Hanaraj, 2013). The existence of two categories of farmers that is being member and nonmember to the cooperative in a scheme will have a problem to enforce decision to all water users which is only made by members of the cooperative. This situation indicates that there is no difference in benefit between members and non-members of the IUC, which discourage members to actively participate in irrigation management activities and could be a cause for non-membership of the IUC (Gebremariam and Ghosal, 2016).

According to Gebremariam and Ghosal (2016), Amede (2014) and Abraham et al. (2015), although these challenges can be explained as technical constraints and knowledge gaps are identified (1) inadequate awareness of irrigation water management as in irrigation scheduling techniques, water saving irrigation technologies, water measurement techniques, operation and maintenance of irrigation facilities, (2) Inadequate knowledge on improved and diversified irrigation agronomic practices, (3) Shortage of basic technical knowledge on irrigation pumps, drip irrigation system, sprinkler irrigations, surface and spate irrigation methods, (4) Loss of water through seepage: this is caused by non-durability of the physical structure of river diversion, (5) Scheme based approach rather than area/catchments based approach for the development of small-scale rain water harvesting and small scale irrigation schemes, (6) inadequate baseline data and information on the development of water resources, (7) lack of experience in design, construction and supervision of quality irrigation projects, (8) low productivity of existing irrigation schemes, (9) inadequate community involvement and consultation in scheme planning, construction and implementation of irrigation development, (10) Poor economic background of users for irrigation infrastructure development, to access irrigation technologies and agricultural inputs, where the price increment is not affordable to farmers (Gebremariam and Ghosal, 2016).

Future opportunities for promoting of SSWHT and PSSIS in the Ethiopia

According to (Gebremariam and Ghosal, 2016) when farmers grow more food and earn more income, they are better able to feed their families, send their children to school, provide for their families health, and invest in their farms in a sustainable way. Helping farmers improve their yields requires a comprehensive approach that includes the use of seeds that are more resistant to disease, drought and flooding; information from trusted local sources about more productive farming techniques and technologies. Although there is sell more crops (greater access to markets; and government policies that serve the interests of farming families), is the most effective way to reduce hunger and poverty over the long term. This makes their communities economically stronger and more stable. Addressing this gap can help food security and livelihood of rural households become more productive and reduce malnutrition within poor families (Hintsa Libseka and Welde, 2015).

According to Amede (2014) and Hintsa Libseka and Welde (2015), although these future opportunities can be explained as technical freedoms and knowledge opportunity are identified (1) High water potential, (2) High commitment of the Ethiopia government, donors and NGOs to support irrigation management and development activity, (3) Opportunity for implementing multiple use water systems (MUS), with regions coordinating sub-activities. Effective utilization of scheme infrastructure through diversification of uses to meet various needs for water such as domestic, irrigation, livestock and hygiene is the most important, (4) Opportunities for improving knowledge of policy makers, planners, designers. (5) Contractors and development agencies through education, training, dialogues and participation, (6) Opportunities for more gender-equitable investments, targeting poor women, through for example MUS and micro irrigation.

CONCLUSIONS AND FUTURE LINE OF WORK

Over the last few years experiences concerning the development of PSSIS and SSRWHT systems are often designed to maximize efficiencies and minimize labour and capital requirements. A number of scholars have disputed on the PSSIS and SSRWHT facilities play a crucial role in ensuring food security. Review shows that numerous problems in all PSSIS and SSRWHT. Government, donors and NGOs are investing in developing irrigation systems, especially on PSSIS and SSRWHT. Nowadays, the policies and strategies of Ethiopia strongly supports the irrigation developments especially the PSSIS and SSRWHT via the Water Sector Development Programs (WSDP) and Ethiopian Irrigation Development Plan (IDP). Still used 5 to 10% of 5.3 million hectares of irrigated potential area. Among various issues that affect sustainability in community based of PSSIS and SSRWHT, 'design of the irrigation scheme' is the major component that needs special consideration. Thus the challenges to continuous PSSIS and SSRWHT development indicators monitoring will be immense. In Ethiopia is a viable development strategy but attention needs to be paid to improving the technology available to farmers under both rainfed and irrigated production. The major bottlenecks for sustainability of PSSIS and SSRWHT project are profitability, water management and infrastructure maintenance. Therefore, need urgent intervention on the PSSIS and SSRWHT development strategy all stakeholders is highly recommended.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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Review

Review on distribution, importance, threats and consequences of wetland degradation in Ethiopia

Bahilu Bezabih* and Tadesse Mosissa

Department of Natural Resource Management, Jimma University College of Agriculture and Veterinary Medicine, P. O. Box 307, Jimma, Ethiopia.

