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A review on: The over-view of irrigated wheat production and the research achievements of lowland irrigated wheat in Ethiopia

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Abstract
This review summarized the irrigated wheat production and its research achievements including the overall wheat production status of Ethiopia. The opportunities and challenges of irrigated wheat production and the current government initiatives on irrigated wheat production has been also reviewed where availability of excess surface water, human labor and a huge irrigable land were identified as the main opportunities for implementing it in most wheat cultivating areas of the country concluding that a great attention should be given for such income generating and food securing agricultural system. It has been reviewed that wheat is the most important staple crop and widely cultivating in most highlands of the northern, central and south-eastern parts of the country under rainfed though the country has an estimated 3.8 million hectares of irrigable land. Although the potential benefits of irrigation are great, the actual achievement in many irrigable areas of the country is substantially less than its potential that is only almost 5% of the irrigable land is currently irrigated and less than 3% of households having access to irrigation. The national irrigated lowland wheat research and development program identified that the national wheat productivity could be progressed from 30 quintals to 50 quintals per hectare concluding that the irrigated wheat production is a very promising farming system. Thus, it has been reviewed that the confidence of small-hold farmers and commercial farmers in the irrigated wheat production needs to be increased with the increased roles of researchers in the development of irrigated wheat technologies.

Keywords: Ethiopia, irrigation, wheat

Introduction

Wheat is the most important and is ranked second in its total production next to rice in the world. Its global production increased from 763.49 million metric tons in 2019/2020 and 775.82 million metric tons in 2020/2021 production season with an increase of 18.63 million metric tons or growing at an average annual rate of 2.40% from last year [26]. It shares 14% of the total calorie intake in Ethiopia which makes it the second most important food behind maize and ahead of teff and 'Enset' [21] and ranks third after teff and maize in area coverage and second after maize in its total production. It also ranks third in its productivity (30.46 quintal per hectare) after maize and rice [14]. It is the most widely grown crop in the world under a wide range of environments (temperate under irrigated, temperate under high rainfall, temperate under low rainfall, high temperature under rainfed and irrigated, and high latitude under rainfed and irrigated). In Ethiopia the crop is widely grown under high rainfall temperate area under rainfed [17] commonly in the highlands at altitudes ranging from 1500 to 3000masl widely in Arsi, Bale, Shewa, Ilubabor, Western Harerghe, Sidama, Tigray, Northern Gonder, and Gojam agricultural areas of the country [27]. However, the current government initiative is pushing the crop to be cultivated in lowland temperate areas of the country under irrigation with the objective of increasing its area of production and national productivity.

The annual wheat consumption of Ethiopia is increasing at the rate of 9.0% but the local production of the crop is increasing at only 7.8%. This makes the annual demand of the crop to outstrip its annual supply and the country is still importing high amount of wheat every year and is currently grown by an average of 6.6% (for about 34% of the domestic production and >160% of the marketed wheat in the country) [21]. The existing agricultural technology and knowledge in low-income developing countries will not ensure their current food insecurity problem though it has been confirmed that better food provision ensured by increasing the productivity of agriculture and expanding the range of agricultural land use seems to be a possible method to eradicate hunger. Thus, expanding investments in agricultural research and extension systems in developing countries increase the productivity of agricultural production per unit of land and per agricultural workers [23]. Therefore, the fact that Ethiopia has become increasingly dependent on external sources of food supply has become a major concern for policy makers and agricultural researchers that the question of how to make Ethiopia self-reliant in food production has become a major concern in recent years concluding that irrigation agriculture is a crucial agricultural system in reducing food insecurity with the increasing population growth and food demand, and increasing pressure on rain-fed agriculture due to land degradation and climate variability

where income from irrigated agriculture is significantly higher due to dual season crop production and increasing the crops' productivity[6].

