

Mapping and Analysis of the Sorghum Value Chain in Tehuledere District, Amhara Region, Ethiopia

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ABSTRACT

This study describes sorghum-cultivating households and assesses factors affecting different activities of the sorghum value chain in the Tehuledere district of the Amhara region, Ethiopia. Primary data were obtained by administering structured questionnaires and interviews to 297 respondents across the value chain from smallholder farmers, agro-dealers, traders, retailers, wholesalers, and processors. In this context, the study was able to map the value chain to establish the main actors involved and their relationships. The current value chain has Input Suppliers, Producers/Farmers, Wholesalers/Distributors, Transporters, Processors, and Consumers. Some issues were identified as input supply with some inefficiency and marketing and processing channels as supply was interrupted and producer prices were low. This implies increasing interactions with extension agents to enhance the use of better sorghum seed varieties and fertilizers. The proposed solutions are the cooperation of different actors, higher levels of investment in R&D, better extension services, private sector engagement, encouraging legislation, and infrastructure development to overcome institutional weaknesses.



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1. Introduction

The study on Sorghum in Ethiopia began in 1953 at the former Jimma Agricultural Technical School (JATS), currently known as Jimma University College of Agriculture. The study encompassed the gathering, examination, and assessment of sorghum germplasm. The reference is attributed to Seyoum et al. (2019). Later, in 1957, the research project was moved and started in the former Alemaya College of Agriculture and Mechanical Arts, currently called Haramaya University. The establishment of the Ethiopian Sorghum Improvement Project (ESIP) in 1972, which received substantial funding from the International Development Research Center (IDRC), can be seen as a noteworthy achievement in the field of sorghum research in Ethiopia (Yali & Begna, 2022). In 1982, the Ethiopian Institute of Agricultural Research (EIAR), previously referred to as the Ethiopian Agricultural Research Organization (EARO), integrated the Ethiopian Sorghum Improvement Program (ESIP) into its nationwide endeavors and took charge of spearheading sorghum research. Since then, EIAR has been supervising the organization of sorghum research carried out at the Melkassa Research Centre across the country. The national sorghum research program now collaborates with worldwide, national, and regional research institutes and universities. The citation is Seyoum et al. (2019).

The national sorghum research program was established to improve food-security in feeding the ever-increasing human population in Ethiopia. At no time has this challenge been more evident than it is today, as the present population of Ethiopia is estimated to be around 126 million (Jones et al., 2014). Against this background, the importance of Sorghum to Ethiopia's national food basket and socio-economic development has been recognized by the Ethiopian government, particularly in the drought-prone agro-environment of the country where poor smallholder sorghum-growing farmers strive (Manual, 2019).

Sorghum improvement research aims to establish itself as a prominent sorghum research program that generates high-quality information, knowledge, and technologies. These advancements aim to enhance livelihoods and promote sustainable development (Fetene, Okori, Gudu, Mneney, & Tesfaye, 2011). The objective is to improve the efficiency of technology generation through modern techniques and strengthen the program's capacity. This will be achieved by generating, adapting, and promoting sorghum production technologies. Additionally, the aim is to enhance the collaboration between all stakeholders in the value chain to increase sorghum productivity, improve the quality of Sorghum for food, feed, and malt, and ensure the sustainable development of the sorghum industry. The citation "Tonapi et al. (2020)" refers to a publication by Tonapi and colleagues in 2020. The objective of Ethiopian sorghum improvement research is to raise the productivity and output of Sorghum by creating and implementing advanced sorghum technologies, aiming to improve livelihoods and promote sustainable development.

Sorghum improvement efforts in Ethiopia have emphasized knowledge and technology generation over the years, which are then disseminated by the extension system and used by farmers. Instead, the focus has been on supplying improved sorghum varieties and related husbandry practices. However, the impact of such linear and top-down technology generation and dissemination approaches has not been sufficient for sorghum innovation progress to occur (Aerni, Nichterlein, Rudgard, & Sonnino, 2015).

The importance of Sorghum to Ethiopia's national food basket and socio-economic development has been underlined in Ethiopia, particularly in drought-prone environmental areas of the country in which poor sorghum-growing smallholder farmers strive.

Due to national and regional sorghum improvement research efforts, many open-pollinated and hybrid Sorghum varieties have been developed and made available for Ethiopia's agroecological zones. The absence of collaboration among the participants in the sorghum innovation ecosystem and various stages of the sorghum value chain is a significant obstacle that prevents the development of dynamic sorghum innovation paths. Despite the implementation of various technical strategies to enhance sorghum production, supported by regional, national, and international projects, the progress of the sorghum innovation system has been limited, and the strength of its value chain remains weak (Wubeneh & Sanders, 2006). Enhancing interactions among stakeholders along sorghum value chains is a crucial topic of discussion in semi-arid tropical regions. This study aimed to enhance agricultural output in the sorghum-producing areas of Eastern Amhara, Ethiopia. This was achieved by examining the sorghum agricultural innovation system and the various stages of the sorghum value chain, using an integrated framework that combines innovation system and value chain analysis. Additionally, the study aimed to create a map of the sorghum value chain, specifically in the Tehuledere district, located in the eastern part of the Amhara National Regional State.

