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Review Article

Economic Potentials and Use Dynamics of Sorghum Food System in Ethiopia: Its Implications to Resolve Food Deficit

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Agriculture continues to be vital to Africa's future in both spatial and temporal contexts. Nonetheless, the sector keeps on confronting production challenges as a result of frequent and extended droughts, and these necessitate the use of drought-resistant crops such as sorghum. This review initiates one of the most common food grains grown in the poorest countries and the most food-insecure regions of the nation. We used deductive logical reasoning to develop a comprehensive scientific understanding of the crop that can be used to inform future research and policies. Various exclusion and inclusion criteria were used to filter the most prominent findings. Sorghum has the highest utility for its climatic adaptability and has grown for multiple purposes: From staple to industrial outcomes, its economic, social value, and health outcomes, and for animal silage. It is a gluten-free crop, has high nutritive value, and is preferred by healthy consumers. It is among the top five cereal crops worldwide in both production and acreage. This has necessitated the development of coping measures, such as the cultivation of drought-tolerant crops suitable for the affected areas. Therefore, this crop is used to ensure productivity, food security, and availability of food when other crops fail and food deficit and famine are affected in the region. This will contribute to the ongoing discussion on how to better inform private and public sector policy and investments in Ethiopia to increase sorghum and other drought-tolerant crop production, transform agriculture, improve nutrition, and food systems, and end hunger, food insecurity, and poverty.

1. Introduction

Sorghum (*Sorghum bicolor* (L.) *Moench*) is the fifth most significant cereal crop in the world after maize, rice, wheat, and barley [1]. It is a significant food security crop in Sub-Saharan Africa, with 300 million people depending on it. It is produced in semi-arid zones in drought-prone and marginal locations where other crops fail to thrive. Sorghum is a key staple food crop in Ethiopia, coming in second after maize in overall production. It is third in terms of productivity per hectare, after wheat and maize, and third in terms of farmed area, behind teff and maize covering a total land area of 1.8 million ha [2]. It is grown in practically every part of the world.

Global food security discourses often focus on how to grow sufficient food to feed a population of 9 billion through 2050 [3]. Nowadays, with increasing world populations and changing diets, much more nutritious foods are a vital issue. In one way, food is linked with a host of sustainability challenges [4–6].

African countries such as Seychelles, Nigeria, Mauritius, Algeria, Morocco, Egypt, and South Africa have been trying to show some progress in poverty reduction, but the reality today is that a high number of people remain vulnerable to hunger [7–9]. Especially, food, anxiety, and hunger are widespread in Sub-Saharan Africa. This is because food insecurity is still an unsolved headache as a result of many problems, Mainly various scholars [10–12], and [13] mentioned that political instability, environmental deterioration, conflicts, civil wars, corruption, inequality, misdirected policies, and problems associated with the investment, strategic trade, healthcare, and food system are the key challenges to put impoverished people under their briefcase.

Similarly, Ethiopia is one of the most frequent food deficit and famine-affected countries in Sub-Saharan Africa. Pastoral and agro-pastoral in arid and semi-arid areas are taking a large portion of the challenge due to natural and man-made problems [14, 15]. Nevertheless, cereal crop production has an enormous contribution to solving food and economic victimizing problems in Ethiopia, which covers 29% of the agricultural GDP (14% of total GDP), and 64% of the calories consumed [16]. Specifically, sorghum is one of the staple food grains grown in the poorest and most food-insecure areas of the country.

Moreover, sorghum is a versatile crop produced under adverse conditions of low-input use and marginal land, of which 35% are directly grown for human consumption and the rest for use for animal feed, alcohol, and industrial products [17]. Instead of its extra usage of sorghum crops (used as an animal feed alcohol), it has proven a potential remedy for famine in the wider population of Ethiopia. Similarly, grand populaces in the East, West, and Southern parts of Ethiopia are reliant on it [18]. Culturally, it is a staple food that saves millions of people in Ethiopia. In addition to this, it is a drought-resistant crop and a vital food supply in terms of dietary as well as social-economic values, more than ever in semi-arid agro-ecology [19].

Although the crop is adaptable to water-stressed and less fertile soil areas, it has suffered from stem borers, shoot flies, quelea birds, and Striga weeds in Eastern African countries. Even though the yield of sorghum is reduced, the impact of these constraints differs from region to region, within and between countries [21].

Lots of research has been conducted so far about sorghum production in different parts of Ethiopia. For instance, IDIOUF [21] focused on sorghum production. Deribe *et al.* [22] and Solomon [23] also stated about the efforts in the use of technology in sorghum production and in the creation of sorghum-based products are minimal. However, none of them are comprehensive enough to handle the food system dynamics, economic potential, and casual loops of the crop to reconcile the food deficit in Ethiopia.

In this review, we emphasized the issue of food insecurity, which is a major concern coupled with inadequate agricultural practices in Ethiopia. This has necessitated the development of coping measures, such as the cultivation of drought-tolerant alternative crops. Sorghum is our concern because it is a common stable crop in drought-affected parts of the nation. To improve the consumption of the crop at large in the country, it is necessary to explain its potential use, nutritional values, and productivity potential. Hence, sorghum is one of the potential crops under high-stress situations, ensuring productivity, food security, and availability of food when other crops fail. As a result, we place a great deal of reviews on sorghum and its relevance to drought-affected areas.