Now a days, irrigation farming is identified as an important catalyst for increased agricultural growth in Africa [5] and expanding the countries' irrigation potential can improve agricultural productivity and extend annual growing seasons reducing poverty, food insecurity, and import dependency with an individual and the collective action by governments, the private sector, and communities in rural and urban areas [20]. It is proved that both irrigated and rain fed agriculture are important in the Ethiopian economy but virtually all food crops are rain fed with irrigation accounting for only about 3%. Irrigation in Ethiopia is considered as a basic strategy to alleviate poverty and hence food security by transforming the rain-fed agricultural system into the combined rain-fed and irrigation agricultural system which is believed to be the most prominent way of sustainable development in the country [28]. Thus, irrigation agricultural system is considered as necessity rather than an option and the irrigated wheat production area needed to be expanded especially in arid and semiarid areas of Ethiopia to minimize the commercial wheat imports of the country. The objectives of this review paper were:

1. To review the historical overview of irrigation farming and irrigated wheat production in Ethiopia.
2. To review the irrigated wheat production status of Ethiopia regarding to its production opportunities & challenges.
3. To Review the research achievements on the irrigated lowland wheat production technologies in Ethiopia.

Historical overview of irrigation farming and irrigated wheat production in Ethiopia

In the country, almost 74 million hectares of the land is suitable for agriculture [22] from which it has been estimated that 3.8 million hectares of the potential is the irrigable area [10]. While the potential benefits of irrigation are great, the actual achievement in many irrigated areas of the country is substantially less than its potential that is only almost 5% of the irrigable land is currently irrigated and less than 3% of households having access to irrigation [25].

Ethiopia is gifted with various water resources with 12 rivers, 22 natural and artificial lakes and groundwater [29] with 5.3 million hectares of irrigation potential in which 3.7 million hectares from gravity-fed surface water, 1.1 million hectares from groundwater and 0.5 million hectares from rainwater harvesting [6] but majority of its population are still directly or indirectly engaged in irregular rainfall-dependent agriculture. To use this irrigation potential effectively, the development policy of the country, regional states and non-governmental organizations are promoting small-scale irrigation scheme development so as to increase and stabilize food production in the country [30] considering the number of irrigable rivers in the country which are suitable for large-scale production providing the opportunity for designing appropriate agricultural policy by motivating large-scale farming industries for wheat production with expanding irrigable land bringing a satisfactory productivity of wheat so as to make Ethiopia a competitor to other African wheat-producing countries [2]. Currently, the Ethiopian government is pushing the wheat crop to the lowland temperate areas of the country (the areas where the rain fed wheat production was not yet practiced) to be cultivated under irrigation.

It has been directed that irrigation agriculture is going to be a means for increased agricultural production to meet the growing food demands of rapid population growth. Thus, Irrigation development in Ethiopia can be considered as a basis for assuring food security and poverty reduction tool by stimulating economic growth and rural developments [28] that it has been continued to be a special concern and one of the focus areas of policymakers and planners [31]. Modern irrigation in Ethiopia was started at the Awash River basin in the rift valley with bilateral cooperation of Ethiopia and Dutch company during the 1950s for the productions of commercial crops such as sugar cane and cotton. However, Irrigation was not likely a driving force for the initiation of ancient civilization in Ethiopia [28].

It is proved that there was an increase in Ethiopia's wheat production from 39 million tons in 2016/2017 to 50. 03 million tons in 2020/2021 cropping seasons while the area remained relatively stable mainly due to improved practices, introduction of irrigation and increased support to wheat farmers [3]. Even though there is an increase trends of wheat production in the country, the demand for the crop is continuously increasing with an average annual growth rate of 9%, while the local production is growing only at an annual growth rate of 7.8% mainly due to the increasing population size, changing food preference, a time-to-time reduction in the crop's productivity. But still 90% of Ethiopia's wheat production is on small farms without irrigation [8] and the current national wheat demand gap is being bridged through import putting a pressure on the foreign currency reserve of the country. Now a days, to minimize the imbalance between supply and demand for wheat, the Ethiopian government is heavily expanding irrigated wheat cultivation throughout the country as this enables to yield more harvest at irrigation farming system when compared to the rain-fed wheat cultivation.