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Wetlands are the ecosystems that are found on the interface between land and water. It is also areas of marsh, ponds and swamps, whether natural or artificial, permanent or temporary, with water, that is static or flowing, fresh, brackish or salty, including areas of marine water, the depth of which at low tide, does not exceed six meters. Although, wetlands by nature are dynamic ecosystems, anthropogenic activities continuously changing the land uses in and around wetlands speed up the ecological changes in wetlands. Ethiopia exhibits a wide range of geologic formations and climatic conditions which create numerous wetland ecosystems including 12 rivers, eight major lakes and many swamps and floodplains. It is found on every agro-ecological zones from alpine (high mountains) to desert ecosystem in the low-lying regions and across all traditional climatic zones. Riverine wetlands are other common types of wetlands throughout the country. Based on scattered information, the total wetlands coverage of Ethiopia is approximately 2% (22,600 km^2). This, wetlands provide natural resources and services for humanity. They are a source of food, tourism, cultural resources, flood control and improved water quality. They are also important for biodiversity and wildlife conservation. However, there are numerous threats to wetlands in developing countries including Ethiopia. Ethiopian wetlands are increasingly being lost or altered by unregulated over utilization, including water diversion for agricultural intensification, urbanization, dam construction, population pressures, food shortages, increased drainage and cultivation, collection of sedges and reeds for roofing and housing. The consequences of wetland loss and degradation in Ethiopia are enormous and directly affecting the livelihood base of rural communities. The change of wetlands has created numerous problems including decrease and extinction of wild flora and fauna, loss of natural soil nutrients, water reservoirs and of their subsequent benefits. They have affected various traditional occupations, socioeconomic conditions and cultural activities. Therefore, it needs intensive research and development works by different stakeholders and needs policy attention from the government to provide enabling environment for sustainable wetland management.

Key words: Wetland loss, drainage and cultivation, types of wetlands, threats to wetlands.

INTRODUCTION

Wetlands are ecosystems or units of the landscape that are found on the interface between land and water. While water is a major factor of wetland definition (Ramsar Convention Bureau, 1997), soils, vegetation and animal life also contribute to their unique characteristics (Koetze, 1996; Howard, 1995; Roggeri, 1995). As a result, it has proved difficult to define wetlands, and over 50 definitions exist. That used by the Ramsar Convention (1997: 2) is as follows: “areas of marsh, fen, peat land or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water with the depth of which at low tide, does not exceed six meters”. Wetlands are also areas of marsh, ponds and swamps, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salty, including areas of marine water, the depth of which at low tide does not exceed six meters (Sivaperuman and Jayson, 2000; Kafle, 2006). Water is the most determinantal component that distinguishes wetlands from other ecosystems. It also controls the processes, interactions and functioning of the other biotic and biotic components of the ecosystems (Schot and Winter, 2006; Hughes and Hughes, 1992).

Although, wetlands by nature are dynamic ecosystems, anthropogenic activities continuously changing the land uses in and around wetlands speed up the ecological changes in wetlands. Drainage for agriculture is responsible for the largest extent of wetland losses worldwide (Schot and Winter, 2006; OECD, 1996; Roggeri, 1995). Estimates show that about 50% of the global wetlands have been lost since 1900. Since 1950s, tropical and sub-tropical wetlands particularly swamp forests and mangroves have also been rapidly disappearing. The largest losses were recorded in the industrialized world (Finlayson and Davidson, 1999). However, the limited documented information on wetland loss in developing countries like Ethiopia leaves us with little to say. Multiple authors suggest that more information should be published to improve wetlands management and protection in Ethiopia (Abunie, 2003; Wonderfrash, 2003; Hailu, 2003; Woldu and Yeshitela, 2003; Desta, 2003; Vogt et al., 2006; McHugh et al., 2007). The authors confirmed that inadequate information is a common problem in lesser developed nations, causing issues in the evaluation of current and changing environmental conditions, and eventually leading to a lack of decision making or uninformed decision making. This lack of information becomes crucial, as wetlands play a vital role in the livelihoods of many people in developing nations via a variety of environmental services and socioeconomic benefits (Millenium Ecosystem Assessment, 2005; Dixon, 2008). Therefore, the main target of this critical review is to compile limited information on wetland distribution, importance, threats and consequences of wetlands degradation in Ethiopia.