Our primary concerns and ambitions are to expand the notion of the sorghum food system, use dynamics, and its function in food security discourse in Ethiopia, where drought and climatic disasters are the most severe. There is little actual evidence on how sorghum production is seen, as well as the economic and environmental benefits it renders. Therefore, this work was initiated to review scenarios from the relevant literature on sorghum production and spatial distribution. Moreover, with food shortage and marketing opportunities; nutritional potential, causal loop, and use dynamics of the crop were largely reviewed.

2. Methodology

This review article is held based on analytical review techniques following and agreed upon the necessary principles and procedures. For example, we have to scrutinize the burden of food shortage, the spatial distribution of sorghum, market prospects of the crop, the casual loop, and its food system. The review process held thorough searching of various related literature and empirical findings in multiple databases as mentioned below in the sub-topic of our search strategy. The authors' experience and long-term exposure to people who have enormous sorghum farming methods were also taken into account during the review process.

This review is also organized using temporal and spatial features that can filter information, such as current and older studies that show the dynamic function of the food system and the nutritional potential of sorghum in comparison to typical stable crops for Ethiopians. Furthermore, the authors attempted to comprehend scientific facts from various articles to create maps of the food system that interlink how the casual loop works and how this affects us as individuals and communities based on our country's experience. Moreover, the writers answer what will be the nutritive potential, health benefits, economic roles, social, and industrial outcomes of the sorghum food system.

2.1. Search Engine Strategy. This review article was based on information from Google Scholar, Web of Science, Scopus, MPDI, and SAGE that mostly focused on peer-reviewed published journal articles, books, reports, journals, and conferences. Important keywords like "sorghum," "food system," "sorghum contribution," "food security," "sorghum farming," "nutritional content of sorghum," and "current challenges of sorghum production in Ethiopia" were used to narrow down the results. Over 130 journal articles, books, conference papers, thesis works, and agency reports connected to the issue were collected using the searching keywords. Then, we ignored 30 articles that are unpublished theses, conference papers, and those which lack full publication addresses. Then, we also leave 14 articles that are the oldest ones (beyond 15 years of publication) and use the exclusion criteria here mentioned. Finally, we have remained 86 relevant resources prioritized for use in this review. The inclusion criterium was the relatedness of the study to our objective (s), being peer-reviewed journal articles under highly indexed databases such as Scopus and Web of Science, Social Science cite score, and recentness. While we exclude the oldest articles, not indexed in the above-selected journals, as well as the less relevant items from our total collection of articles for the crop under review.

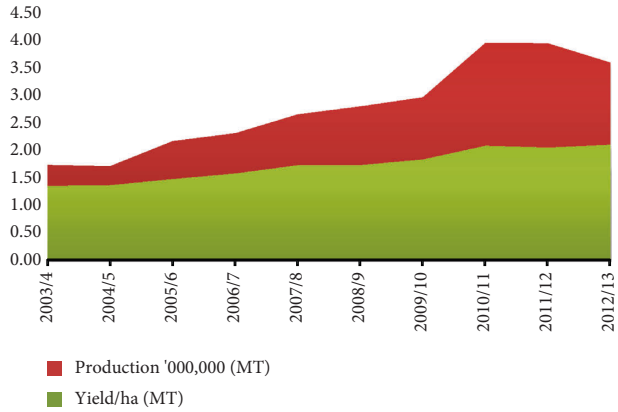

Figure 1: World sorghum producers (averaged 2006–2012) Source: CSA reports from 2003 to 2013.

2.2. Sorghum Production and Spatial Distribution in Ethiopia. The imbalance rise in population growth and food production [24–27] was helped by the larger reliance of rural livelihoods on agriculture-led revenue sources [28]. This will cause the country to get into a lot of trouble such as it leading to a decline in human health and production capacity. Enhancing productivity with the help of improved varieties and modern technologies is the key to eliminating such problems, and it must play a key role in boosting productivity such as staple crops.

Sorghum is one of Ethiopia's most important grain crops, and it is a staple diet for a large number of people [29, 30]. In terms of cultivation area and production value, it is the most significant crop. Ethiopia supplies about 5% of global sorghum production (Figure 1). It accounted for an estimated 1.7 million hectares in 3.60 million metric tons of output and 2.11 metric tons of yield per unit area in Ethiopia (Figure 2). As can be observed in the same figure, the trend of farmers grew significantly between 2003 and 2013. From 2000 to 2017, the average annual growth rates of area coverage (ha), production (Qt), and productivity (Qt/ha), according to FAOSTAT [1]; were 4.3%, 9.2%, and 4.97%, respectively. According to the analysis of the same survey, although the production rate is outgrowth year by year in Ethiopia. The current sorghum output is insufficient to fulfill local demands, forcing the country to import the grain. However, in terms of agricultural land usage and total value, it is one of the significant food crops for the people. It may grow in a variety of environments and can even survive in severe conditions. The crop is important for income, food, and nutrition security and is farmed by a large number of smallholder farmers across the country.