2. Literature Review

2.1. Agricultural value chain

The agricultural research for development (AR4D) community increasingly gravitates towards using agricultural value chain analysis. The dynamics of individual commodity markets and the relationships and interactions between the various entities in the chain have been investigated using value chain methodologies. A study conducted by Muflikh, Smith, and Aziz (2021) is cited. In order to get smallholders involved in manufacturing goods for sale, many development programs employ the agricultural value chain approach. One must be well-versed in the ideas and methods for analyzing agricultural value chains to comprehend the effects of development interventions on smallholders and the rural poor. Like the agricultural innovation systems approach, the value chain method emphasizes

agricultural development from a systems viewpoint. All the steps involved in creating, manufacturing, delivering, receiving, using, and eventually disposing of a product or service are collectively known as the value chain, as defined by Kaplinsky and Morris (2000) and Kaplinsky, Morris, and Development (2008). An agricultural value chain is one economic unit that studies a particular commodity, like Sorghum. Interactions in the market link a variety of economic activity in a vertical fashion. According to Tesfay, Kahsay, Girmay, Welu, and Healthcare (2016) and Atoma, Onoh, Emerhirhi, and Practice (2018), the emphasis is on the interdependencies among supply chain networks that include input providers, manufacturers, dealers, processors, and distributors.

The value chain concept involves the incremental increase in value as a product moves through the stages of input suppliers, manufacturers, and consumers. A value chain encompasses transforming and adding value to a product or service at every stage. Throughout the value chain, the product is transferred between different players, resulting in transaction expenses and typically contributing to value creation. Value addition is achieved by various actions, such as consolidating, purifying, categorizing, packaging, shipping, storing, and processing (Basu and Horticulture). Value chains consist of interconnected organizations, institutions, resources, players, and activities that supply inputs, production, processing, and distribution of a particular commodity (Mishra & Dey, 2018). Put, a value chain can be seen as a collection of individuals and actions and the regulations that regulate those actions within businesses. Value chains serve as channels for the flow of finance (revenues, credit, and working capital) from consumers to producers. They also facilitate the dissemination of technologies among producers, traders, processors, and transporters. Additionally, value chains transmit information on customer demand preferences from consumers to producers, processors, and other service providers (Rodrik, 2018).

2.2. Agricultural Value Chain Analysis

Kaplinsky and Morris (2000) state that agricultural value chain analysis can be a heuristic or analytical instrument. The research may include descriptive, prescriptive, and operational instructions to improve logistics networks' effectiveness for commodities. According to Kaplinsky and Morris (2000), value chain analysis is a methodical methodology that aims to identify and comprehend the various actors and their roles across the several stages of production, processing, transportation, distribution, and sales of a product or product. During the mapping exercise, the structural components of the value chain are evaluated. These components include the players' characteristics, the flow of products, the destinations to which they are delivered, and the conditions for accessing and leaving the chain (LEGIDE, 2021). Value chain analysis is a descriptive technique that provides a heuristic framework for data generation (LEGIDE, 2021). According to Kaplinsky and Morris (2000), value chain analysis provides a methodical framework that may be utilized to learn the structure, functioning, and efficiency of the chain of activities that comprise a business.

Agricultural value chain analysis is a proactive strategy that studies the reactions of markets and industries to fluctuations in domestic and international demand and supply for a specific commodity. This method is used to improve agricultural production and efficiency. In addition, it considers the effects of technology improvements in production and marketing, as well as alterations in organizational structures, institutional arrangements, and managerial strategies. In the study, the value chain should be analyzed in three different ways: as a collection of organizations and rules, as a sequence of activities connected to the production, processing, and distribution of goods, and as a group of individuals engaged in activities that enhance value. An examination of the evolution of value chains, including their structure, behavior, and outcomes, in response to changes in market conditions, technological advancements, and legislative changes is what value chain analysis has been doing.

2.3. Purposes of Value Chain Analysis

There are multiple reasons to do a value chain analysis. Understanding the sources of inefficiencies in a commodity's value chain—for example, Sorghum's—and identifying possible areas for improvement is the primary goal of value chain analysis. A mix of qualitative and quantitative information is used in this investigation. An important agricultural product, like Sorghum, goes through many stages of production, processing, and distribution; the value

chain provides a useful framework for understanding these stages (Grain, 2014). To comprehend the structure and functionality of a product system, value chain analysis looks at how various links in the chain work together (Deribe, Kassa, & Agriculture, 2020). Several factors influence the efficiency of agricultural value chains, affecting product attributes, especially quality (Szapiro, Vargas, Brito, & Cassiolato, 2016). Like innovation systems see development, the value chain paradigm enables us to take a more comprehensive view. According to Binz and Truffer (2017) and Gereffi, Humphrey, Kaplinsky, and Sturgeon (2001), the current objective is to analyze a particular commodities production system by combining a research-for-development framework with an innovation system perspective and a value chain analysis framework. During the Sorghum Value Chain Analysis, this issue should be addressed in particular.