Distribution and extent of wetlands in Ethiopia

Ethiopia exhibits a wide range of geologic formations and climatic conditions which create numerous wetland ecosystems including 12 rivers, eight major lakes, and many swamps and flood plains (Abunje, 2003) (Figure 1). It was found on every agro-ecological zones from alpine (high mountains) to desert ecosystem in the low-lying regions and across all traditional climatic zones (Wood, 2001). Except coastal wetlands, all the other wetland types are found in Ethiopia which consists of flood plains, lakes, swamps/marshes, swamp forests and human made wetlands. The widely recognized wetland types are however, swamps and marshes, which together account for about 0.16% of the country’s total area (EPA, 2004). There are several important swamp areas in the country. Lakes are also the widely distributed types of wetlands in Ethiopia both on highlands and lowland parts of the country with the largest concentration in the great East African Rift valley system (Hughes and Hughes, 1992; EPA, 2004; Leykun, 2003). Similarly, riverine wetlands are other common types of wetlands throughout the country. Such wetlands are particularly extensive in the flood plains of Aawsh, Abay, Baro, Gibe, Wabe Shebelle and Dawa Rivers (Getachew, 2004). Detailed inventory of the wetland resource base of Ethiopia is not carried out yet. However, based on scattered information, the total wetlands coverage of Ethiopia is approximately 2% (22,600 km^2) of the country’s total surface area (EWNRA, 2008). However, Tesfaye (1990) estimated that Ethiopian wetlands covered an area of 13,699 km^2 or 1.14% of the country’s land surface. There are 58 major lakes and marshes and a total of 77 wetlands in Ethiopia. However, Wonderfrash (2003) maintains that Ethiopia is “endowed with an array of wetlands too numerous to be counted”. He further comments that Ethiopia is often referred to as the “water tower of northeast Africa,” as Ethiopia spans an entire watershed area between the Mediterranean Sea and the Indian Ocean. Ethiopian wetlands can be broadly grouped into four major categories based on ecological zones, hydrological functions, geomorphologic formations and climatic conditions. These categories interlink to form four major biomes, which also describe climatic conditions in Ethiopia. These biomes are the Afro-tropical Highlands, the Somali Masai, the Sudan-Guinea and the Sahelian Transition Zone groups (Tilahun et al., 1996) (Figure 2).

Importance of wetlands

Wetlands are important resource in sub-Saharan Africa including Ethiopia that sustains rural livelihoods, particularly in areas with low or unpredictable rainfall, land scarcity or where uplands have poor soil

*Corresponding author. E-mail: bahilubezabih@ju.edu.et or behailubeza@gmail.com.

