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Challenges and Opportunities of Irrigation Practices in Ethiopia: A Review

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Author's contribution

The sole author designed, analysed, interpreted and prepared the manuscript.

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ABSTRACT

Ethiopia has been started traditional irrigation practice since ancient time for the aim of subsistence food production. Since 1950's modern irrigation system was introduced in Awash and Rift Valley basins for production of industrial crops. Government, donors and non-governmental organizations are investing to the development of irrigation systems from small to large scale irrigation schemes. As a result, irrigation is developing rapidly. However, its contribution to the national economy is insignificant when compared to rain-fed agriculture. This review was conducted to investigate the irrigation practice challenges and opportunities in Ethiopia. The extension service was inadequate and not packaged. Credit service bureaucracy like group collateral was constrained to improve irrigated crop production. Water governance was done by water users but interference by the government bodies aggravated water use conflicts. Streams drying, percolation and seepage of water are the most challenges. Irrigation created employment opportunity for household members and the rural community and also improved their income. Therefore, policy makers and development practitioners should improve policies and strategies based on the agro-ecology and socio-economic settings of irrigation areas to overcome the challenges and strengthen the opportunities.

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1. INTRODUCTION

Ethiopia is a landlocked country with a land area of 1.13 million km^2, found in Eastern Africa [1]. About 67% of area lies in arid and semi-arid and 33% covered by humid and semi-humid areas [2]. Geographically, the country is placed in between the latitudes 5ºN and 15ºN, and longitudes 35ºE and 45ºE [3]. Most of the population lives in highland areas, with 85% being rural and dependent on agricultural practices with a low level of crop productivity [1,4,5]. Thus, agriculture is the major source of employment, revenue, and export earning and besides providing raw material to the industrial sector of the country [6]. Agriculture is the backbone of the Ethiopian economy which contributes 46 percent to Growth Domestic Product (GDP) [1]. Cognizant to this fact, the country focused its development policy, that is, Agricultural Development Led Industrialization (ADLI) on agriculture to transform the economy. ADLI aims to boost agricultural productivity and improve the rural standard of living, which in turn increase the demand for goods and services and further lead to industrial development. One of the impetuses to achieve the agricultural policy objective is the promotion of irrigated agriculture and integrated water resource management [7]. The country is endowed with ample water resources with 12 river basins with annual runoff volume of 122 billion m^3 and an estimated of 2.6 billion m^3 of groundwater potential [1,2,4]. Due to this, Ethiopia, is considered to be the water tower of East Africa [8]. Though the country Ethiopia is blessed with plentiful water resources, little has been developed for irrigation [1]. Agriculture is the dominant sector but most of country cultivated land is under rainfed agriculture. Due to lack of water harvesting structure and large spatial and temporal variations in rainfall, there is shortage of water for most farmers to produce more than one crop per year and hence there are frequent crop failures due to dry spells and droughts which have resulted in chronic food shortage currently facing the country. So to overcome this problem and to use the available water resources since the mid-1980s, the Ethiopian government has responded to drought and famine through promoting and construction of irrigation infrastructure aimed at increasing agricultural production. In Ethiopia, the constructed irrigation schemes are categorized as small, medium and large-scale and will develop for the future to supplement the rainfall shortage. But the developed irrigation schemes are not viable and fail outright for failing to consider long term support due to different uncertainties [4]. Moreover, in many parts of Ethiopia, irrigated or rain fed agricultural production is affected by environmental extremes (e.g. drought, high soil salinity, etc.) and the country has been seriously affected by climate change and related hazards, and millions of people are left without sustenance mode of life every year. To increase productivity and diversify the livelihood scenarios as an option, development of irrigation schemes has been introduced through water harvesting technology including construction of concrete or embankment dams. Irrigation practice is an important strategy in reducing risks associated with both rainfall variability, production of different crops twice or three times within a year and improving income of rural farm-households. Ethiopia has not yet developed more than 5% of the irrigation practice potential [9]. Irrigation has the potential to stabilize agricultural production and mitigate the negative impacts of variable or insufficient rainfall of the country. In some part of the country, delayed entrance of rainy seasons, early withdrawal and mal-distribution of rain were challenges from which great lessons have been drawn to critically look into development of small-scale, medium-scale and large-scale irrigation structure. The country has many problems in development and management of irrigation schemes such as Bio-physical, technical and socio-economic and institutional factors [10]. Therefore, the purpose of this article is to review the challenges and opportunities for the development and management of irrigation practices in Ethiopia.

