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Review Article

# Review on Economics of Teff in Ethiopia

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**Abstract**

Teff is widely cultivated throughout Ethiopia as a staple cereal crop, which appears in everyone's dishes of everyday life. With a gluten free and high nutrition values; teff could be the next super-grain and Injera could be the next super-food in the globe. Teff productions in terms of cultivated area and number of producers are incredibly increases over the last 14 years. Teff is the second most important cash crop and generating about 500 million USA dollar incomes per year for local farmers. Apart from this, teff producing farmers are highly depending on the behavior of the other teff producing farmers who spatially closed. Moreover, Teff straw is produced in the largest quantities estimating about 6.93% of the total quantity of cereal crop's straw produced in the country; this helps to address the insufficient animal feed supply for animal production and productivity improvement through enhancing its palatability. The exports of teff in terms of injera in 2015 were estimated at around 10 million US dollar, and the main injera global market outlets were North America, Middle East, and Europe. Among several teff production constraints, technical inefficiency has a leading one. Due to the technical inefficiency of teff production; about 0.4ton/ha grain yield gap between the expected maximum potential and the actual teff grain yield. Teff grain yield gap is estimated about1.1 million ton in 2013 at countrywide due to technical inefficiency. Thus, this review as sought to ascertain of the economics of teff and put highlight policy implication for further assuring food security through teff.

**Keywords:** Ethiopia; Injera; Spatial analysis; Technical efficiency; Teff; Teff export

## Introduction

Teff (Eragrostis teff) is an ancient tropical cereal crop that has its center of origin and diversity in the northern Ethiopian highlands from there it is believed to have been domesticated [8,25,26]. In addition; teff is an untouched cereal crop at worldwide than other cereal crops like maize; wheat; sorghum and barley; however; it is a staple food grain in Ethiopia mainly used to make injera as a traditional fermented Ethiopian pancake. In other countries; like Australia; South Africa; and the United States; it is predominantly used as a forage crop for animal feed [24]. Teff is a cereal crop comprehensively cultivated in Ethiopia with annual coverage of about 2.8 million hectares. This crop has special useful traits both for producers and consumers. For instance;

i) teff is tolerant to extreme environmental conditions (teff is resisted to many biotic and Abiotic stresses);

ii) the seeds are not attacked by storage pests;

iii) the seeds are gluten-free (safe for diabetics as well as sufferers of immune reactions to wheat gluten) and rich in minerals and protein;

Despite all these advantages; a scientific improvement on the crop has lagged far at the back than the level made for the major cereals like wheat and rice. As a result; teff is considered as an untouched (under-studied) crop; and its yield is one of the lowest compared to other major world cereals [20,18]. Teff production area continues to get bigger; and a greater number of farmers are producing teff. Approximately 6.3 million farmers were growing teff in 2013 compared with 4.4 million farmers in 2001/2002. Similarly; teff area planted increased from 1.8 million hectares in 1997 to 2.7 million hectares in 2013. Teff grows in different agro-climatic conditions; including elevations from sea level to 2;800 meters above sea level under a similarly wide variety of moisture; temperature; and soil conditions [15,16].

Teff has a significant role on Ethiopian agriculture; food; and trade sectors. Major Ethiopian farmers rely on teff production because teff is their daily consumption. Therefore; Ethiopia has a great chance to assure food security by boosting teff production and exporting. With a numerous benefit (gluten free and high nutrition values); teff could be the next super-grain and Injera could be the next super-food in the worldwide. Despite of these facts; the productivity of teff is still lower due to spatial heterogeneity like climatic variability; technical inefficiency and other factors. Even though the Ethiopian government gives an attention for disseminating improved teff varieties; fertilizer and other modern

agricultural technologies to small holder farmers; teff is untouched cereal crops to advocate its importance. There are limited comprehensive strategies for teff large scale production; adoption of farm implements at country level. Therefore; information on the role of teff in food; agriculture; and trade sectors; the pattern of teff production as well as challenge and its future prospects should be synthesized.