Sorghum is currently cultivated in a wide range of agroclimatic settings [31, 32]. It is cultivated in all regions of Ethiopia, as shown in Figures 2 and 3. It can grow between 400 and 2400 meters above sea level [34], and another research [35] found that it can grow between 500 and 2,300 meters. Figure 3 shows the Geographic distribution of Geo-referenced sorghum production access. Color

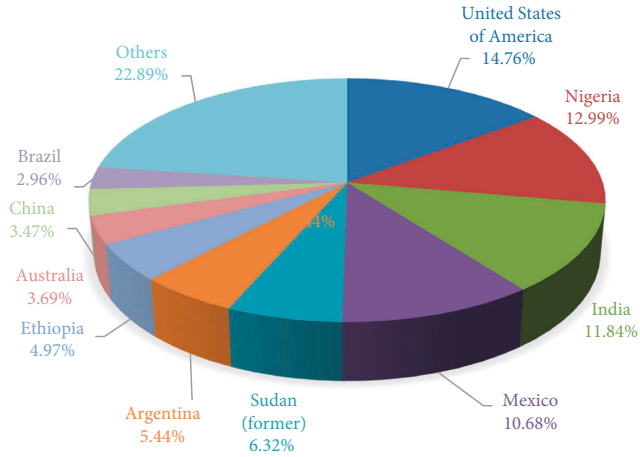

Figure 2: Area (ha) and production (MT) trend of sorghum in Ethiopia. Source: FAOSTAT, a report from 2006 to 2012.

highlighted areas in the map represent sorghum sample accession collection sites within regions of their genetic diversity [33]. Furthermore, Figure 4 depicts the four main regions of sorghum producers as Oromiya, Amhara, and Tigray, and the people of the southern nation and nationality region among other sorghum producer regions.

Likewise, this crop is mostly grown in the western, southwestern, north-eastern, north, and eastern parts of the country. Dry lowlands (1000 mm), and highlands (>1900 m) are suitable agro-ecological zones for the crop [37]. According to EIAR [35]; dry lowland (<1600 m with <800 mm), wet lowland (<1600 m with>1000 mm), intermediate altitude (1600–1900 m with 900 mm rainfall), and highland (1900–2500 m). Moreover, Deresa et al. [38]; reveal that the highlands comprise locations with altitudes between 1900 and 2700 meters.

2.3. The Burden of Food Shortage and Market Prospects for Sorghum Production. Since 1980, Ethiopia had a structural food shortage [39]. The gap between rich and poor in terms

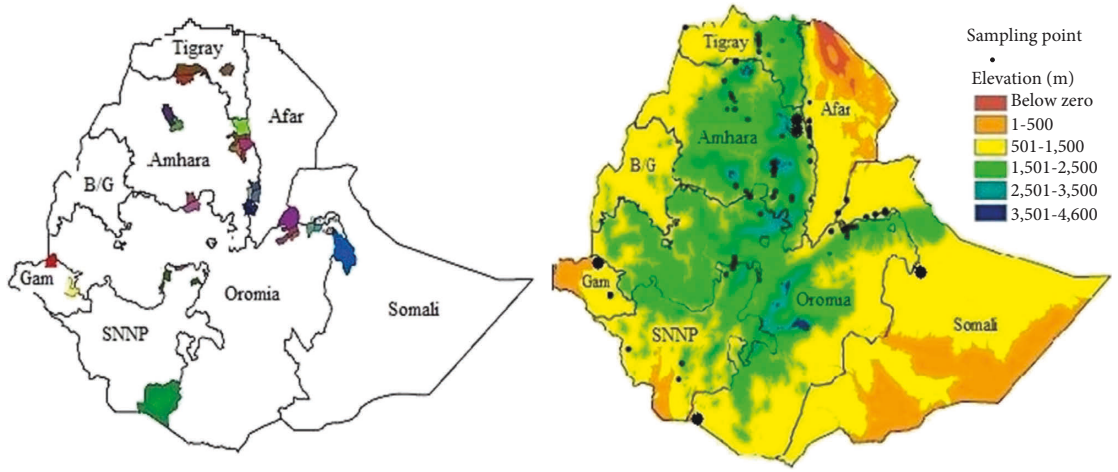

FIGURE 3: Spatial distribution of Ethiopian sorghum accessions. (a) Geographic distribution of geo-referenced Ethiopian sorghum accessions. Color highlighted areas represent accession collection sites within regions. (b) Geographic distribution of the Ethiopian sorghum accessions along an elevation gradient. B/G (Benishangul-Gumuz); Gam, Gambella; SNNP(Southern Nations). Source: Wondimu, et al., [33].