1.1 Objectives

The main objective of this study is to review the major challenges and opportunities of irrigation practices in Ethiopia. Moreover, this review has the following specific objectives:

a. To review the status of irrigation practices.
b. To review the challenges faced to the irrigation practices.
c. To review the opportunities of irrigation practices.

2. DEVELOPMENT OF IRRIGATION IN ETHIOPIA

Irrigation can be defined as an artificial application of water for the aim of supplying the moisture in the plant root-zone to prevent stress that may cause reduced yield and/or poor quality of harvested crops [11]. So, this is an planned action made by human to apply water for growing crops, especially during dry seasons where there is a shortage of rainfall or to supplement it [12]. Irrigation practice is one means by which crop production can be increased to meet the growing demand of food and other services in Ethiopia [13]. A study also indicated that one of the best alternatives to consider for reliable and sustainable food security development is expanding irrigation development on various scales, through river diversion, constructing micro dams, and water harvesting structures, among others [14]. Irrigation has been practiced in the country since ancient times producing subsistence food crops. However, modern irrigation systems were started in the 1950's with the objective of producing industrial crops in Awash Valley and Rift Valley. Private concessionaires who operated farms for growing commercial crops such as cotton, sugarcane and horticultural crops started the first formal irrigation schemes in the late 1950's-Metri-Agro industry in the upper and Amibara in lower Awash Valley. In the 1960's, irrigated agriculture was expanded in all parts of the Awash Valley (Metahara and Wonj in middle Awash) and Bilate farm in the Rift Valley [1].

3. STATUS OF IRRIGATION PRACTICE IN ETHIOPIA

Irrigation practice is a very important to the sustainable and reliable agricultural developments in Ethiopia. Subsistence farming that is dominant in the country economy can be improved through the use of irrigation activity [15]. Similarly, making use of irrigated agriculture is going to be a means for increased agricultural production to meet the growing food demands due to rapid population growth and, it accounts 3.02% [16]. Irrigation development in Ethiopia can be considered as a basis of food security and poverty reduction tool as it has power to stimulate economic growth and rural developments [17]. As shown Table 1 according to Hagos, et al. [17] in Ethiopia the irrigation scheme are classified into three such as small-scale, medium-scale and large-scale this is based on land size that can be irrigated.

The development of irrigation practice in Ethiopia is in infancy stage [4]. Therefore the government is pursuing plans and programs to develop irrigation in an effort to substantially reduce poverty and create an atmosphere for social change. As a result, the Ethiopian average rate of irrigation development for 12 years (1990-2001) was about 1,090-1,150 ha/year [18,10]. In line with this, irrigation infrastructures from small to large irrigation schemes are increasing each year, which show that in the countrywide positive development implications and even if the developed structures faced a number of challenges. In Ethiopia, only 2% of cultivated lands are irrigated [19] and 10% of the estimated potential irrigable land is actually irrigated [20]. Similarly, irrigated agriculture in Ethiopia comprises merely 3% of the total national food production [21]. That is why; irrigated agriculture is far from satisfactory despite of considerable investment, public interest, and strategic support of the government. Belay and Bewket (2013) argues that irrigation practice is critical to poverty alleviation through increased production in rural areas so as to improve food security and rural livelihoods status and also contribute to national economy. Smallholder irrigation has recently received significant focus from local governments to enable farmers to cultivate crops twice or more per year. Bacha, et al. [21], reported that land productivity, asset ownership, credit utilization, extension support, resilience to poverty, mean