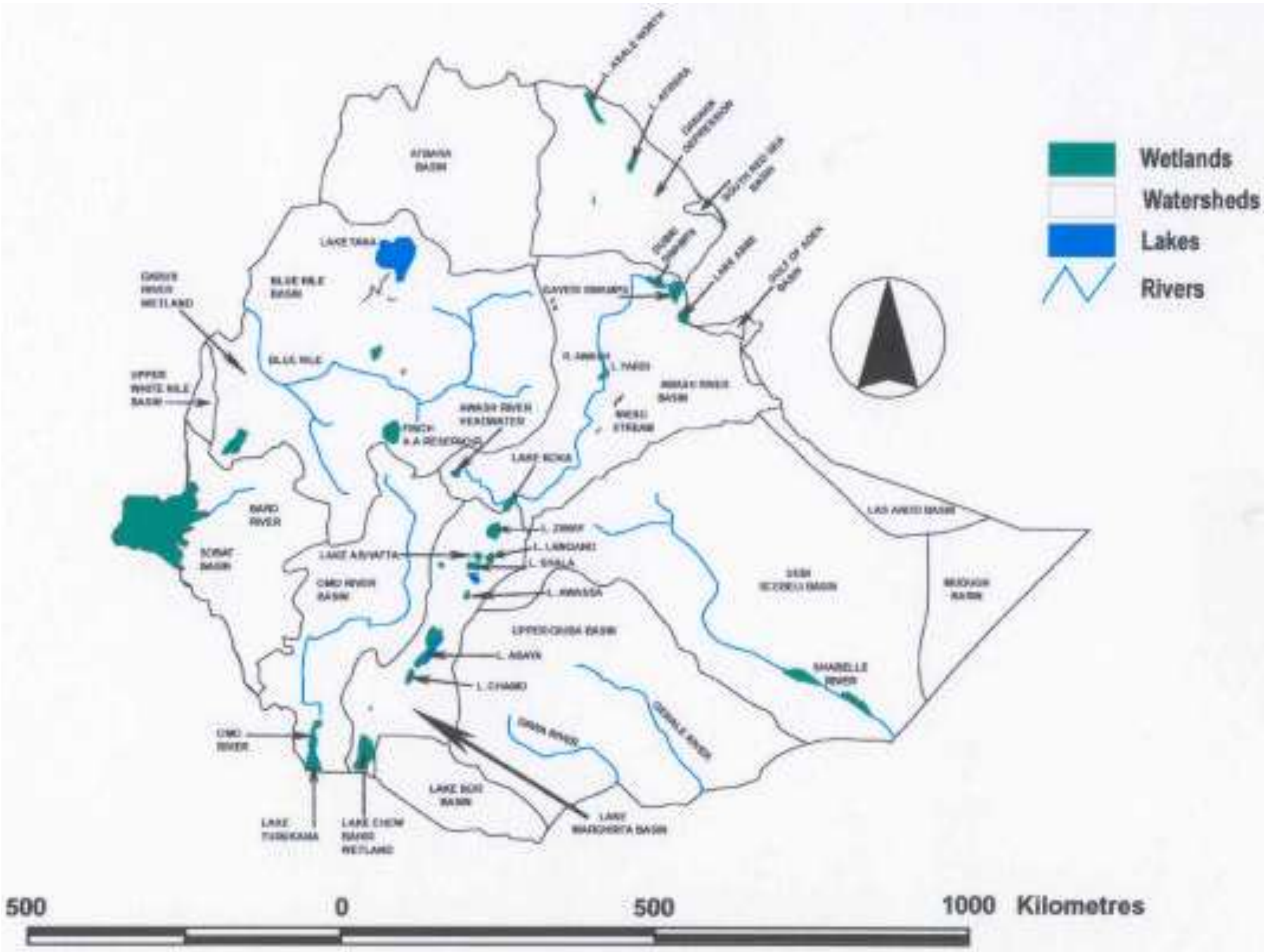

Figure 1. Lakes, rivers and wetlands of Ethiopia (Source: Abebe and Geheb, 2003).

characteristics and thus low potentials for agriculture (Dixon and Wood, 2002; 2003). Wetlands provide natural resources and services for humanity. They are a source of food, tourism, cultural resources, flood control and improved water quality. They are also important to biodiversity and wildlife conservation (Desta, 2003). As noted earlier by Hailu (2003), wetlands play a crucial role in the well-being of citizens in lesser developed nations, with Ethiopia being no exception. According to Hailu (2003), wetlands are used virtually by all households in the Western Wellaga and Illubabor zones in Ethiopia directly or indirectly. The main uses are social/ceremonial reeds, medicinal plants, thatching reeds used for housing construction and granary roofing, domestic water supplies, dry season grazing land, water for livestock, temporary crop-guarding huts of reeds, cultivation and craft materials. Dixon (2008), noted that cheffe (Cyperus latifolius) is the dense reed vegetation used for roofing, craft material, fodder for cattle, and as a marketable commodity in a range of ceremonies and celebrations in Ethiopia. Furthermore, minor uses such as establishing coffee and tree nurseries on wetland fringes, clay collection for pottery, and use of wetland tree bark for making ropes were also noted. The indirect uses of wetlands are due to their hydrological and ecological functions, which support various economic activities, life support systems and human welfare. This includes ground water recharge, flood control, nutrient cycling, erosion control and sediment traps, climate regulation, stream flow moderation, water filtration and purification, plant and fish products, biodiversity, wildlife habitat for migratory wildlife and pest control (Dugan, 1990, McHugh et al., 2007). According to Abebe and Geheb (2003), wetlands also support crop production, fishing and sources of medical plants among others. Ecologically, wetlands are instrumental in water storage, filtration and supply, flood control; perform sediment, nutrient and toxins retention functions and habitats for biodiversity of