## Objectives

A. To provide information on the role of Teff in food; agriculture and trade sectors

B. To give insight on the spatial heterogeneity of Teff production pattern over time

C. To review the challenges and future prospects of teff

## Teff production in Ethiopia

Teff is one of the most important and dominant staple cereal crops in Ethiopia. Cereal crops grown on 71% of the total area cultivated and about 61% of total agricultural production shared [15]. Though teff is untouched cereal crop; it is the second largest share of cereal crops production following maize. Teff accounted approximately 28.4% of the total cereal crop's cultivated area and 50% of total cereal production quantity [15]. Teff production area continues to expand; and a greater number of farmers are producing teff. Approximately 6.3 million farmers were growing teff in 2013; compared with 4.4 million farmers in 2001/2002. Similarly; the cultivated area which is allocated to teff is increased from 1.8 million hectares in 1997 to 2.7 million hectares in 2013 (Figure 1).

| Season | Number of holders (millions) | Area (millions of hectares) | Production (millions of metric tons) | Yield (metric tons per hectare) | Total cereal area (millions of hectares) | Teff area share (%) |
|---|---|---|---|---|---|---|
| 1997/1998 | — | 1.75 | 1.31 | 0.7 | 5.6 | 31.2 |
| 1998/1999 | — | 2.09 | 1.64 | 0.8 | 6.7 | 31.0 |
| 1999/2000 | — | 2.12 | 1.72 | 0.8 | 6.7 | 31.5 |
| 2000/2001 | — | 2.18 | 1.74 | 0.8 | 7.6 | 28.6 |
| 2001/2002 | 4.4 | 1.82 | 1.63 | 0.9 | 6.4 | 28.5 |
| 2002/2003 | — | — | — | — | — | — |
| 2003/2004 | 4.6 | 1.99 | 1.68 | 0.8 | 7.0 | 28.4 |
| 2004/2005 | 4.9 | 2.14 | 2.03 | 0.9 | 7.6 | 28.0 |
| 2005/2006 | 5.2 | 2.25 | 2.18 | 1.0 | 8.1 | 27.8 |
| 2006/2007 | 5.4 | 2.40 | 2.44 | 1.0 | 8.5 | 28.4 |
| 2007/2008 | 5.9 | 2.57 | 2.99 | 1.2 | 8.7 | 29.4 |
| 2008/2009 | 5.8 | 2.48 | 3.03 | 1.2 | 8.8 | 28.3 |
| 2009/2010 | 5.6 | 2.59 | 3.18 | 1.2 | 9.2 | 28.0 |
| 2010/2011 | 6.2 | 2.76 | 3.48 | 1.3 | 9.7 | 28.5 |
| 2011/2012 | 6.3 | 2.73 | 3.50 | 1.3 | 9.6 | 28.5 |
| 2012/2013 | 6.3 | 2.73 | 3.77 | 1.4 | 9.6 | 28.4 |

**Figure 1:** Teff production characteristics over time.
Source: Ethiopia, CSA data at different time periods cited by [28].
Note: The blank space indicates that data is not available.

Although area coverage for teff continues to increase; the growth in production has been driven more by yield increases (that doubled) over time than area increases. This increment is due to a number of factors including relatively high market prices of teff grain and straw. In addition; teff is versatile; as it grows in a wide variety of agro-climatic conditions; including elevations from sea level to 2;800 meters above sea level (masl); under a similarly wide variety of moisture; temperature; and soil conditions. The cultivated area for teff and other cereal crops has increased proportionally over time.

## Farming practice in teff production and their effectiveness

There are two major types of Teff farming practices in Ethiopia; such as; broadcasting and row planting. Teff planting with broadcasting method is considered as a traditional teff farming practice and it has a number of disadvantages like it need much amount of seed rate; reduces the productivity computation of soil nutrients and alike. On the other hand; Row teff planting method is expected to increase teff productivity; requires small amount of seed rate; but; in reality; it is labor intensive and requires mechanization issues due to the size of the seed is too small. As a result; farmers exposed only put a relatively small part of their farm plots aside for row sowing due to requiring additional labor and back to the traditional way (teff sowing with broadcasting). The issue of the viability of teff row planting under the current agricultural technology of Ethiopia is debatable. Some studies disproved that teff row planting is not cost effectiveness. In contrast; the cost-benefit analyses showed that the increase in teff yield compensates the cost of the additional labor in the first year of adoption when yields increase by 8% and more. Apart from this hard fact; suitable mechanization for row planting of teff would change the cost-benefit picture significantly and is shown to be an investment with possible high returns [23].