Table 1. Summary of typology of irrigation schemes in Ethiopia

Typology	Size of the scheme (ha)	Infrastructure	Water management scheme
Small scale	<200	Fixed or improved water control and diversion structures made of local materials	Water user association or irrigation cooperatives, local water users' association
Medium scale	200-3000	Fixed or improved water control and diversion structures	Water users' association/ irrigation, cooperative or state.
Large scale	>3000	Fixed or improved water control diversion structures	Mostly state enterprises

off-farm income, and mean food consumption and expenditure on food and non-food property were extensively higher for irrigators than non-irrigators. Poverty eradication and food security are among the priority concerns of the government in Ethiopia. As a result, irrigation development is taking place through the use of government budgets, donor programs and non-governmental organization (NGOs). However, as compared to its potential and rain-fed farming, contribution of irrigation to the national economy is quite limited contributing about 3% of the overall GDP [17,4]. Moreover, the existing irrigation development in Ethiopia, as compared to the irrigation potential, is not significant due to different uncertainties [15]. These uncertainties are explained in the following sub-title.

4. CHALLENGES FACING IRRIGATION PRACTICES

4.1 Poor Scheme Management

Many of the schemes were under severe challenges due to salinity, siltation or sedimentation problem. For instance, from five to eight years after the irrigation project was commenced salinity and sedimentation became very severe [22]. The same source indicated that the main cause of salinity was poor irrigation water management. Inefficient drainage systems along the canals has caused severe siltation problem [23]. The majority of farmers raised salinity problem as minor while few farms reported as severe problem in poor canal management. Drainage system is also the cause of irrigation practice. Due to the poor scheme management, land and soil productivity is declining with years of irrigation. In consequence the yield per hectare has been declining year after year. It is directly related to the water use system adapted by the farming community [24]. The other aspect of poor scheme management is inadequate and late maintenance of canals due to lack of effective coordination, inefficient control system, frail linkage with relevant stakeholders, and lack of regular training is the peculiarity of much water user association (WUAs) [4]. Most of the irrigation beneficiaries responded that they were not willing to contribute financial resources for the irrigation scheme management. It was also found that some farmers consider irrigation water as a free good and gift of nature. Canals are not protected against livestock, siltation and sedimentation and are more likely damaged the schemes at the lower level when livestock freely graze in the command area [25]. Inadequate drainage invariably increases water logging and salinity accompanied by health hazards like malaria [26]. Wooden and steel parts in irrigation structures suffer from being alternately wet and dry. The wooden parts of irrigation structures will rot and disintegrate, while steel parts will rust, expand and get jammed in the slides. All such corrosion affects in a negative way the operation of the structures. Routine maintenance is necessary to avoid these problems, or to reduce their effect to a minimum. Fig. 1 shows an intake gate of the irrigation diversion structure, which is deteriorated due to rust and is not manageable to operate [10].