It is estimated that the average productivity of wheat is increased from 28 quintals/ha to 50 quintals/ha at rain fed and irrigation farming system respectively predicting that wheat self-sufficiency can be achieved while cultivating the crop using irrigation [2] which agrees with the approval that irrigation agriculture improves an agricultural productivity [32]. It has been also confirmed that bread wheat cultivation under irrigation has a positive impact in the crop's yield [32] directing the possibility of improving the current national rain fed wheat productivity (2.8 ton/ha which is lower than the world average of 33 quintals/ha) by using improved irrigation wheat cultivation techniques that the government of Ethiopia has embarked on its goal to achieve wheat self-sufficiency within a period of 3-5 years by expanding production in the irrigable lowland areas and increasing productivity in the rain-fed agro-ecologies of Ethiopia [33]. During 2020/2021 cropping season, project based

irrigated wheat production have been successfully carried out in 12 woredas of Amhara regional state (on almost 5,000 hectares of farming land) and 21 woredas (on almost 300, 000 hectares of farming land) of Oromia regional state [16].

The Irrigated wheat research achievements of Ethiopia

The wheat research system of Ethiopia has been working to generate yield enhancing of improved varieties along with their full production packages to assist wheat producing farmers of the country. Ethiopian institute of agricultural research (EIAR), in collaboration with its strategic partners, has long been striving to change the production system of wheat by developing its production technologies suitable for the irrigated lowland areas of the country in sequence with cotton and soybean by showing that the irrigated wheat in Ethiopia is the untapped resource.

Variety improvement and development

Worer agricultural research center (WARC) of Ethiopian agricultural research center is the coordinating center for lowland irrigated wheat research and with the effort of the research teams working on the center's irrigated wheat research program and other collaborative stuffs of the institute seven bread wheat and one durum wheat lowland irrigated varieties have been released & it has been showed that improved packages of high-yielding, heat and stress-tolerant wheat varieties could yield up to 65 tons per hectare in hot lowland irrigated areas of Ethiopia.

An irrigated lowland wheat varieties adaptation trial for two consecutive years has been conducted in Mehoni Agricultural Research Center of Ethiopian institute of agricultural research center during 2016 to 2017 under irrigation so as to identify and evaluate the varieties' adaptability and select the high yielding varieties for the lowland areas of Tigray region of northern Ethiopia from which the variety irrigated lowland wheat bread wheat varieties named as 'Lucy' and 'Gambo' were identified and recommended for the study area and similar agro-ecologies of southern Tigray regional state of Ethiopia with their better yield potential of 6.41 ton/ha and 5.79 ton/ha respectively [34].

Table 1: List of recently released irrigated lowland wheat varieties

Type	Variety name	Year of release	Days to maturity	Yield (t/ha)
Bread wheat	Ga'ambo	2011	85	4.5-5.0
	Lucy	2013	81	4.0-5.0
	Werer-2	2013	82	4.0-4.5
	Fentale-1	2015	82	5.0-5.7
	Amibera-1	2015	90	5.0-5.1
	Fentale-2	2017	81	5.5-6.5
	Amibera-2	2017	79	5.0-6.0
Durum wheat	Werer-1	2008	87	3.0-3.5

Source: Ethiopian Institute of Agricultural Research

Improved irrigated wheat technology demonstration

The on-farm improved irrigated wheat technology demonstration was started on a hectare of land in 2012 by WARC in Afar regional state of the country.

Now adays, the demonstration and production activity of irrigated wheat has been expanded to other regions such as Oromia and SNNP by involving many farmers, agro-pastorals and large-scale commercial farmers. During 2019/20 cropping season, almost 15, 100 ha of cultivated land has been cultivated by irrigated wheat mainly in the above listed regional states of the country (Afar takes the lion's share).

Table 1: Improved irrigated wheat technology promotion trends in Ethiopia (2012-2019)

Year of demonstration	Area covered (ha)	Productivity (t/ha)	Total Production (ton)
2012/13	1	2.9	2.9
2013/14	3	3.8	11.6
2014/15	30	4.2	126.0
2015/16	58	3.7	213.7
2016/17	109	2.9	316.7
2018/19	804	3.7	3,029.8
2019/20	3,502	4.4	15,400.0
2020/21	15,100	??	??