The intensity of use of improved teff varieties was high in Ethiopia; which is estimated about 84% [33]. This indicates that farmers have established a system whereby they produce and exchange the seed of improved teff varieties locally either sold by Ethiopian currency or exchange by items (exchange by another crop). The main teff seed sources were neighbors; own saving from the previous year; farmers union or cooperatives; local traders;



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extension agent; local seed producers and research institutes [33]. Among such types of seed sources; seed sources from neighbors are the first largest improved teff seed source; which is estimated about 47% [33]. This implies that teff producing farmers are highly depending on the behavior of the other teff producing farmers who spatially closed; for instance; information exchange; making network and other issues regarding agricultural improved inputs and knowledge might have high for spatially closed or neighbor farmers.

## Dynamics of spatial heterogeneity for teff production

The use of spatial analysis in agriculture also began in the 1990's with the realization that factors such as climate; pest populations; land configurations; and soil characteristics all had spatial variability [4]. Another geographical issue that is investigated in agriculture is the neighborhood effect. Neighborhood interactions change individuals' decisions; information sets; preferences; and behavioral outcomes [3]. In agriculture; neighborhood interactions have primarily been opened to investigate drivers of technology adoption [5]. The optimal growing conditions for teff corresponds about 1;800–2;100 meters above sea level; average annual rainfall of 750 to 1;000 millimeters; and an average annual temperature of 10 °C to 27 °C [6]. Due to this spatial heterogeneity; there is great variation in the production and productivity of teff within this growing condition area.

Ethiopia has a diverse agro-ecology zones; such as from extremely lowland up to highland throughout all regions. Oromia and Amhara regions represent the largest teff producing regions; these accounted about 85% of the national teff production volume and 84% of area cultivated during 2010/2011 cropping season. The third largest teff producing region was Southern Nations; Nationalities; and Peoples' (SNNP) region; despite the fact that its contribution to national teff production and cultivated area coverage was significantly lower; estimating 8.5% and 9.6% during 2010/2011 cropping season; respectively [28].—Additionally; the amount of teff straw available for livestock feeding is also a spatially significant difference between different regions; which is dominated by Oromiya and Amhara having 45% and 40.4% of the national share; respectively. Like teff grain yield production variability; the trend of teff straw availability is spatially diverse [36].

Both of the production of teff grain yield and its straw were heterogeneous over time across political division of land. However; there is not an any solid reason to support the spatial heterogeneity being analyzed at the political division level because mostly heterogeneity occurs owing to geographical and climatic characteristics of the area [17]. Therefore; regional teff grain and straw yield heterogeneity do not necessarily correspond to the political divisions of the land. We could not find any literature about the spatial heterogeneity of teff production and productivity based on the geographical and climatic characteristics rather than political division (regions).

## The role of Teff in Ethiopian agriculture

Teff made up 22% of all the cultivated area by private smallholder farmers which estimating about 3 million hectares and that it was grown by 6.6 million farmers [30]. There is a total of 15.3 million farmers in Ethiopia; this implies that 43% of all Ethiopian farmers grow teff. Therefore; this sector is the most important in Ethiopia's agricultural economy; which accounts for 72% of all cultivated land. [22]. On the other side; the price of teff per kilogram is significantly higher than other cereal crops; for instance; the production value of teff in 2013/2014 comparing it to other cereals is found to be valued at 2.52 US dollar [22]. The role of teff in agricultural production has significant differences in different regions. This significant difference could be driven by climatic variability and other factors. Oromia region is the most important teff producing area in the country; and its share in total national production is estimated to be as high as 48%. The second highest region is Amhara region with 39%. The rest regions are comparatively less important [22].