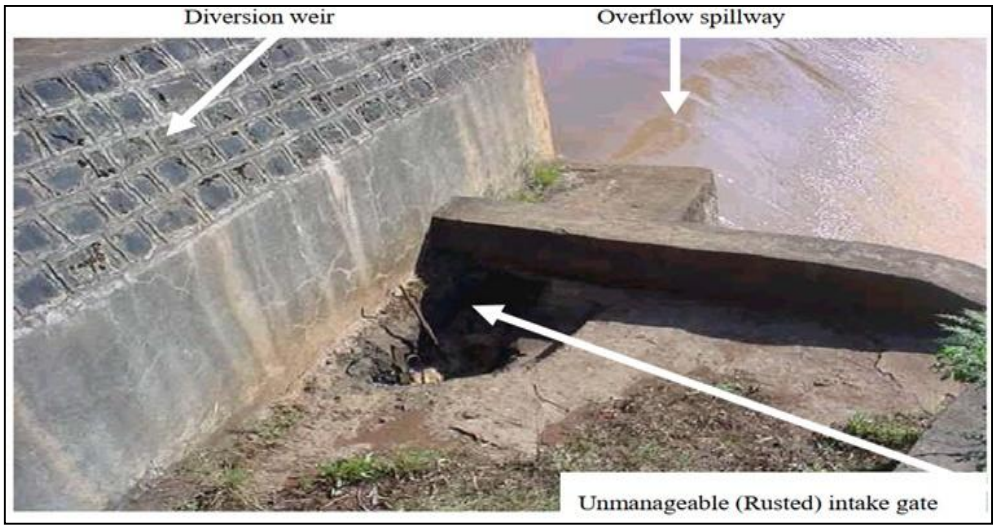

Fig. 1. An intake gate of diversion head work

The deposition of soil and debris can affect the functioning of a structure. For example, a stilling basin collects soil deposits the available water mass diminishes and power dissipation will be less effective. Similarly, in the case of soil deposits in a flow division box, the division of the flow will be less accurate due to imbalance inflow velocities and water levels. The same applies for irrigation intake structures and night storages, such as the pumping stations. Large volumes of sand in the intake chamber of the pumps causes damage to the pumps and will lead to sand deposits in the canal system too. Fig. 2 shows night storage of the irrigation scheme, which is silted up by sediments and misused as trough for drinking animals [10].

4.2 Socio-institutional Problem

At all levels, there exists low institutional capacity which is critical to enhance improvement of irrigation scheme with respect to planning, design, implementation, operation and maintenance including irrigation advisory services [4]. Water theft which means during water distribution is a common scenario in many schemes. Additionally, the water user associations (WUAs) have a weak coordination skill to solve scheme related problems. Upper stream households were get adequate water, whereas lower stream beneficiaries do not get adequate water. As a result, some sort of conflict and dissatisfaction was rising [4]. The participation of women in WUAs is not satisfactory. Inequity in water distribution between locations, and between socioeconomic groups is the social problem [27]. Other institutional barriers include limited or no priority given to sustainable irrigation during national and local planning and budgeting; poor management structures in place to support farmers and promote irrigation development [28]. For example, the infrastructure to facilitate agricultural development is underdeveloped [29,30]. Poor coordination between institutions dealing with sustainable irrigation: for example, there are no clear-cut duties and responsibilities between the Department of Agriculture and Department of Service Cooperative and Promotion [31]. Inadequacy of extension support with respect to irrigation management is a common phenomenon for many schemes. There is ample evidence from all regions that most of the failed projects are those implemented without sufficient and effective beneficiary consultation and participation. Absence of sanction and poor coordination of water users association are the main administrative problems in irrigation schemes [32]. The irrigation structure turnouts were far apart and not evenly distributed in some areas. Hence, the users breakout the canals and extract irrigation water where there is no turnout. These illegal users caused a huge damage on canals and threatened safety and sustainability of distribution and conveyance canals [25]. The education status of the household is one of the challenges to practicing irrigation in different farm lands. That means illiterate farmers find it difficult to practice irrigation. If the farmers are educated, it is easy to search and adopt new technologies and extension services that given by the irrigation experts. Education enables farmers to search for new irrigation management practices [25]. In order to alleviate irrigation water scarcity and conflict, each irrigation areas had water management bodies though the organizational structures and acknowledged by different formal and informal institution. The water management bodies were organized by the beneficiaries. The water users have their own rules and regulations. The management committee had five to seven in member and they are responsible to manage and plan water schedule, mobilize beneficiaries during repairing, cleaning and digging of silted dam and canals, schedule water use turn, punish offenders who violate the rules with a specified amount and use other individual watering turn. If the accused farmers do not accept the punishment made by water users, the “Cell” would try to negotiate with the water users. If still could not possible; the “cell” would take measure to settle the situation. But management was influenced by the government bodies “cell” interference aggravated water use conflicts. This caused lack of solidarity among irrigation water users to implement their own irrigation rule. Thus, it caused lack of sense of ownership both from the management committee and from the members. Therefore, water governance often cause a challenge on the efficient and equal utilization of irrigation water, thereby improves irrigated crop production [33].