Irrigated wheat production opportunities and challenges in Ethiopia

Ethiopia has 124.4 billion cubic meter (BCM) river water, 70 BCM lake water, and 30 BCM groundwater resources [7]. This abundant water resources in the country could be considered as an opportunity for irrigated wheat production. The country has also 3.8 million hectares of potentially huge irrigable area [10] of which only

less than 5% of the irrigable land is used for irrigation farming [25]. Availability of wheat cultivating irrigable and fertile land, good weather conditions, strong interest of research organizations for the crop improvement, the increase in farmers interest to use improved wheat varieties, the importance of the crop in food self-sufficiency, availability of human resource, and expansion of wheat processing industries are the different irrigated wheat production opportunities in the country. The increase in price of the crop through time and an increasing demand of consumers for processed wheat products are also identified as the main wheat marketing opportunities of the country enhancing the irrigated wheat production [2]. The huge Human Labor in the country is an opportunity for implementing a resource intensive irrigation farming. Equations

The area coverage, production, and productivity of wheat is increasing from time to time steadily, and fluctuating as a result of population growth, changing food preferences and a strong urbanization trend. The main market participants of wheat in Ethiopia are producers, processors, assemblers, wholesalers, retailers, and consumers, financial institutions, governments and NGOs [1]. Low level of irrigation, shortage of improved seeds of the varieties, shortage of farming inputs, low educational level of farmers and lack of awareness for new technologies, Lack of technical knowledge about the crop, Low price of wheat grain, Lack of harvest and post-harvest machines and Bird attack are observed as the main wheat production challenges of Ethiopia whereas low quality of wheat produces and less demand for domestic wheat, lack of storage facility, lack of grade and standardization, shortage of infrastructure and traders price cheating are identified as the marketing challenges of the country [2]. Less access to extension services training and less exposure of local farmers to off-farm activities had also a negative effect on the decisions of farmers to adopt irrigation wheat varieties which could be considered as the main challenges of convincing the profitability of irrigated wheat production. [35]. Additionally, credit capacity problems to mobilize capital have been identified as the main challenges of irrigated wheat production in the country [4].

Conclusions and Recommendations

This review presented the short summary of the irrigated wheat production and its research achievements including the overall view on the wheat production status in Ethiopia. Currently, the irrigated wheat production and research achievements received the most attention. This study was also reviewed the opportunities and challenges of irrigated wheat production and the current government initiatives on increasing irrigated wheat production in the country.

There are outlined points of view on the challenges and opportunities of the irrigated wheat production in Ethiopia where availability of excess surface water, human labor and a huge irrigable land considered as the main opportunities for implementing the irrigated wheat production in most wheat cultivating areas of the country including in those area where still wheat cultivation is not yet practiced. Therefore, it has been concluded that a great attention should be given for such income generating and food securing irrigation agricultural system particularly in the area of irrigated lowland wheat production.

From the research results on the irrigated lowland wheat varieties confirming that the wheat current productivity could be progressed from 30 quintals per hectare to 50 quintals per hectare, it is possible to conclude that irrigated lowland wheat production is a very promising farming system. Thus, the government of Ethiopia should give a great attention for the area and even the Ethiopian institute of agricultural research (EIAR) should give a great emphasis on conducting agricultural research on irrigated lowland wheat production technologies since the area is not yet addressed by most farmers of the country specially by those farmers who are living in the lowland pastoral and agro-pastoral areas of the country. The farming system will meet up with its developmental plan on the national economy and rural development that the government planned to stop wheat import from the external sources.

However, irrigated wheat production, whether on small hold or commercial farms, offers some benefits, which also comes with some challenges and already, considerable challenges have been identified in irrigated wheat production. Investment in irrigated wheat production should not be an issue of debate but rather on how to improve the performances of various irrigation schemes across the country by addressing the various challenges encountered, and changing the attitudes of the local and commercial farmers of the country.

Generally, the government is now aware of the significant role of irrigated wheat production for insuring food security and economic growth. The confidence of small-hold farmers and commercial farmers in the area also needs to be increased. Specifically, the roles of researchers in the development of irrigated wheat technologies should be motivated and considered by the government.

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