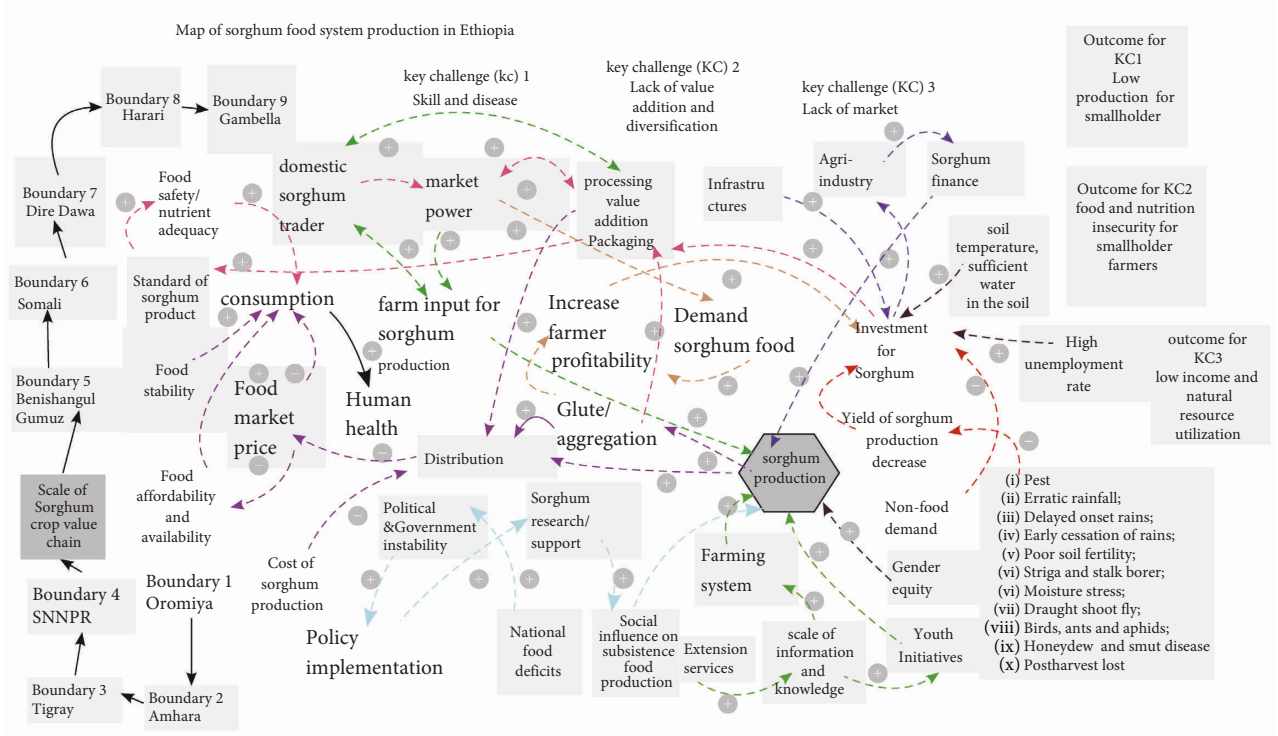

FIGURE 4: Causal loop and system dynamics relationship map for sorghum production, concept ideas from [36] Source: Authors' elaboration.

of food is gradually widening [40]. The line between temporary and long-term food poverty is becoming increasingly complicated [41]. Saifaddin [42] indicated that Ethiopia had 22.4 million people without enough food to eat as of April 2021. In Ethiopia, food insecurity was estimated at 20.5 percent of the population. Altogether, the number of persons with inadequate food consumption has increased by almost 51.4 percent since the beginning of the year.

According to Global Hunger Index [43, 44], Ethiopia was a severe food shortage and ranked as one of the world's poorest countries, with an estimated 5.2 million people who need food aid in 2010. The same agency predicted that Ethiopia has been a high-ranked food shortage country in the world. As World Food Program [45]; estimates that Ethiopia has 5.9 million people with urgent food needs, and 3.9 million women and children who are nutritionally

vulnerable. There are 13.2 million individuals who are food insecure, according to estimates. Food insecurity and hunger are on the rise in northern Ethiopia, according to the World Food Program, as the war in Tigray spills over into the surrounding regions, while other reasons stay consistent.

Besides, economic reform in the form of structural adjustment programs for sustainable development, aimed at maintaining a liberalized market-oriented economy, has allowed smallholder farmers in Sub-Saharan Africa to diversify their products and target high-value markets such as export and processing-oriented market channels [46]. Due to the development of strong markets for possible alternative grains in recent years, Ethiopian sorghum output and consumption have expanded. With the government investing heavily in extension initiatives and tightening government control over the importation of all commercial grains, efficient policy execution is playing a key role in markets.

Currently, urbanization represents a wonderful opportunity for the growth of agricultural cereal crop marketing, such as sorghum. Similarly, advantageous agricultural marketing locations in districts increased domestic demand for industrial sorghum products as a result of urbanization and lifestyle changes; increased sorghum utilization; rising agro-processing capacity; the growth of sorghum input-taking industries; and several policy initiatives are one of the major available marketing opportunities for sorghum production in Ethiopia. Therefore, it is crucial to focus on improving the production and marketing aspects of the sorghum sector in each region.

2.4. Causal Loop and Food System of Sorghum in Ethiopia. A system dynamics linkage is a system that includes all elements regarding food production, processing, dissemination, marketing, preparation, and utilization, as well as the boundaries, critical factors, and consequences of these activities: input and output, people, environment, operations, organizations, infrastructural facilities, sectors of the economy, and transactions [47–49]. The different aspects of the system dynamics and their relationships are described using system dynamics loop analysis. This provides a unique understanding regarding intervention paths, improving the 'options' for interconnecting important policy tools and integrating various stakeholders [50, 51].