4.3 Market Problem

All over the rural areas of Ethiopia; market access and marketing facilities are the major challenges influencing irrigation practices. There is no rational place or customer for selling their product. Market problems mainly related to irrigated agriculture are acute due to perish ability of irrigation based agricultural commodities. In addition, lack of storage facilities and processing agro-industries in many of the

schemes caused a great loss. Price instability and lack of market are almost invariability confirmed as conspicuous major constraints to irrigated agriculture. Cooperative marketing was conspicuously missing or proved to be too ineffectual to reduce risks arising from price instability and marketing problems [34]. Small holder farmers face high costs and risks when entering markets, which severely limit the returns from irrigation product. Rural markets in Ethiopia are thin small and the transaction costs of entering are high due to the lack of transport infrastructure [35,36]. The lack of access to market in close has greatly reduced the income that farmers could have otherwise gained. Price information is chaotic, some small holder farmers get it from neighbors or friends visiting the markets and some do not get it at all. The irrigation users do not have market chain to sell their production [4]. In the absence of the necessary marketing facilities and infrastructure, farmers have no choice but to sell their production at prices that may not cover costs of production. Most of the irrigation farmers in Ethiopia have been constrained by market and infra-structure and no proper government intervention has been made to avert existing farmers problems related with facilitating marketing systems [37]. Market place is the vital challenge for marketing agricultural products and to buy inputs for irrigated agriculture. They walk on foot long distance for three to six days into the marketing place in that offers a better price. They argued that they do not worry about the distance, but their main concern is the price of their products. To sell their agricultural products, farmers transport their irrigated crop products by car, cart, pack animals (i.e. donkey, horse) and human loading according to their accessibility and affordability, the use of vehicles for transportation of market commodities is hindered by high cost of car service [33]. Shortage of water ponds and diversion, infrastructure specially road and storage space, theft of fruits, diseases and pests such as rust, root ruts, ball worm, blights, powdery mildew, gummosis and water borne diseases, inefficient insufficient market information and market networks are have been reported to be major challenges of the irrigation scheme [38]. Regarding to sources of market information for irrigated crop products before going to market places they got from their neighbor, agricultural development agents, merchants and sometimes sell their products without any information gained before. Market prices vary from time to time based on supply and demand principle [33].

4.4 Insufficient Technical Skill

In many parts of the country; the farmers are practicing irrigation without know-how on crop water need, water application method and irrigation interval. Lack of knowledge on irrigation water management aspects has resulted in wastage of irrigation water, deterioration of some structures and water logging problems on some farms [29,30]. Poor irrigation scheduling, crop water requirement imbalance; inappropriate irrigation methods are widely recognized [4]. Other challenges were faced by the farmer when they practice irrigation include lack of improved technologies (such as technical problem, inputs preventing seepage and evaporation) [39]. Irrigation water was not distributed based on which crop requires what amount, at what soil and time. But it was also done through guessing. This was reported due to technical weakness of water user association (WUAs) executive committees, water distributors and lack of strong assistances from the concerned offices [25]. Agricultural extension service is basic for the development of irrigated agriculture through adapting and introducing improved technologies, providing training, accessing and timely supplying of inputs and giving different information that ranges from production to marketing to the farmers. However; the extension services provided are not focusing on identifying and organizing farmers' problems and support farmers in supplying and accessing inputs such as pesticides, improved seeds and fertilizers. The main rational for this extension service problem towards provide training that the development agents divide their mandate area into different aspects of agriculture such as livestock production, crop production, natural resource management, irrigated agriculture, and rain-fed agriculture. Training and technical advice is a vital factor to enhance the knowledge and skills of farmers. The more training and technical advice is provided to the farmers, the higher is the probability that farmers adopt the technologies to improve their production system. Untimely input supply (i.e. seed variety) and poor utilization of fertilizer are the other major problem. Seed varieties are needed to increase production and productivity. In the area, there is no improved varieties of a crops yet introduced to the locality. The farmers complained that improved seed varieties were available on the rainy season but not for irrigated crop production during the dry season so that, some farmers were forced to buy on the rainy season to plant on the next dry season for irrigated crop