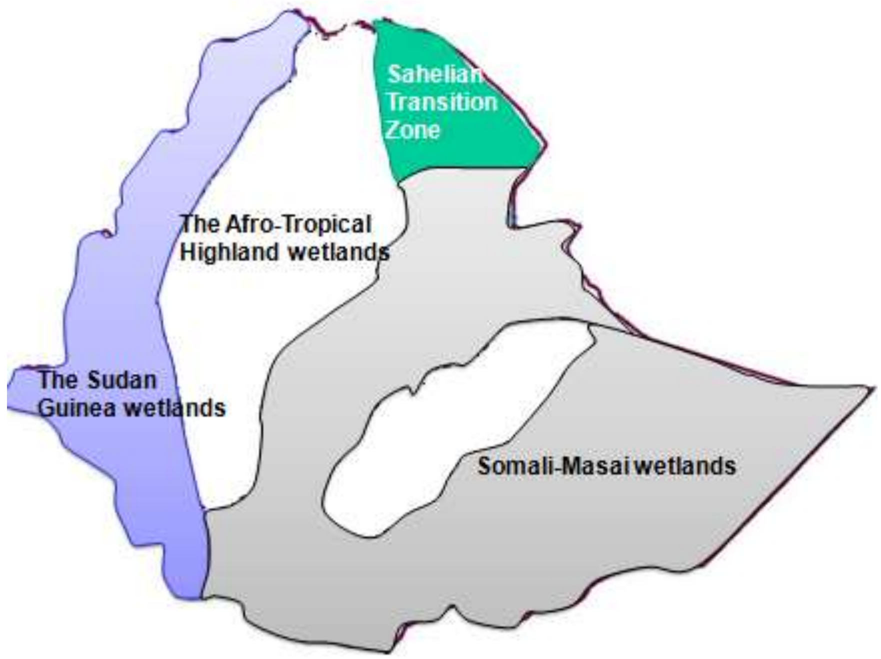

Figure 2. Categories of wetlands by biomes (Source: Abebe and Geheb, 2003).

both flora and found (Abebe and Geheb, 2003)

Their ecosystems support both aquatic and terrestrial biodiversity, such as migratory birds, wildlife, fishery resources and aquatic and terrestrial vegetation. These ecosystems serve as wintering grounds and maintenance stations for a large number of terrestrial and aquatic birds. Thirty-five fish species and ninety-four mammal species are recorded from the Ethiopian Rift lakes, of which six are endemic (Tesfaye, 1990).

Growing threats to wetland ecosystem

The most common threats of wetlands are the result of a combination of social, economic and climatic factors, which have increased pressure on the natural resources in Ethiopian wetlands. Another constraint to the judicious use of African wetlands is lack of knowledge by planners and natural resource managers of the benefits that they provide and techniques by which they can be utilized in a sustainable manner (Jogo and Hassan, 2010). This has caused the degradation of watersheds, increased soil erosion, decreased water quality and caused immeasurable loss to biological diversity (Tesfaye, 1990). For instance, in the Lake Alemaya catchment which is located at the eastern part of Ethiopia, has been degraded due to soil erosion which is caused by the intense rainfall, steep topography, and poor vegetation cover coupled with cultivation of steep lands, and inadequate conservation practices. Sediment from the catchment has affected the storage capacity of Lake Alemaya (Muleta et al., 2005). The loss of these wetlands is devastating to several endemic species and particularly to wetland dependent species. Wetlands are the most productive ecosystems on the earth, they are also the most threatened and the most fragile component of the ecosystems susceptible to changes. There are a number of environmental and anthropogenic driving factors of hydrological changes in wetlands that obscure the residence, input and output of water (Hughes and Hughes, 1992). Wetlands loss, destruction and alteration have been and are still seen as an advanced mode of development, even at the government level (Abebe and Geheb, 2003). Wetland loss is evident wherever major developments like dams, irrigation schemes and conversion projects are present in the developing world. While most of the threats that wetlands face result from their misuse, many are also related to unsustainable resource extraction. Another important reason for their vulnerability is the fact that they are dynamic systems undergoing continual change (Barbier et al., 1996). As a result, many wetlands are temporary features that disappear, reappear and re-create themselves over time (Barbier et al., 1996).