54% of the total cultivated area in 2013/2014 was cultivated by farms that are less than two hectares and the rest 46% of the cultivated land was in the hands of farmers with farms larger than 2 hectares. Apart from the general crop cultivation area allocation; 73% of the teff cultivated farm area was in the hands of farmers who have less than 2 hectares and the remains 27% of teff cultivated farm area belongs to farmers who have greater than 2 hectares [11, 12, 14, 22]. This indicates that teff producing farmers are small scale; meaning that teff production system is not commercialized in the country; it remains still fragmented and it might have a negative influence on the role of teff for Ethiopian economy. Another role of teff in agriculture is that it serves as animal feed. The sources of livestock feed in Ethiopia are grazing (61.48%); crop straw (27.71%); hay (6.35%); by-products (0.82%); improved fodder (0.8%) and others (3.47%); [10]. This indicates that crop straws are the second most important sources of animal feed in Ethiopia Teff straw is a cereal crop straw which is accounting about 6.93% of the total quantity of cereal crop straws produced in the country [2].

Moreover; 36.3% of total cultivated land in the 2004/2005 cropping season was allocated to teff and that 6.47 tons of crop straws were produced. At the household level; teff straw (33%) followed by maize stover (31.6%) and wheat straw (6.97%) contributed to the total annual crop straw production by households [31]. The other study showed that among the total teff straw (9.54 million tons); only 6.68 million tons of teff straw was available for animal feeding at the national level [36]. The reason could be wastage due to the long distance between crop fields and homesteads and unavailability of transport though teff straw has least wastage than another crop's straw [31]. Therefore; teff is not only grain yield; but also its straw yield has a valuable role in the agriculture sector in Ethiopia. Meaning that; there is a room to improve animal production and productivity by fostering teff straw and enhancing its feeding value because inadequate feed supply



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both in terms of quantity and quality is the major constraint for livestock production in Ethiopia especially during the dry season.

### The role of teff on food economy in Ethiopia

If teff consumption is disaggregated by region (Figure 2); distinctive patterns become apparent. As indicated; the highest teff consumption appears in Ethiopia's major cities; with Addis Ababa in the lead (101 kilograms per capita); followed by Harar (40 kilograms) and Dire Dawa (38 kilograms). The country's major production zones also show relatively higher per capita consumption levels; 36 kilograms in Amhara; 35 kilograms in Oromia; and 38 kilograms in Tigray. Consumption levels are relatively low in the southern (a region known for consumption of root crops) and western parts of the country (a region where maize is commonly consumed) that is; 19 kilograms in SNNP; 17 kilograms in Gambela; and 3 kilograms in Somali. Injera is consumed more in urban areas both in relative and absolute terms. Except for Addis Ababa; the Amhara region is the only region where white teff consumption exceeds 10 kilograms per capita per year.

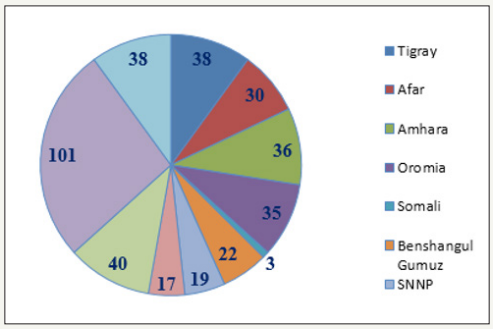


**Figure 2:** Teff consumption by regions and major cities in kilograms per capita per year.
Source: Own analysis based on [22].