production. Therefore, this show that the concerned bodies pay less attention to irrigated crop production than rain fed crop production [33]. Some crop types were attacked by fungal diseases. Consequently, crop production is decreased from time to time. The farmers complained on the failure of the concerned bodies to give a solution to the problem though they were telling the respective development agents. Therefore, in the irrigated area, crop production faced challenges such as lack of access to improved seeds, pesticides and insecticides [33,38,25]. Lack of training, uncertainty about new irrigation inputs and lack of know-how between the irrigator, are the most serious challenges hindering irrigation development. Further, weakness of local farmer training center (FTCs), weakness of extension personnel in supporting farmers were also identified as main hampering points of extension service provision. Low awareness of the technology, poor implementation procedures (site selection problems and poor construction management) equally hamper irrigated agriculture [26,40]. Similarly, Bitew [10] reported that the collapsing of many irrigation structures and subsequent leakage cause problems to irrigation practices. When the water level upstream of a structure is higher than the downstream water level and so at this level the water may find another way underneath or along the irrigation structure, or even through a crack in the bottom or sides of the structure to this lower level. Fig. 3 shows that part of the diversion weir that collapsed due to scouring and Fig. 4 shows the leakage on headwork of the irrigation structure and results in water loss and damaging of the weir. This was associated with improper design problem of the irrigation structure.