A large number of wetlands in Ethiopia are considered vulnerable zones and some of the most exploited, mismanaged and lost their regenerating capacity (Alemayehu, 2006). Ethiopian wetlands are increasingly being lost or altered by unregulated over utilization, including water diversion for agricultural intensification, urbanization, dam construction, population pressures, food shortages, increased drainage and cultivation, collection of sedges and reeds for roofing and housing, extraction of clay materials for brick making, pollution and other anthropogenic interventions (Abebe and Geheb, 2003; Wood 2003, Mulugeta, 2004; Melaku et al., 2012; Getachew et al., 2012). Kumsa (2015) noted that the most serious threats to Jarmet wetland in the western region are unsustainable use of wetland resources through overgrazing, over cultivation, over abstraction of water for domestic use, agriculture and improper use of forest practices, establishment of new human and livestock settlements in wetland areas, cutting and burning of aquatic and other vegetation for housing and commercial activities like charcoal and fire wood, lack of an operational national wetland policy and cross cutting sectorial policies, limited funds where by wetland management institutions, lack adequate and continuous fund personnel for monitoring, management, and research and community awareness, lack of community participations in management of various wetland resources in the district. Generally, conversions of wetlands, agricultural encroachment, demographic pressures, over grazing and climate change are the major factors threatening wetlands. The major factor limiting the availability of resources of wetlands in Ethiopia is extensive farming which has increased largely over the past century in the Western Wellaga and Illubador Zones (Dixon et al., 2008). Wetland cultivation in these zones may date as far back as the mid-19th century, and possibly centuries earlier (2008). During this time period, cultivation extended beyond the use of wetland margins which include much larger wetland areas was completely drained and cultivated. Mulugeta (2004) also maintains that cultivation of wetlands has existed for at least eight decades, with an average cultivation of 23% of the total wetland area. Complete drainage of wetlands in the mentioned region leads to many issues regarding to the local collection of sedges and reeds for roofing and housing, as only the rich can afford alternative building supplies. Today, wetland cultivation provides between 10 and 20% of the annual food needs of the region, but can be as high as 100% during the summer months in some areas (Dixon and Wood, 2008). Coffee production in the early 1900's also placed pressure on starting further wetland cultivation, as more uplands were being used for its cultivation, making it necessary to expand into new portions of habitats (Hailu 2003). This expansion was largely due to a food shortage because of drought conditions (Hailu, 2003; Dixon et al., 2008). According to Hailu (2003), roughly 20% of the Illubabor Zone wetlands were cultivated between 1986 and 1998, increasing drastically in 1999 to 35% or 7,100 hectares of the wetland area. Some of this might be accounted for by increased government pressure from 1974-1991 as food-sufficiency targets were set for the region, and those unwilling to cultivate their wetland plots risked losing them to those who were willing to do so (Dixon et al., 2008). In addition, over 100,000 people were moved to the region by a government decision during a famine in 1984 (Dixon et al., 2008). In 1999, the government increased their pressure on farmers to cultivate wetlands in order to compensate for more drought-induced food shortages (Dixon et al., 2008). Eucalyptus, banana, sugarcane, and 'chatt' cultivation on the edges of wetlands, and teff cropping in wetlands, has been identified as a threat to the survival of these areas. Farmers are of the opinion that the cultivation of these crops and trees on the wetland edge is responsible for their drying out. Grazing by domestic stock has also been identified as a threat to wetlands. When grazing follows continuous cultivation, wetlands easily become degraded and lose their natural characteristics. Livestock trample the soil and compact it and their grazing destroys natural vegetation. They erode drainage channels leading to gullies and increase water outflow. These effects often result in the complete degradation of wetlands by reducing the water table and by changing the original vegetation (Afework et al., 2003). Moreover, sand mining; mineral salt extraction and other development intervention like soda ash factory are other threats of wetland management (Gemechu, 2010)