Cause-effect linkages and feedback loops, in which specific interactions reinforce or balance one another, are a crucial component of system dynamics maps. Improved agri inputs, for example, can lead to increased output and income, which can lead to additional agri-inputs. A system dynamics interrelationship analysis can identify the overarching structure that emerges from the interactions, but which is invisible when focused long on the individual factors. As a result, the systems dynamics approach allows us to look at more than just the production process. This movement in emphasis from production chain operations to their results is reflected in greater attention to sustainability and climate resilience (and adaptability) in system dynamics activities. This represents the socioeconomic and environmental consequences.

The boundaries of sorghum production, farming systems, infrastructural facilities, agro-industry, finance, inputs, transportation, processing, trading, profitability, key strive, producer determination, and food consumption, as well as its impacts on the environment, human health, producer income, and society, are all closely linked. This model emphasizes the relevance of social welfare and the trade-offs that exist between various intervention alternatives, enabling more efficient use of social aid. It covers everything from raw material suppliers to end-users, as well as sorghum product manufacturing, processing, and distribution. Within Ethiopia's borders, several positive (+) casualties reinforce one another and have a favorable impact on the model, as illustrated in Figure 4.

Furthermore, a negative sign in the system implies that the first variable inhibits the following variable and the positive sign reveals a favorable impact. For instance, the cost of sorghum production has an unfavorable influence on the dissemination, similarly, food market price has a decreasing ability to afford and consumption. On the contrary, infrastructure facilities, investment in sorghum production, spending capacity, and sorghum production have a positive interlink. Furthermore, key challenges that have been verified from the rich picture include lack of skill, disease, value addition, diversification, market, and technology. These lead to low production, food and nutritional insecurity, low income, and natural resource utilization, and the potential for reducing land protection that is not fully utilized Figure 4.

2.5. Consumption and Economic Value of Sorghum in Ethiopia. Sorghum is consumed in many ways by humans and livestock in many parts of the globe (see Figure 5). Many countries use a variety of raw materials to make many traditional fermented food and beverages, such as cereals. Sorghum is a staple of many traditional foods in many continents, including Africa. According to the Ethiopia institute of agricultural research (2014) *Injera*, *Dabo, Ambasha, Kocho, Bula, ergo, Siljo, Tella, Teji, Areki, Borde, Cheka, Shamita, Korefe, Keribo, Bukire, Kineto, and Merissa* are produced by sorghum grains. *Nifro, Genfo, Kitta, Kollo* (roasted) weaning foods are also sorghum-produced foods consumed by all age classes [34]. This versatile crop is used as staple crops like wheat, barley, teff, maize, and *enset*. This multipurpose crop is used as an entire grain or processed into flour. Sorghum plays a crucial role in food and nutritional security for millions of Ethiopians.

Grain sorghum is primarily utilized as an energy source in animal nutrition and is a good feed for beef, dairy cattle, laying hens, poultry, pigs, and small ruminants. Compared to other grains, higher-quality sorghum has a nutritional value comparable to that of other grains. It can be processed to raise its feed quantity, with procedures like grinding, crushing, steaming, steam flaking, popping, and extrusion. This crop has excellent livestock feed for different grounds. Not only does it fit well into a low-cost feed ration formulation, but it also has a high rate of feed acceptance. It also contains a low-level prevalence of mycotoxins like aflatoxins