2.4. Sorghum Value Chain Analysis

The African Union conducted a sorghum value chain analysis in five countries in the Sahelo-Saharan Zone of Africa (Burkina Faso, Mali, Sudan, Niger, and Chad). The analysis revealed that both rural and urban people widely practice sorghum cultivation and consumption. Over 80% of small farmers in Burkina Faso and Mali and 75% in Sudan cultivate Sorghum. Sorghum holds the fourth position in Sudan in terms of production area and output. In Burkina Faso and Niger, it holds the highest position. Mali holds the second position in the ranking. In terms of cultivated land, Sorghum accounts for 88% in Niger and 71% in Sudan. In Burkina Faso, it encompasses 43% of the arable land. The primary purpose of sorghum production in Burkina Faso and Mali is domestic consumption, with any excess sold in local markets. Approximately 81% of Sorghum is sold in local markets in Burkina Faso, while in Mali, the figure is 75% (Parrilli, Nadvi, & Yeung, 2016; Union, 2017; Wortmann & Sones, 2017).

According to several studies (Gulati, Minot, Delgado, & Bora, 2007; Morrison & Sarris, 2007; Musara, Musemwa, Mushunje, Mutenje, & Pfukwa, 2019; Pye-Smith, 2013; Sarris, 2010), the creation and maintenance of wealth are heavily influenced by efficient agricultural value chains. Most value chains have an imbalance, with farmers getting the smallest share. While many rural farmers have other sources of income, agriculture is still their primary source of revenue. Sorghum is an essential crop for small-scale farmers in Southern Africa's semi-arid and desert regions to maintain economic viability, social stability, and self-sufficiency. By shifting to sorghum production focused on the market, we can encourage more participation in the supply chain, save precious resources, and build mutually beneficial relationships, all of which contribute to better health. However, several challenges are unique to households and the market that make sorghum-based livelihood options less than ideal (Mukarumbwa & Mushunje, 2010). Poor yields and extremely unfavorable market circumstances reduce net marketing margins, a double whammy for small-scale farmers. These farmers are not taking part in the value chain component award program. They face high transaction costs and low market pricing. The policy climate benefits some groups but lacks institutional support and a significant physical distance between major production regions and major market hubs (Musara et al., 2019).

Southern African regions with hot temperatures and little rainfall tend to grow maize at the expense of other promising crops like Sorghum. In this case, the second part refers to a particular crop that has been neglected and is still seen as something poor farmers usually cultivate. According to Anderson and Rosesboom (2013), Rukuni, Tawonezvi, Eicher, Munyuki-Hungwe, and Matondi (2006), and others involved in the crop's value chain, it receives very little help. Sorghum is subjected to unhealthy rivalry among value chain actors and alternative living choices, inhibiting the efficient execution of activities along sorghum value chains. Researchers in Zimbabwe looked at the sorghum value chain (Musara et al., 2019) and described its many functions. The methods of seed supply, seed origins, and the various types of transactions involving sorghum seeds are the subject of this article—supply and demand for sorghum seed and its price.

As for other inputs, inorganic fertilizer is a significant player in growing cereal crops. According to the survey done with agro-dealers, Urea is a feasible alternative to NPK, which is the most commonly sold fertilizer (Shapiro & Sanders, 1998). However, inorganic fertilizers are supplied mainly by non-governmental organizations (NGOs) through various development projects. Due to heavy competition, smallholder farmers only obtain a limited amount of

fertilizer that is accessible in mainstream markets. Many farmers would be unable to afford the skyrocketing prices if they materialize. Despite government subsidies, farmers still report being unable to afford prices, which limits their usage of inorganic fertilizers. Instead of using the usual rates, farmers spread out the available fertilizer thinly across a large area. The 2013 study by Tiftonell and Giller also confirmed this result (Tiftonell & Giller, 2013). In addition, they detailed the constraints that the input sector has in its operations.

3. Method

The study employed a descriptive research design. The micro-level analysis concentrates on characterizing households engaged in sorghum cultivation and evaluating the characteristics linked to different stages of the sorghum value chain. The investigation seeks to characterize the sorghum value chain system at the household level in specific sample kebeles to map the value chain nodes. The study included a combination of quantitative and qualitative data. The quantitative method primarily uses quantitative data from primary and secondary sources to characterize the sorghum value chain. The primary data were gathered via focus group discussions, interviews with key informants, and surveys conducted at the home level. The primary objective of the qualitative approach is to elucidate the Ethiopian sorghum innovation system by analyzing the perspectives and ideas of different actors involved in the system. The primary data were gathered from a sample of farmer households utilizing a structured questionnaire administered through interviews, employing computer-assisted data collecting software (Kobo Toolbox). Additional pertinent secondary data were gathered from various institutions, such as the Ministry of Agriculture, the Ethiopian Agricultural Authority (FAOSTAT, 2021), and other published and unpublished sources. The investigation at a micro-level consisted of utilizing descriptive data evaluating critical informants through the examination of secondary literature and conducting interviews with informants at national and regional state levels. The data analyses employed The primary objective of the Structural Analysis study approach is to identify and map the actors and their responsibilities within the sorghum innovation and value chain system. Specific commodity-level structural analysis can be conducted to comprehensively understand the particular commodity under consideration, such as Sorghum in the current scenario. The critical components of a sorghum technological innovation system are the people involved, their specific roles, and the interactions between them. Actors, including sub-categories, and their roles in sorghum innovation and value chain systems can be defined based on the interaction patterns they create with other actors, which provide a systemic perspective. The assessment focused on evaluating the existence or absence of individuals, their respective responsibilities, and their interactions.