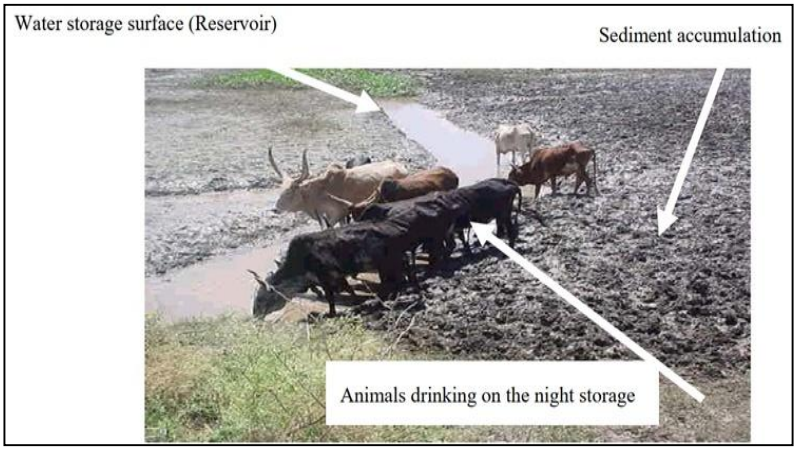

Fig. 2. Night storage of the irrigation scheme

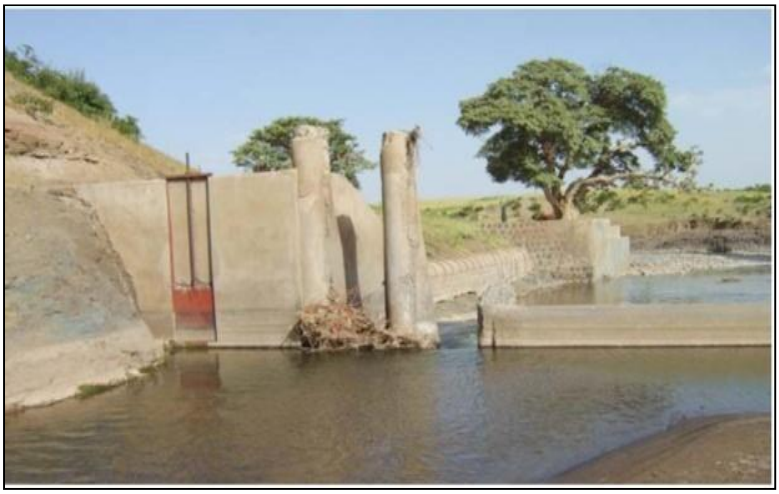

Fig. 3. Part of river diversion head work

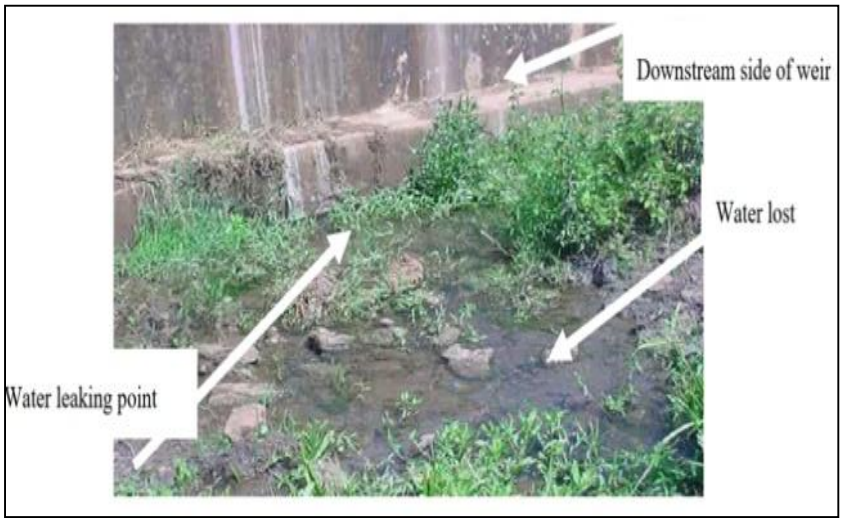

Fig. 4. Leakage on river diversion structure

4.5 Financial Shortage

Lack of long and short-term credit provision affects the production of the irrigation scheme. The input for production like fertilizers, improved seeds and chemicals requires high financial input for purchasing [29,30]. Moreover; lack of legal status for water users' associations (WUAs) also a challenge to farmers as it is a requirement by most financing institutions as collateral for accessing loans. Access to credit for financing investment and farm operations is crucial for the commercialization of small holder agriculture. In line with this, it provides the facility of accessing inputs to the farmers and produce good and sufficient production without constrain by shortage of money. Farmers use different sources of credit services to get money for the cultivation of irrigated crop production. There are formal and informal institutions which provide credit service. The informal credit services gain from relatives, neighbors and the likes while the formal credit service is from governmental institution [33]. Informal sources of credit are good opportunities for the farmers in addition to formal sources to intensify irrigated crop production but it is not enough to purchase the input. Moreover, the sampled households were asked whether they need formal credit service from the institution or not to intensify and/or extensive irrigated crop farming. To get credit from governmental institution the irrigators faced complex bureaucracy, short repayment period, high interest rate, lack of collateral to get credit and fear of failed of the planted crop due to uncertain condition. In addition; the farmers fear to borrow money from the institutions because they perceived that if the borrowed money is lost due to uncertain condition; for instance disease, the institution would force them to pay back. Hence, they would sale either their oxen or iron sheet house to recover the collateral credit. Consequently, they would be forced to migrate to other areas to sustain their life. In addition, the complex bureaucracy to get credit is tiresome and involving when beneficiaries only come up as a group. The group members' ranges from five to seven individual farmers and each of them should have collateral to get credit otherwise access was impossible. In this case, if an individual failed to pay back, the group would be forced to pay the money to the institution. But till now, the farmers' informal sources such as borrowing from their relatives without interest could make them beneficiaries but the money from relatives is inadequate to buy inputs. Therefore, the complicated bureaucracy and the need of collateral from governmental organization create a real challenge to the development of irrigated agriculture [33]. Credit access was an important institutional service to purchase agricultural inputs and water pumping motors to enhance the irrigated practice. Microfinance institution and informal credit institutions like *Equb* offer the credit services to user. It facilitated the use of new technological innovations like improved seed varieties [40,38,25]. Similarly; as per Ali and Deininger [41] reported that the availability of formal credit from institutions in Ethiopia is limited due to banking regulations. Credit rationing systems, often practiced in informal forms in Ethiopia.