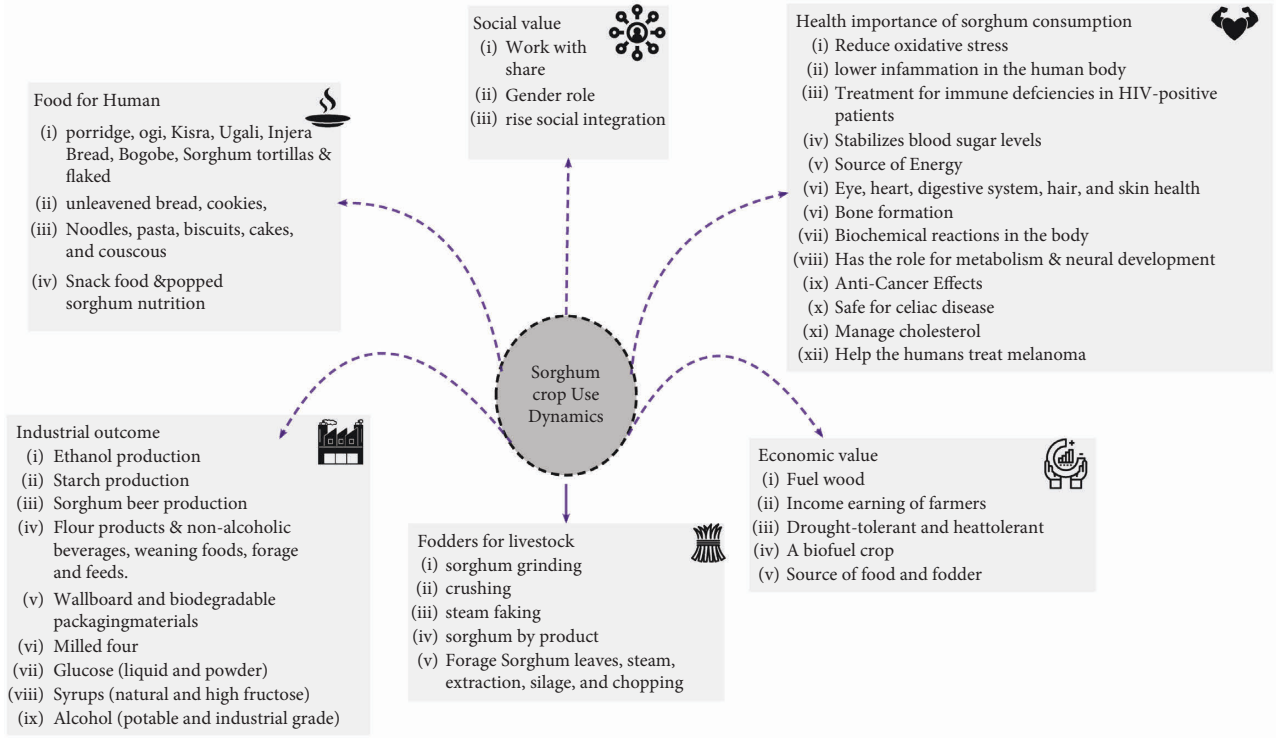

Figure 5: Use dynamics of sorghum multipurpose crop. Source: Authors' elaboration.

and vomitoxins, which are occurred in other grain sources but not in sorghum crops. Reduced growth and feed conversion have in the past been attributed to increased tannin content in sorghum-based feeds. Nowadays, low-tannin, high-digestibility sorghum varieties have been created, increasing sorghum digestibility and making it a formidable rival to maize due to its relative advantage as a low-input crop that thrives better in harsh environments.

As a similarity to Figure 5, sorghum has a great purpose for Ethiopian farmers, and Wako [52] and Semahegn [53] show that sorghum crop is no part of it should be through away. This plant is almost self-sufficient by farmers to meet the needs of food, income, animal feed, beer production, and construction [54]. The commercialization of smallholder farmers has the potential to improve incomes and lift them out of poverty. The driving force behind commercialization includes population growth; urbanization; institutional change; non-agricultural growth and economic development have taken shape; rising labor costs; and the macroeconomic, trade, and sectoral policies affecting these forces [17].

2.6. Industrial Potential of Sorghum. Sorghum is utilized for a variety of uses, including human consumption, animal feed, and fuel in many nations [55]. Because of its various applications and tolerance to a variety of agroclimatic situations, sorghum has recently received interest as a new-generation bioenergy crop. It has many additional industrial uses, such as health, pharmaceutical diagnostics, packaging, organic chemical production, and utility goods, which have also been implemented [56, 57]. Figure 5 shows that sorghum is used primarily for the manufacturing of lager beer, ethanol, starch, confectionery, alcoholic and nonalcoholic drinks, packaging materials, glucose syrups, weaning meals, and feeds as an industrial raw material.

2.7. Environmental Effects of Sorghum Production. Sorghum has a low carbon footprint compared to other food grains and uses a modest amount of water to produce. It is reasonably sustainable since no substantial damage to air, water, land, soil, forests, or other natural resources that have been identified. Sorghum is also a good rotation crop since it enriches and renews soil fertility. Because it is inherently pest-resistant, it does not need a large degree of chemical input. Because of its minimal resource requirements, sorghum is appropriate for a wider range of weather conditions, making it a potential local food item in a variety of settings (food) [58].

2.8. The Nutritional Value of Sorghum and Its Role in Human Health. Sorghum is a nutrient-dense grain that is strong in antioxidants such as flavonoids, phenolic acids, and tannins [59]. It is gluten Autonomy and simply digested by celiac disease patients, as shown in Figure 2, and it has been used to cure blood sugar, digestive system, hair, skin, eye, and heart disease. It can also help with metabolism, brain development, anticancer, cholesterol management, melanoma, and biochemical reactions in the body. It also plays an important role in immunological inadequacies in HIV-positive individuals, as well as energy and bone formation. Sorghum, in particular, has more macro-and micronutrients than many

other grains (see Tables 1 – 4). Millions of people throughout the world suffer from gluten-related disorders (GRDs), as well as other diseases [68–71]. To alleviate this problem, sorghum is a highly healthy crop [75, 76].

Food is a basic requirement that has become a human right, as well as a source of energy, power, and strength for all creatures to exist and carry out their daily tasks. It is also essential for survival, and its achievement has a significant impact on the ongoing economic and other activities of human beings. Wheat, maize, rice, sorghum, maize, millet, fonio, cassava, soybeans, teff, and enset are among the cereals used in food aid. A comparison of the nutrient content of these grains is shown in Tables 1,2,3, and 4 in a different form. These are made at different times, places, laboratories, forms, and researchers. In general, as these tables show, sorghum products have better nutritive content than several other grains; also it has less than some other food grains, and additionally, it has the same as other cereal nutritive values. For instance, sorghum is greater in total carbohydrates (g) than cassava, corn, soybean, maize, wheat, and teff, but it is less than in rice and enset grains. Sorghum is higher in total Iron content than cassava, corn, rice, and wheat but lower than soybeans (see Tables 1, 2, and 3). Table 4 illustrates how dry matter (DM) is used to determine physicochemical composition, and it confirms that all cereals in this table have an acidic pH. Wheat and maize contain smaller iron than sorghum. Manganese, sodium, and phosphorus are all higher in sorghum.