4. Results

4.1. Analysis of Key Actors and their Roles in the Value Chain

Sorghum value chain analysis is a process that examines and assesses the various stages and actors involved in the production, processing, and distribution of Sorghum. The analysis typically involved mapping out the different activities and processes involved in each value chain stage, analyzing the costs, quality, and efficiency at each stage, identifying bottlenecks or constraints, and evaluating potential opportunities for value addition and market development. Through this analysis, stakeholders in the sorghum value chain could gain valuable insights into optimizing production and processes, enhancing the quality and marketability of sorghum products, improving coordination among actors, and developing strategies for sustainable growth and competitiveness in the sorghum industry.

The value chain analysis of the Eastern Amhara area of Ethiopia, namely Tehuledere, focused on studying the primary individuals or groups involved in the various stages of sorghum production, processing, and distribution. It involved various interrelated participants who performed different functions at various value chain stages. Both primary and secondary stakeholders conducted the value chain study of Sorghum. The primary actors engaged in the direct commercial activity of Sorghum and its products include input suppliers, producers, aggregators, distributors, processors, and final users or consumers. They possessed the ownership status of the commodity they managed. On the other hand, secondary actors fulfilled the duty of either providing assistance to or exerting influence on the principal

characters. The actors were either involved in the primary value chain or provided ancillary services to ease the movement of Sorghum and its byproducts from one actor to another.

4.2. Input suppliers

Input suppliers were the main initiators in this value chain as they supplied farmers with inputs required in production. It was the first value chain actor in the production to which the farmers had access to supplies of improved varieties of sorghum seeds, fertilizers, pesticides, and other production utilities. These were farmer's cooperatives, unions, research centers, and universities. Major sources of the varieties were all from cooperatives, input providers, traders/organizations, and research institutions, with percentages of 99, 99, and 98%, respectively. The inorganic fertilizer sources are Farmer's cooperatives, public service/government institutions, and input provider's traders/organizations at 99.7, 99.3, and 99.00 Percent in their descending order. The sources of organic fertilizers are also from these providers at the rate of 93.3- 97.6 %. In a similar token, pesticides were also sourced from these institutions at the rate of 98 to 99.7 Percent.

Table 1

Source of Improved Sorghum Seed Varieties, Fertilizers, and Pesticides

Category (Value) (N=297)	Sorghum seed varieties		Inorganic fertilizer		Inorganic fertilizer		Pesticides	
	Freq.	%	Freq.	%	Freq.	%	Freq.	%
A nearby farmer	252	84.8	13	4.4	231	77.8	8	2.7
Farmer's cooperatives	291	98.0	296	99.7	289	97.3	296	99.7
Public service/Gov. institutions	294	99.0	295	99.3	290	97.6	295	99.3
Input providers	294	99.0	294	99.0	277	93.3	291	98.0
traders/organize.								
Research centers	276	92.9	11	3.7	19	6.4	8	2.7
Universities	260	87.5	9	3.0	10	83.4	5	1.7
Non-governmental institutions	259	87.2	10	3.4	17	5.7	13	4.4
Others	7	2.4	-	-	-	-	1	0.3

Source: Own computation results (Survey, 2023)

4.3. Sorghum producers/farmers

Sorghum-growing farmers in the value chain played a crucial role in sorghum production. They were responsible for selecting appropriate seed varieties, growing the crop, applying fertilizers and pesticides, and harvesting the grain. Farm experience in producing crops was necessary for farmers to get high output. In the study area, data collected indicated that farmers had various experiences in sorghum production, ranging from one to forty-one years. The most common method for land preparation in the study area was using an ox-plough, while a limited number of respondents explained that hand plough was practiced in areas with the highly sloppy landscape. Land preparation in the surveyed kebeles was done before planting, whereas in some pocket areas, land preparation and planting were done simultaneously. Although no specific data was collected on oxen plough method in the study area, according to Melaku 2011, almost all farmers own this simple implement.

Nevertheless, a mere 33% of highland farmers possess a pair of oxen. A growing percentage of farmers are unable to sustain a pair of oxen. Approximately 29% of Ethiopian farmers do not possess any cattle, whereas 34% own a single ox, 29% possess two oxen, and 8% own two or more oxen. Therefore, over 60% of the farmers are compelled to lease or borrow one or two animals for farming, a situation comparable to that in the Tehuledere district.

In all the surveyed kebeles, the standard farm management system of sorghum farming was the sole plantation of Sorghum. However, they can use their indigenous knowhow to grow two crops simultaneously with an intercropping system with haricot beans that would be used as cash crops and enhance soil fertility. Of the total respondents, 149 farmers (51.2%) experienced intercropping pulse crops, most likely common beans with sorghum, to use pulse crops to add nitrogen and yield them before harvesting sorghum. Crop rotation is one of the agronomic practices 60.9% of the farmers used, while 39.1% did not

practice. More detail: haricot beans, teff, and vegetables in either order were planted not to use Sorghum as a mono-cropping system.