The incidental and intentional introduction of invasive alien species is another emerging issue severely affecting the wetlands of the country. Some of the world's worst invasive species, which are threatening Ethiopia's wetlands, include *Mimosa pigra* in the Baro-Akobo Basin, and *Eichhornia crassipes* in Koka and Abasamuael reservoirs and in Baro-Akobo Basin. *M. pigra* is aggressively invading wetlands and other areas in the Baro-Akobo Basin, threatening fishing, grazing and other agricultural activities by forming impenetrable thickets and hindering movements of humans and animals, and destroying and replacing natural biodiversity. *E crassipes* disrupts hydropower generation (e.g., Koka dam), increases siltation and evapotranspiration, reduces fish stocks, impairs water transport and fishing activities, and reduce water quality (Dereje, 2003).

According to EPA (2004) report, most of the wetlands' ecosystems in Ethiopia are severely degraded and most of the floristic and faunistic species are endangered mainly for two reasons. Firstly, land use does not take wetlands conservation into account while they are under pressure by the farming population which is in dire need of land for pasture and crop farming. Humans usually and very dramatically accelerate natural processes often unintentionally but usually in the course of activities like agriculture, industry and urban development. These activities can involve anything from drainage and diverting water, to dredging and loading water sources with toxic chemicals. For instant, Lake Hawassa in the southern region of Ethiopia is being degraded as a result of unmanaged and harmful human activities in the catchment. Land use and modification, toxic industrial discharge and activities associated with urbanization are the major causes of this degradation. Another most destructive activities could be mining (Williams, 1990) which permanently destroys the substrate and prevents the natural restoration of a site. Wetlands whose biotic balance has been disturbed can often recover. The situation is aggravated by the fact that wetlands are considered as either state property or a property belonging to no one. The second reason is that people in the wetland vicinities (in lowland areas) devegetate herbaceous vegetation to avoid the harboring of mosquito flies and snakes. Because of these and related actions, most of the wetlands are seriously denuded, except those situated in remote areas.

Furthermore, wetlands are usually considered as wastelands and are thought of as nuisance to human development (Dixon and Wood, 2003; Schot, 1999; OECD, 1996; Roggeri, 1995). This view has led to considerable conversion of wetlands, which has usually been seen as a progressive public-spirited endeavor believed to enhance the health and welfare of society, alleviate flooding, improve sanitation and land reclamation. Moreover, the underlying causes of wetland loss are that they are assumed to be less important than other priorities or tend to be regarded as free goods. This is due to the absence of a proper guiding policy and an accountable institution for addressing problems associated with wetland degradation. The lack of any strategic planning and capacity for wetland management programmes and sustainable uses are other impediments (Leykun, 2003). Currently, some wetlands are at the edge of extinction. The situation of Lake Haramaya in the east wetland exhibits this reality. The resources and the lake disappeared for reason they cannot comprehend. Many lakes of Great Rift Valley are also similarly exposed to severe degradation. The dangers would refer to Ziway, and Abijiata wetlands where currently human actions related to resources extraction are being maximized beyond the resources rejuvenating capacity. In Ethiopia, wetlands are often considered as wastelands and are thought of as obstacles to agricultural development, human and animal health associated with nuisances and calamities such as floods, diseases like malaria and schistosomiasis (Legesse, 2007)

Consequences of wetland loss and degradation in Ethiopia

Alterations of the hydrological regime of wetlands have significant physical, chemical and biological effects that can have significant ecological and socio-economic implications at wider scale. On the other hand, presence of water is the main obstacle to human when wetlands have to be transformed into other form of land use (OECD, 1996; Roggeri, 1995).