Table 2. Net income of households from rain-fed and irrigated crop per year

Irrigation areas	Net income (birr)	Mean	P-value
Net income gained from irrigated crop production			
Laytemamagn	33	13.44	
Yewela	70	128.6	0.000
Gotu	0	-	
Total	103	91.71	
Net income gained from rain fed crop production			
Laytemamagn	35	22.41	
Yewela	68	170.31	0.000
Gotu	35	272.81	
Total	138	158.81	

5. OPPORTUNITIES OF THE IRRIGATION PRACTICES

Irrigation contributes to increase food production, promotes economic growth and sustainable development, creates employment opportunities, poverty reduction and protects the environment from degradation and pollution. Furthermore, it increases sub-surface water levels and recharges groundwater [42,43,33]. Crop production is the major source of income. Crop production divided into two, that is, irrigated and rain-fed crop production. As shown Table 2 the study tried to assess the average net income of households gained from both irrigated and rain-fed crop production.

Here, the irrigated crop production average net income per year was less than the rain-fed agriculture net income per year this is due to the cultivation of larger areas during rain-fed farm land is greater than the irrigated farm land. The same irrigated area in the dry season is used to produce crops in the rainy season. Hence, the analysis considered the crops produced by rain-fed during rainy season as rain-fed crop while the crop produced by irrigation as irrigated crop on the same plot of land. Due to this, the average net income gained per year from irrigated crop production is an additional income to rain-fed crop production average net income. Therefore, irrigation is additional gain [33]. The basic opportunistic considerations regarding irrigation developments are: emphasis and priorities are given to irrigation in the growth and transformation plan of the country; indigenous knowledge and introduction of promising household water harvesting and micro-irrigation technologies; government's strong political commitment and encouragement to private sector and public enterprises involvement in irrigation development; abundant water resources, climate and land suitability; availability of inexpensive labour; availability of suitable lands for irrigation developments especially at arid areas of the country [4,44].

6. CONCLUSION AND SUGGESTION

This study has in detail reviewed the Ethiopian irrigation practice challenges and opportunities. The country Ethiopia is gifted with ample amount of water resources, but little has been developed for irrigation. Even if the developed irrigation systems are limited they face a number of challenges and opportunities or within a very low level of performance. The cause for this poor achievement and the dilemma for the failure of the country Ethiopia irrigation development to significantly contribute to the overall socio-economic development lie mainly in the absence of a well defined coherent policy, lack of the required huge investment, weak awareness creation to farmers, and ineffective of irrigation extension system. The other major challenges are technical, socio-economical, Bio-physical, institutional and legal-environment challenges. The suggestions to boost the sustainability of irrigation practice are;

1. There is a strong need to enhance access to institutional support services such as credit and extension, availing market information to guide users.
2. The institutional relation should be strengthening and there should be well defined authorization to each of the institution.
3. The capacity building in various aspects of irrigation management to offer the necessary policy framework at all levels to give more attention to poor people.
4. More opportunities are available to the future but policies and strategies, socio-economic and institutional research should be a prior activity to enhance irrigation development.

5. Participatory approach of irrigation development should be enhanced. This is because of sustainability cannot be achieved without the community participation.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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