2.9. Sorghum and Its Role in Food Security. Food security, according to the 1996 World Summit, exists when all people have physical or economic access to sufficient and nutritious food to always suit their dietary needs and food preferences for an active and healthy life [77]. Food insecurity, on the other hand, is defined by the FAO as a condition in which individuals lack appropriate physical, social, or economic access to food, as is the case in some regions of the world, particularly in Africa [78]. Despite considerable efforts by stakeholders to solve the matter, Ethiopia's food security status continues to deteriorate.

In another way, food and nutritional security vary in each country, based on economic growth and resources available. Specifically, in developing countries, the task is not just to increase productivity, but also to ensure that nutritious food is distributed, available, and accessible. For that matter, sorghum is a key crop under high-stress situations, ensuring productivity, food security, and availability of food when other crops fail.

According to the IFPRI, yields for other key cereal crops like wheat and maize, as well as root and tuber crops like sweet potato, yam, and cassava, will be reduced by 5–25%, while yields for sorghum would increase. Sorghum is one of the only crops that has adapted to the changing climate in a world where water is scarce and temperatures are rising, according to model predictions for Sub-Saharan Africa. According to a meta-analysis published by Zereyesus and Dalton [79]; the social returns to sorghum and millet research are positive and large, at over 20% per year.

Table 1: Nutritional composition of sorghum crop grain compared to other crops.

Nutritional content	Sorghum	Maize	Wheat	Teff	Rice	Enset
Ash	1.6	1.4	1.6	2.8	1.4	9.13
Crude protein (CP)	8.3	8–11	11.7	11	7.3	5.98
Crude fat (CF)	3.9	4.9	2	2.5	2.2	0.84
Crude fiber (CF)	0.6	—	2	3	0.6–1.0	9.48
Carbohydrates	74.6	64.77	64.72	73	78.24	74.57
Starch	63	72	71	73	64	60.62

Source: [60].; USDA/ARS. 2014; [61–63] [64, 65].

Table 2: Nutrition values of sorghum compared to other crops.

Nutrition	Content per 100 g				
	Rice	Sorghum	Cassava	Corn	Soybeans
Calories (Cal)	360	332	146	361	286
Protein (g)	6.8	11	12	8.7	30.2
Fat (g)	0.7	3.3	0.3	4.5	15.6
Carbohydrates (g)	78.9	73	34.7	72.4	30.1
Calcium (mg)	6	28	33	9	196
Iron (mg)	0.8	4.4	0.7	4.6	6.9

Source: Faqih et al., [66].

Table 3: Mineral content of Sorghum grain compared to other cereals, mg/100 g.

Minerals	Content per 100 g			
	Sorghum	Wheat	Corn	Rice
Calcium (mg)	28	32	7	28
Iron (mg)	4.4	4.28	2.71	0.8
Magnesium (mg)	0.19	108	127	25
Phosphorus (mg)	287	345	210	115
Potassium (mg)	350	399	287	115
Sodium (mg)	6	2	35	5
Zinc (mg)	2.3	3.1	2.2	1.1
Copper (mg)	1.08	0.4	0.3	0.2
Manganese (mg)	1.63	3.7	0.5	1.1

Source: Henley et al., [67]; Waniska And Rooney [68]; Neucere and Sumrell [69]; Barrowa Agee Laboratories, LLC, Memphis, TN; Nutrient data from Commodity Reference Guide, updated 2006.

According to the study, research is providing significant producer and consumer benefits to billions of people living in the traditional sorghum-producing agricultural belt (arid and semi-arid regions) around the world. Sorghum has a lot of potential as a long-term, lucrative crop with a lot of resilience to climate change-related environmental pressures.

As a result, sorghum is a crop that is well suited for the future as a food and feed security crop for a growing share of the world's population. Improving sorghum quality for traditional and innovative food applications is critical to ensuring the crop's broad and long-term commercial appeal. Breeders, processors, and nutritionists must collaborate with worldwide sorghum enhancement efforts to make sorghum more appealing to consumers in both developed and

Table 4: Physicochemical composition of Sorghum and other cereals.