## The Role of Teff on Ethiopian Trade Sector

### Teff exports

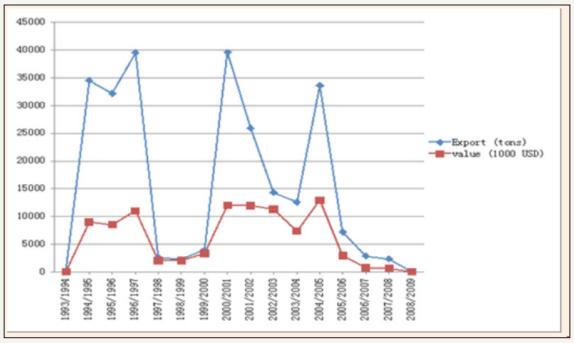


**Figure 3:** Trend of teff export in Ethiopia.
Source: FAOSTAT teff is considered as cereal [37].

Teff is largely produced for market because of its high price and absence of alternative cash crops [8]. Teff is the second most important cash crop after coffee and generating around 500 million USA dollar incomes per year for local farmers [29]. The volume of export has fluctuated and relatively a larger quantity was exported in 1995-1997; 2001 and 2005 but export has declined since January 2006; mainly due to high domestic prices and government export ban on unprocessed Teff grain (Figure 3). The main reason was to bring domestic inflation price into consumers' affordable level and meet local food security demand before export. However; the imposed ban averts the Ethiopia government particularly farmers from engaging and benefiting in the raising world trade; which could increase GDP and change the livelihood of producers. However; some report showed that demand is thought to be very high in the USA; middle east and Europe due to an enormous number of Ethiopian immigrants live there.

### Value-added products of teff

Teff is the most value-added crops compared to other cereal crops. Following the imposing ban on raw teff grain export; selling of processed from of teff product is started to rise at national and global level as well as benefited many stakeholders involved in the process. Currently; Ethiopian pancake (injera) is found for sale in domestic and international market. It contributes to job creation for many people of the country.

### Injera exports

Due to the number of benefits (gluten free and high nutrition values); the demand for Ethiopian teff is exponentially increased at worldwide; therefore; it is suitable to prepare food products for people who suffer from celiac disease [24]. Additionally; teff has even been reported by some international newspapers and media as the new super-food like Quinoa [32]. The international market for quinoa is speedy. Quinoa is a gluten-free cereal crop like teff; which typically produced in Peru and Bolivia the quinoa market has given to attention for the Ethiopian government to revise the export ban of teff and reopen teff export markets in order to increasing global market demand.

As depicted in (Figure 4); the exports of injera in 2015 were estimated at around 10 million US dollar. Then main injera international market outlets were North America; Middle East and Europe. The largest share (approximately 2.5 million US dollars) of injera exports has gone into North America in the 2015 year. The reason could be driven by in millions of Ethiopian immigrants' demand who remain attached to the cooking culture of their homeland. However; in the future; the demand for injera might be exponentially increased due to its high nutritional values and gluten free grain crop.

### Teff nutritional values and its contribution to human health

Before some years ago; there was limited knowledge of teff's nutrient composition. Due to this reason; it was hard for making teff-based food products for global consumers. Consequently; the human consumption of teff at globally was too low. However, studies stated that on the nutritional consumption of teff and its processing quality and new teff-based products have grown. Teff provides two-thirds of the basic nutrition for the people. According to a numerous-studies; Teff is highly rich in: Minerals; protein;



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carbohydrate (the newly discovered teff dietary fiber is good for blood sugar management; weight control; and colon health) and also; it has low in sodium; bad fat; and cholesterol. The main interesting point is that teff is a gluten-free grain and it helps to fight the celiac disease like diabetics and obesity. Estimated about 285 million people worldwide were diabetic in 2010 [34]. But; about 20-30% reduces the risk of developing type 2 diabetes by consuming teff [32]. Teff is a good possible solution in preventing and controlling iron deficiency and diabetes. This implies that the potential of teff to be a future global functional food for health promotion and disease prevention mechanism.

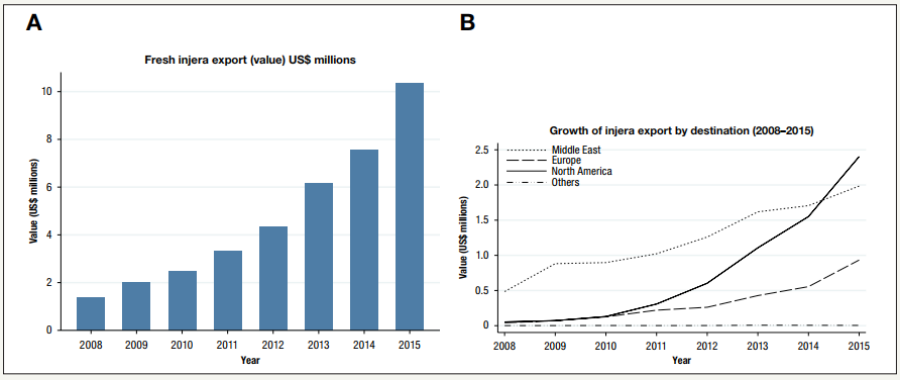


**Figure 4:** Injera exports from Ethiopia, by value, 2008–2015.
Source: CSA agricultural Sample Surveys, 2003/2004–2013/2014 cited by [22].