Table 2
Technology, Inputs, and Agricultural Practice Aggregation in the Study Areas

Variable (Background), N=297	Value	Frequency	Percentage (%)
Improved sorghum variety usage	Yes	169	56.9
	No	128	43.1
Type of sorghum varieties used	Abshir	167	56.2
	Gubiye	163	54.9
	Teshale	155	52.2
	Others	48	16.2
Trends of crop rotation practice in sorghum production	Yes	181	60.9
	No	116	39.1
The sequence of rotation	Faba bean-tef-vegetables	180	60.6
	Tef-Faba bean-vegetables	179	60.3
	Vegetable-Faba bean-Tef	169	56.9
Trends of cropping practice in sorghum production	Yes	152	51.2
	No	145	48.8
The primary source of improved sorghum technologies/ information	DAs	295	99.3
	Research	294	99.0
	Input suppliers	293	98.7
	Radios	264	88.9
	Demonstration	295	99.3
	Field day	295	99.3
	8028	278	93.6
	Neighbors	295	99.3
Relatives	286	96.3	

Source: Own computation results (Survey, 2023)

Most often, farmers spread compost on their farms before planting. 99.3 percent of the sampled households used compost, while the remaining 3.7 percent did not. Different fertilizers, such as inorganic fertilizers (NPS B and NPS Zn) and liquid fertilizers, were used for the sampled kebeles. Out of the total sample size, 22.2% of respondents used inorganic fertilizers, while 77.8% did not use them.

The farmers used improved sorghum varieties, Abshir, Gobiye, and Teshale, in most of the households in the study area. Around half of the sampled farmers use the three varieties 52.2 - 56.2%, while 16.2% of the farmers used other varieties that could be local ones. The seeding rate was a detrimental factor for sorghum production productivity, and the research recommended a seeding rate of 7–10 kg per hectare. Farmers in the study area used seed rates similar to the recommended amount, but farmers in the area with low soil fertility doubled the amount to compromise the survival of the total population.

Extension services played a vital role in creating awareness and improving farmer's knowledge and skills in sorghum production. Sources of information on sorghum production in the study were development agents, research, input suppliers, radios, demonstration field days, 8028 media services, neighbors, and relatives, ranging from 88.9 to 99.6 Percent.

Table 3
Amount of Fertilizer Used and Amount of Sorghum Produced

Variable (Background), N=297	Minimum	Maximum	Mean	Std. Dev.
Amount of NPS B	0	75	33.45	16.035
Amount of NPS Zn	0	509	43.58	66.955
Amount of liquid fertilizer	0	50	1.54	4.286
Amount of Sorghum produced in a hectare of land (Qt)	1.5	13	2.13	1.32

Source: Own computation results (Survey, 2023)

4.4. Postharvest practice

The analysis of the East Amhara study on postharvest handling of Sorghum was analyzed by analyzing the data available from the same region, which has a climate and farming techniques comparable to those of the East Amhara study. The research being discussed was conducted in four distinct administrative divisions referred to as woredas. These woredas are as follows: Alamata, West Armachiho (Amhara region), Fedis (Oromia region), and Derashe (SNNP area). The total amount of Sorghum produced annually in each of the four woredas was 86,400 tonnes, 85,750 tonnes, 395,928 tonnes, and 71,428.8 tonnes from year to year. In Alamata, West Armacho, Derashe, and Fedis, the mean post-harvest loss of Sorghum was 35.1%, 29.8%, 32.7%, and 34.1%, respectively. West Armacho had the highest loss, measuring at 32.7%. When harvesting, field staking and drying, threshing, winnowing, and storage occurred, the most significant stages of loss occurred then. To store their sorghum harvest, farmers in the eastern Amhara region, which included the woredas that were the subject of the study, utilized underground cavities and iron containers.

The farmers could not capitalize on their land, amounting to around 68,671 hectares, resulting in wasted potential for cultivating other crops and enhancing food security. Inadequate post-harvest handling procedures, including delayed harvesting, use of unsuitable threshing and shelling gear and methods, and improper storage conditions for grains caused the losses. These factors made the crops susceptible to harm from insect pests, rodents, and mold contamination. Farmers employ indigenous techniques, such as appropriately timing their harvests (although unexpected rainfall poses a typical challenge), maintaining clean storage facilities, and utilizing botanicals and other traditional methods to minimize losses.

4.5. Aggregation and the collection activities of Sorghum

The Sorghum produced by smallholders primarily goes through aggregators before reaching the market. Some farmers sell their products in modest quantities to meet their immediate needs. Another option is to route the produce through brokers to exporters, millers, and animal feed makers, which have not been included in the value chain mapping. Once farmers have finished harvesting, they transport their sorghum crops to nearby farmers' cooperatives or unions, of which they are members. Another product delivery method involves aggregators or collectors, who serve as mediators connecting farmers with other participants in the value chain. The company procures large quantities of sorghum grains from farmers, consolidates the harvest, and supplies it to wholesalers, processors, or distributors. Aggregators facilitated simplifying the procurement process and diminished transaction expenses for farmers and purchasers.