Parameters	Cereals				
	Sorghum	Wheat	Maize	Millet	Fonio
pH	6.63 ± 0.01	6.83 ± 0.01	6.57 ± 0.01	6.45 ± 0.01	4.80 ± 0.01
TA (mEq/100 g DM)	3.97 ± 0.00	2.49 ± 0.00	4.48 ± 0.00	5.46 ± 0.00	7.25 ± 0.28
Moisture (%FM)	11.57 ± 0.75	10.72 ± 1.05	11.51 ± 0.82	11.31 ± 0.42	11.72 ± 0.20
Proteins (% DM)	8.99 ± 1.86	12.24 ± 0.94	7.10 ± 0.96	11.09 ± 0.12	8.12 ± 1.12
Lipids (% DM)	3.65 ± 0.70	1,73 ± 0.42	4.18 ± 1.15	4.58 ± 0.43	1.62 ± 1.11
Carbohydrates (%DM)	71.82 ± 3.89	73.91 ± 3.56	75.48 ± 2.89	71.82 ± 3.62	70.40 ± 3.95
Sugar (% DM)	2.56 ± 0.55	2.91 ± 0.30	3.66 ± 0.66	3.31 ± 0.75	2,01 ± 0.75
Starch (% DM)	61.20 ± 4.25	68.24 ± 2.16	65.69 ± 5.09	64.80 ± 3.51	65.12 ± 2.65
Fibers (% DM)	8.14 ± 1.07	2.81 ± 0.26	6.69 ± 0.15	3.89 ± 0.51	3.38 ± 1.04
Ashes (% DM)	4.16 ± 0.58	1.41 ± 0.57	1.79 ± 0.09	2.16 ± 0.71	8.22 ± 0.49
EV (Kcal/100 g DM)	308.84 ± 15.13	308.22 ± 14.36	321.79 ± 18.03	319.39 ± 17.67	284.72 ± 19.65

Source: Jocelyne et al., [67]. Energy value (EV); Dry Matter (DM); fresh matter (FM).

developing countries. Increased production, improved processing quality and sensory quality, and improved nutritional properties of sorghum should be the focus of research.

In addition, sorghum has a cheaper cost of production (e.g., seeds, fertilizer, land rent, pesticides, etc.) and a larger net income than other basic cereal crops such as maize [80]. Farré and Faci [81]; observed that sorghum outperformed maize in a water-deficit irrigation study, with sorghum outperforming maize in terms of aboveground biomass, harvest index, and water usage efficiency. This suggests that in water-scarce, arid, and semi-arid regions of the planet, sorghum yields a higher return than maize.

Furthermore, the future and its importance for global food security in changing climate change are widely acknowledged as one of the most pressing issues confronting humanity in terms of global food security and environmental sustainability [82]. Many main staple crop yields have been proven to decline in Africa because of increasing desertification caused by climate change [83]. According to the International Food Policy Research Institute (IFPRI), sorghum is one of the few crops in Sub-Saharan Africa with higher yield potential in such conditions.

3. Additional Points and Conclusions

In Ethiopia, 5.9 million people with urgent food needs; 3.9 million women and children who are nutritionally vulnerable; 13.2 million individuals who are food insecure. The line between acute and long-term food poverty is becoming increasingly complicated. The country has been a high-ranked food shortage country in the world.

One of the versatile crops under such stress and adverse conditions of input use can potentially be expressed as the sorghum food crop. It can be grown on marginal lands and an important crop for food security. In terms of cultivation area and production value, sorghum is the most significant crop in the country. Sorghum is currently cultivated in a wide range of agro-climatic settings. It is cultivated in most regions of Ethiopia. It can grow between 400 and 2400 meters above sea level. The crop is mostly grown in the western, southwestern, northeastern, north, and eastern parts of the country. Oromiya, Amhara, and Tigray, as well as the people of the south nation nationality, are the main sorghum producer regions.

For sorghum production, a causal loop and system dynamics may give a unique knowledge of intervention approaches, boosting the 'options' for linking crucial policy instruments and integrating multiple stakeholders. It shows that all elements regarding food production, processing, dissemination, marketing, preparation, and utilization, as well as the boundaries, critical factors, and consequences, of activities regarding input and output, people, environment, operations, organizations, infrastructural facilities, sectors of the economy, and transactions.

In reality, the crop is a versatile plant with characteristics that allow all portions to be used for multiple purposes. Human food, animal feed, fiber, construction materials, medicine, industrial capabilities, and cultural activities have all been used it. Sorghum agriculture provides a long-term, sustainable food source that can be buffered. This crop plays an important game in the country's efforts to create a long-term food system that is profitable (economic sustainability), has wide social benefits (societal sustainability), and has a positive or neutral influence on the environment (environmental sustainability).

3.1. Possible Suggestions. This manuscript recommends the following efforts to introduce sorghum as a new way to alleviate the food deficit in Ethiopia. First and foremost, improving productivity, resilience, and fighting against diverse biotic and abiotic challenges; by making a strong effort in sorghum research and researchers. A new technology that ensures long-lasting, versatile, and low-cost, mechanized planters and harvesters must be promoted and scaled up. Sorghum crops are adaptable crops, they have to be expanded to a wider region as subsistence crops in other areas of Ethiopia's agricultural system where there are strong opportunities for adaptation and cultivation. Sorghum is a suggested crop for achieving the Sustainable Development Goals (SDGs) of ending hunger, achieving food security, and improving nutrition by 2030. As a result, it must be encouraged in all regions to maintain food security,

particularly among the poor and disadvantaged. Furthermore, a significant participatory study for novel and compatible sorghum varieties, as well as their distribution to farmers, should also be considered. [84, 85]

Data Availability

Data for this study has been included in the manuscript.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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