## The challenges of teff sector in Ethiopia

Among the main challenges for teff production in Ethiopia; inefficiency production system; climatic factors; presence of low yield varieties are the most significant problems which affect the teff production across different agro-ecology zones. Hence; in this paper; only the inefficiency of teff production system in Ethiopia is reviewed.

## The efficiency of teff production in Ethiopia

Theoretically; there are three possible alternatives to increase teff production:

(i) increasing the level of input use; for example; expansion in the area and increasing the level of other external inputs. Mostly; this option is not a viable option because resources like land are becoming limited.

(ii) Improving the efficiency of resource use. Through increasing the technical efficiency of tef production; it is possible produce the maximum possible output from the same level of resources using the current technology. Moreover; it also refers to narrowing the gap between the actual yield and the potential or maximum yield.

(iii) Technological change which involves the use of new technologies such as developing new high yielding varieties. In this case; the change raises the production frontier to a higher level. The last two options are the most important sources of growth in production and have been an area of great interest for both economists and policymakers [33].

Technical efficiency is defined as the effectiveness with which a given set of inputs is used to produce an output. A firm is said to be technically efficient if a firm is producing the maximum output from the minimum quantity of inputs; such as labor; capital; and technology. Technical efficiency requires no unemployment of resources [35]

$$\text{Technical efficiency} = \frac{\text{actual output from the given inputs}}{\text{maximum potntial output from the given inputs}} \times 100$$

The yield potential is defined as the yield of a crop when it is grown without any biophysical limitations other than uncontrollable factors; such as solar radiation; air temperature; and rainfall in rainfed systems [27]. Therefore; the yield gap is estimated by the difference between the yield potential and average farmers' yields. There are three groups of factors that affect the yield gaps in farmers' fields [27]. These are:

i) biophysical factors including varieties; inferior seed quality; weed pressure; insect damage; diseases and other pests; soil problems; drought; flooding; nutrient deficiencies and imbalances; and lodging

ii) socioeconomic factors involving profit maximization; risk aversion; labor shortage; farmers' knowledge and skills on best practices; lack of access to credit; etc.,

iii) institutional factors including governments' policies; output price; agricultural credit and input supply; agricultural research and extension.

Moreover; the major challenges in yield gap analysis identification and gain quantification problem; meaning that it could be hard to identify which factors that have the greatest impact and that it gains that could be realized if these constraints are removed.

## Intuitive Analysis of Teff Technical Inefficiency

The maximum yield of teff at research field level is about 2.7 ton per hectare. Despite this Figure 5; the actual yield of teff at



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farmers' field is estimated about 2.3 ton per hectare (Figure 5). As a result; the yield gap between the maximum potential teff grain yield and the actual teff grain yield is estimated about 0.4 ton per hectare. About 28.4% of 9.6 million of hectares of the cereal crops is allocated to teff production in 2012/2013. Numerically; the share of area allocation for teff is accounted about 2;726;400 hectares in that cropping season. Analytically; 2;726;400ha.*2.7ton/ha=7.361;280ton teff grain yield should be produced. However; in reality; 2;726;400ha.*2.3ton/ha=6;270;720ton teff grain yield was gained. Meaning that 7.361;280ton-6;270;720ton=1;090;560ton teff grain yield was lost. The reason could be technical inefficiency in terms of lack of extension service; inefficient use of the existing resources; pos harvest loss; other demographic and institutional factors. This economic interpretation is similar to the recent findings.