The aggregators played a crucial role in the value chain by gathering Sorghum from small-scale farmers and distributing it to major buyers and public and private organizations in the nearby production region. In order to reduce expenses, certain aggregators have established grain collection centers where farmers can conveniently deliver their produce instead of having to visit the farms themselves. To foster farmer loyalty, most aggregators offer certified seeds to farmers at a reduced cost, a practice not observed in the research area. Proficient aggregators typically offer farmers comprehensive training services before and after harvest to improve production and foster loyalty. As mentioned earlier in the paragraph, aggregators faced a significant obstacle in the form of high transportation expenses incurred while gathering Sorghum from geographically scattered farmers. Insufficient funds to guarantee the prompt purchase of the grain was also a significant obstacle. Aggregators may incur extra storage costs when their clients experience delays in retrieval.

4.6. Wholesalers and distributors

Wholesalers and distributors facilitate the movement of processed sorghum products from farmers, aggregators, and processors and distribute them to retailers, food service providers, or end consumers. As intervened in focus group discussions, wholesalers played a critical role in ensuring the availability of sorghum products in the market by managing logistics, warehousing, and transportation.

Retailers considered distributors under separate business licenses get the product from farmers, aggregators, or wholesalers to sell sorghum products directly to consumers in open market access. Food service providers, such as restaurants, cafeterias, and catering companies, incorporated sorghum-based products into their menus. They had a direct influence on consumer choices and demand for Sorghum.

4.7. Transporters

Transporters in the research area collaborated with farmers, aggregators, wholesalers, and end users throughout the entire value chain. They streamlined transporting resources to the farmers and distributing their goods to the market. The primary means of transportation in the research area for moving produce from the farms to aggregation points or the market were carts and occasionally motorcycles. Motorcycles were advantageous due to their ability to navigate difficult terrains inaccessible to other modes of transport, and they were also more cost-effective. The major transporters focus on the final stage of the commodities transportation process, which entails moving it from the collection points to the primary buyers and other markets in various locations.

4.8. Processors

Analysis of Ethiopian sorghum processing involves examining the existing value chain and processing activities related to Sorghum in the country. This analysis helps identify opportunities, challenges, and potential interventions to enhance the agro-processing sector for Sorghum, which could lead to value addition, increased income, and employment generation. Understanding the current sorghum processing practices in Ethiopia was so essential. This involved analyzing the traditional and modern methods of processing sorghum into various products such as flour, porridge, snacks, and animal feed. It includes examining the processing techniques, equipment, and facilities used, as well as the scale and efficiency of production.

Value addition in sorghum agro-processing had another aspect to be considered to scan whether the processing activities add significant value to the raw Sorghum, such as through improved quality, packaging, branding, and diversification of products. It included evaluating the degree to which processing activities contribute to higher profitability and market competitiveness. In the study area, it was realized that no special value-addition activities were observed beyond converting raw sorghum grains into flour and the by product into animal feed. The sorghum processing activity in the study area, in particular, and the whole country, in general, indicates that much work needs to be done regarding the availability and adequacy of infrastructure that supports sorghum agro-processing. This should focus on access to processing facilities, such as mills, malting plants, breweries, and snack production units. It includes assessing the availability of reliable energy supply, water resources, transportation networks, and storage facilities to support agro-processing activities.

4.9. Consumers

Sorghum is widely consumed by humans and cattle across various world regions. Several nations utilize diverse raw resources to produce numerous traditional fermented foods and beverages, including grains. Sorghum is a fundamental component of numerous traditional cuisines across various continents, particularly Africa. Reality is a prevalent phenomenon in Ethiopia, manifesting in several forms. Sorghum grains produce Injera, Dabo, Ambasha, Tella, Areki, Shamita, Korefe, Keribo, and Kineto nationally and in the study area. Nifro, Genfo, Kitta, and Kollo are food products derived from Sorghum that individuals of all age groups consume. This versatile crop has been a staple crop, including barley, teff, maize, and insects. This versatile crop was utilized either in its whole as a whole grain or refined into flour. Sorghum is essential for ensuring food and nutritional security for many Ethiopians.

According to experts' interviews, grain sorghum was mainly used as an energy source in animal nutrition and was considered a high-quality feed for beef, dairy cattle, laying hens, poultry, pigs, and small ruminants. Compared to other grains, Sorghum of greater quality possesses a nutritional content similar to that of other grains. The feed quantity of the

material could be increased using several methods, such as grinding, crushing, steaming, steam flaking, popping, and extrusion. The ingredient not only integrated effectively into a cost-effective feed composition but also exhibited a high level of acceptability by the animals. Sorghum crops have a low amount of mycotoxins, such as aflatoxins and vomitoxins, found in other grain sources but not in Sorghum. Prior research has linked elevated tannin levels in sorghum-based diets to decreased growth and feed conversion. Sorghum cultivars with low levels of tannin and high digestibility have been developed. This has improved the digestibility of Sorghum and made it a strong competitor to maize. Sorghum has an advantage as a low-input crop that performs well in challenging locations, such as the study area.

4.10. Sorghum Value Chain mapping

Based on the previous analyses of actors and their roles, processes, and functions in the sorghum value chain, the value chain mapping of the study area can be depicted in the following diagram.