The consequences of wetland loss and degradation in Ethiopia are enormous and directly affecting the livelihood base of rural communities. The change of wetlands has created numerous problems including decrease and extinction of wild flora and fauna, loss of natural soil nutrients, water reservoirs and of their subsequent benefits. They have affected various traditional occupations, socioeconomic conditions and cultural activities (Kumsa, 2015). Wetland conversion often results in water depletion, the displacement of populations, the destruction of traditional production systems, habitat degradation, salinization, increase of waterborne diseases and other adverse ecological impacts (WCED, 1987). Wetland dependent communities in different parts of Ethiopia survive by the virtue of wetland resources such as fisheries, dry season food crops, raw materials for construction, water, feed for animals, medicinal plants, income from sale of the products including handicrafts, etc. Thus at community level, the significance of wetlands in poverty reduction and ensuring food security is immense. Wetlands stand first when communities consider their problems of dry season when shortage of water and forage threatens the lives of their livestock, major asset next to land in agricultural areas and may be asset number one in pastoral communities. Wetlands save lives in dry seasons and are thereby the backbone of rural livelihoods for millions. Therefore, considering the impact on the local community from the loss of wetlands such as Haromaya/Alemaya, weakening of wetlands such as Abijata and Cheffa may suffice to understand the role of wetlands in community livelihood.

Losses of communal resources collected from the wetlands, water, dry season pasture, declining of food crop production are a few to mention (Dixon and Wood, 2003). Pollution of habitat and over fishing of selected species is among the biggest concern in the Ethiopian lakes. Wassie et al. (2012) noted that selective fishing in Lake Tana caused a 75% decline in Labeobarbus species during 1990s. Excessive water abstraction from wetlands and erosion and sedimentation are other serious threats. Ghermandi et al., (2008) found out excessive abstraction of water from Lake Alemaya, South-eastern Ethiopia caused complete drying up of the lake by the year 2004, 12 years earlier than the predicted time. Recently, there are increasing treats to the valley bottom wetlands of South-west Ethiopia which mainly arisen from expansion of drainage and cultivation (Dixon and Wood, 2003).

The complete drainage of wetlands in Illubabor Zones, south west Ethiopia has led to a number of ecological and economic problems. Some of these are immediate and clearly linked to drainage, such as the scarcity of thatching reeds, vegetation change, lowered water tables, reduced accessibility and provides unsafe water (Wood, 1996). This unsafe water may lead to even greater issues such as ill health among the entire family, which in turn affects farming and other domestic and economic activities, reducing food security and lowering economic well-being (Wood, 2003). Other problems are more complex and long-term, such as declining agricultural productivity, reduced availability of land for ‘hungry season’ crops, increased fluctuations in stream flow, reduced water quality and downstream hydrological impacts. Loss of wetlands may also decrease biodiversity such as birds and other wildlife (Idris et al., 2001).

Wetland loss also aggravates climatic disturbances by increasing carbon build up in the atmosphere. As Ethiopia is prone to desertification and recurrent drought, the effects of wetland loss could be more visible in complicating the situation locally. It can also affect hydrological cycle or rainfall patterns. Rivers and streams may lose their strength. This will create shortage of water and narrow opportunities for irrigation based agriculture. Wetlands play a vital role in the carbon cycle and wetland loss may have impacts which encourage global warming and climate change (Shimeles and Geremew, 2008).

CONCLUSION AND RECOMMENDATION

In conclusion, wetlands have been ranked amongst the most productive and highly deteriorated and biologically threatened ecosystem in Ethiopia. Wetlands by nature are dynamic ecosystems, anthropogenic activities continuously changing the land uses in and around wetlands and speed up the ecological changes in wetlands. The primary direct causes of wetland degradation in Ethiopia includes drainage for agriculture, over grazing, degradation of catchments, over harvesting of their resources, settlement and urban expansion, pollution, tree plantation and invasion of alien species. The common threats to all wetlands of Ethiopia are: Weak institutional set up for management, over utilization of wetland resources, Lack of awareness, information and research on wetlands; poverty, the lack of livelihood alternatives for farmers, poor agricultural technology and productivity; the delicate arid and semi-arid environment surrounding the lakes, associated low and erratic rainfall and the threat of high human population pressure. Thus, wetland threats and losses are directly affecting the livelihood base of rural communities. Losses of communal resources collected from the wetlands, water, dry season pasture, declining of food crop production are a few to mention. Therefore, it deserves intensive research works, providing different livelihood improvement programs for small scale farmers around wetlands and needs policy attention from the government side to provide enabling environment for sustainable wetland management. Moreover, awareness creation campaign should be promoted by both government and nongovernmental organization in order to minimize over resource extraction that could be conducted by investors or private sectors and small holder farmers.

CONFLICTS OF INTERESTS

The authors have not declared any conflict of interests.

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