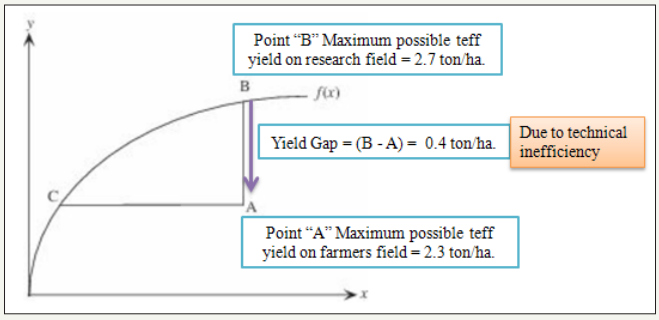


**Figure 5:** Teff yield gap analysis due to technical inefficiency.
Source: Own computation based on [7].
Note: y represents teff grain yield and x represents the level of input usage.

Studies showed that the variation in output due to technical efficiency for teff was estimated about 67.26% [34]. This indicates that there is a room to enhance the productivity of teff by 32.74% at a giving level of input and current technology. According to him; there were giant yield gaps for teff than other cereal crops. This could have a significant negative impact on the share of Ethiopian economy and consumption level of the consumers directly. Another study showed that the technical efficiencies of teff production were on average 80% and 83% for extension package program participant and extension package program non-participant teff producing farmers; respectively [19]. This implies that without investing any additional resources; teff production could be increased by 17% to 20% by using the existing technology. Generally; the technical efficiency of teff productions said to be minimal than other cereal crops (maize; wheat; barely sorghum) in Ethiopia.

## The future prospects of teff sector in Ethiopia

While teff has survived for thousands of years as a major staple food for humans and as fodder for cattle; it has a number of advantages in health benefit; animal feed; crop risk aversion and other aspects. For instance; teff can be grown under moisture-stress areas and waterlogged conditions; is a valuable animal feed due to highly preferred by animals; gluten free; a reliable and low-risk crop; not attacked by weevil and other storage pests; stored for a relatively long period of time [26]. Recently; the government gives permission for a small number of commercial farmers to start producing teff to fulfill this export demand because of the local price increment and exports of injera are rapidly increasing.

As a result; the demand of teff incredibly increases throughout the world. Additionally; with a numerous benefit; teff could be the next super-grain and Injera could be the next super-food in the worldwide. Teff is the most labor-intensive crop and its cost of production is relatively high compared to other cereal crops [1]. Therefore; it requires developing an inclusive strategy at country level for large scale production; adoption; and maintenance of farm implements. Effective and efficient farm technologies might address the most burning backbreaking work of teff cultivation and its cost of production.

## Summary and Policy Implication

Teff is growing in diverse agro-ecology zones from sea level to 2;800 meter above sea level. The share of the cultivated area for teff and the number of farmers; who producing teff are alarmingly increased over the last 14 years. Apart from this; there is a significant difference between production and productivity of teff in Ethiopia among regions. Meaning that teff producing farmers are spatially dependent. Teff has a significant role on Ethiopian agriculture; food; and trade sectors. Therefore; Ethiopia has a great chance to assure food security by boosting teff production and exporting. With a numerous benefit (gluten free and high nutrition values); teff could be the next super-grain and Injera could be the next super-food in the worldwide. Despite of these facts; the productivity of teff is still lower due to spatial heterogeneity like climatic variability; technical inefficiency and other factors. The main challenges for teff production are technical inefficiency because its technical inefficiency is lower. Meaning that; there is a significant yield gap between the expected yield approved by research field and the farmers' actual yield of teff in the country.

Therefore, based on this conclusion; the following policy implication and the area-specific solution can be drawn.

A. The role of teff for Ethiopian GDP and people's livelihood should be disseminated throughout the world and create and expand global demand to foreign exchange earnings for the country.

B. Advocate teff for International research and development institutions to study further for productivity increment.

C. Effective mechanization for teff planting; weeding; harvesting and storing should be innovated.

D. Value-added teff products like biscuits; cake; and beer should be made.

E. Factors affecting the technical inefficiency of teff over time should be considered by policy makers and planners and redesign the appropriate solution in multi-dimension aspects.

F. The detailed spatial heterogeneity analysis of the technical and economic efficiency of teff should be done accordingly.



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G. Teff breeding should be more emphasized to release high yield teff varieties and reach to the whole farmers.

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