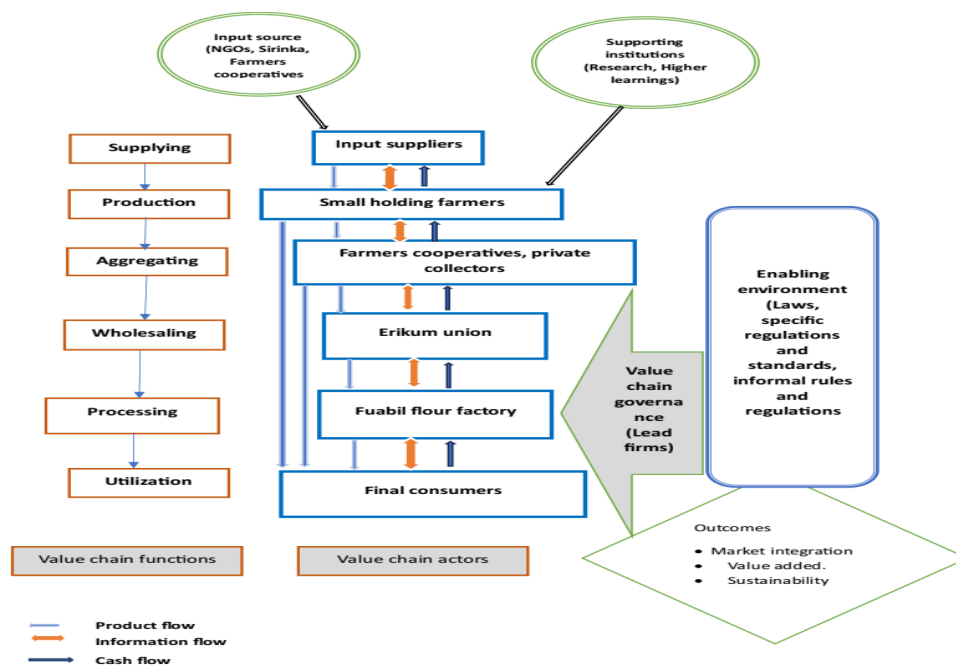


Figure 1: Value chain mapping of Sorghum in Tehuledere Woreda

Source: Field survey, 2023

4.11. Challenges in the Sorghum Value Chain

In a qualitative study using interviews and discussions with stakeholders, several factors that affect the normal flow of the value chain process in the Ethiopian-producing farmers in general, the Eastern Amhara region of Ethiopia in general, and Tehuledere, in particular in the Sorghum value chain process were identified. Some of the factors were:

- The institutional factors that hinder sorghum innovation include (Dahlberg et al., 2020) Limited research and development due to insufficient investment in Sorghum research and development leads to limited crop innovation. Insufficient funding and resources restrict the exploration of advanced technologies, improved breeding techniques, and better agronomic practices (Dahlberg et al., 2020)
- Weak extension services expressed limited access to agricultural extension services and information dissemination, impeding sorghum farmers' adoption of technology. Extension services, which provide education, training, and technical advice, were often lacking or inadequate in many areas, hindering the transfer of knowledge and advancements in sorghum cultivation,
- Lack of private sector involvement and limited participation of the private sector in sorghum innovation create a gap in funding, technology transfer, and market development. Private firms played a crucial role in promoting research, technology, and commercialization, but their involvement in sorghum innovation is often limited due to low profitability or a focus on other crops,

- (4) inadequate policy support resulting from weak policy frameworks, lack of incentives, and inconsistent government support for sorghum innovation hinder its progress,
- (5) Limited access to high-quality sorghum seeds was crucial for farmer innovation. However, many small-scale farmers, especially in developing countries, have limited access to improved seeds due to high costs, limited availability, and lack of local seed production,
- (6) insufficient infrastructure, including transportation, irrigation, storage, and processing facilities, limits the potential for sorghum value chain. Inadequate infrastructure leads to post-harvest losses, reduced market access, and limited value-addition opportunities, discouraging investment and innovation in the sector,
- (7) Limitations in finance and credit access options made it difficult for farmers to invest in sorghum innovation. Adequate financial resources are needed for purchasing inputs (such as seeds and fertilizers), machinery, and technologies that can improve sorghum production,
- (8) Climate change impacts sorghum productivity, particularly in regions prone to drought, flooding, or extreme weather events. Unpredictable weather patterns and increased pests and diseases pose significant challenges to farmers, making it harder for them to adopt innovative sorghum cultivation practices,
- (9) Limited collaboration among various stakeholders, including research institutions, private sector entities, farmers, and policymakers, hinders the effective dissemination of knowledge, sharing of resources, and coordination of efforts. Successful sorghum innovation requires a collaborative approach involving multiple actors, which is often lacking, and addressing these institutional shortcomings requires increased investment in research and development, strengthening extension services, encouraging private sector involvement, formulating supportive policies, and improving infrastructure.

5. Conclusions

Sorghum has been noted as a significant grain crop in the Tehuledereworeda region, with the potential to be incorporated into the primary staple foods. Subsistence farming is practiced extensively throughout the Eastern Amhara region, utilizing diverse resources at various levels. The value chain and innovation system were examined, focusing on the study area's significant contribution to sorghum production. The agricultural value chain development methodology serves as a strategy to tackle issues of rural poverty, income disparities, and food insecurity. The study area conducted a value chain analysis of the sorghum innovation system, utilizing qualitative and quantitative information from interviews, focus group talks, and survey data. The analysis determined the importance of the actors and their responsibilities in the value chain, which will contribute to enhancing sorghum quality, promoting the adoption of innovative seeds, and ultimately ensuring food security.

The initial actors in the value chain responsible for providing improved varieties of sorghum seeds, fertilizers, insecticides, and other production utilities are input suppliers such as farmer's cooperatives, unions, research institutions, and universities. Each actor was a supplier, providing inputs to over 90% of the farms. The presence of multiple input suppliers can provide farmers with various options, but it may also lead to unneeded competition among them. Furthermore, it is necessary to differentiate their roles, particularly in actively engaging agro-dealers (suppliers of inputs and processors) to grant access to sorghum production inputs and output markets, often accompanied by guidance and credit. In the case of farmer organizations, they also act as intermediaries, facilitating farmers' access to agricultural inputs, credit, and markets while being involved in advocacy efforts.

Sorghum-growing farmers in the value chain played a crucial role in sorghum production. Farmers have various levels of experience in sorghum production, which ranges from forty-one years, and they can play a significant role in selecting appropriate seed varieties, growing the crop, applying fertilizers and pesticides, and harvesting the grain. These farmers mainly experienced problems related to oxen farming, postharvesting methods, and limited markets.

The aggregators played a crucial role in the value chain by gathering Sorghum from small-scale farmers and distributing it to large-scale buyers and public and private organizations in the nearby production region. Aggregators facilitated simplifying the procurement process and diminished transaction costs for farmers and purchasers. In the research region, carts and motorbikes were the primary means of transportation for moving goods from farms to aggregation stations or the market. On the other hand, large-scale transportation was employed to convey goods from aggregators to wholesalers. Wholesalers and distributors play a crucial role in transporting processed sorghum products. They help convey these products from farmers, aggregators, and processors to retailers, food service providers, or end customers. Agro-processing has the potential to enhance the value of sorghum products, boost revenue, and create employment opportunities. No processing actor is accessible in the study area save for converting raw sorghum grains into flour and the byproduct into animal feed.

The study reveals that the value chain for sorghum needs to become more efficient and inclusive in the Eastern Amhara region. The required improvement in the value chain may be attributed to better coordination among different actors, increased access to inputs and credit, improved post-harvest handling and processing techniques, and enhanced market opportunities. Promoting the Sorghum innovation project could facilitate improved market access for sorghum farmers in the Eastern Amhara region, leading to increased profitability. Additionally, it may be found that value-addition strategies, such as sorghum processing and diversification into product development (e.g., flour, porridge, beer), have generated higher returns for farmers and increased their resilience to market fluctuations. Therefore, it is recommended that the establishment of agro-processing facilities be supported and that farmers and entrepreneurs be provided training and support in sorghum value addition. This can open up additional income-generating opportunities and enhance the overall competitiveness of the sorghum industry in the region.

5.1. Recommendations

The study mapped the value chain for the study area, which can be shared amongst stakeholders to identify different priority interventions and ensure coordination. It can also be seen as a baseline for the value chain, against which future projects or interventions could be assessed.

The research could identify both challenges and opportunities that farmers face, the impact of environmental factors on the sorghum production process, its effectiveness on the existing agricultural practice, and the potential for leveraging technological innovations to improve sorghum productivity and quality. Furthermore, the research highlighted the significance of integrating traditional knowledge with modern agricultural techniques for enhancing access to improved seeds and other technological resources. In conclusion, the region could harness its agricultural potential and contribute to the broader goal of achieving food and nutrition security, enhancing rural livelihoods, and promoting sustainable and resilient Agricultural development.

This PhD research could comprehensively analyze the sorghum improvement project, its significance for agriculture in the eastern Amhara region, and its potential contributions to broader development objectives in Ethiopia. Based on the research result and interview found in the study, the following recommendations are suggested for research done on the analysis of the sorghum improvement project in the eastern Amhara region of Ethiopia:

- 1.** Collaborate with local stakeholders: It is recommended to establish collaborative partnerships with local agricultural extension services, research institutions, and farmer cooperatives to co-design and implement sorghum improvement interventions in the form of different projects, which could ensure the responsive act on local needs and realities.
- 2.** Use better post-harvest management system: It is advisable to investigate post-harvest challenges and opportunities related to sorghum processing, storage, and value addition to reduce post-harvest losses and enhance market opportunities for sorghum producers.
- 3.** Disseminate findings and recommendations of research results: It is essential to ensure that research findings are effectively communicated to relevant stakeholders, including policymakers, practitioners, and local communities, to inform evidence-based

decision-making and facilitate the uptake of recommended practices.

In conclusion, by addressing those critical areas of recommendations mentioned above, this research could contribute to a comprehensive understanding of sorghum improvement projects in the eastern part of the Amhara region of Ethiopia. It could provide actionable recommendations for enhancing the productivity, resilience, and sustainability of sorghum cultivation in the region to a more significant extent.

Authors Contribution

Wondale Habtamu Teferi: Is the sole author of this study.

Conflict of Interests/Disclosures

The authors declared no potential conflicts of interest w.r.t the research, authorship and/or publication of this article.

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