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Strategic Management and Analysis of the Sorghum Innovation System in the Tehuledere District, Eastern Amhara, Ethiopia

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ABSTRACT

This study investigates the challenges faced in managing and strategizing the sorghum innovation system and value chain in the Tehuledere District, situated in the Eastern Amhara Region of Ethiopia. The study utilizes an integrated innovation and value chain framework to examine data from surveys and interviews conducted with 108 participants, encompassing farmers, agro-dealers, traders, and processors. The obtained data encompasses both quantitative and qualitative information. The research analyzes the fundamental components of the sorghum innovation system, encompassing its functionality, structure, capability, and environment. It highlights both the achievements and significant challenges. The challenges include inherent weaknesses in the structure, unexplored potential for innovation and value chain operations, and inadequate implementation of policies in many industries. Moreover, insufficient interactions between stakeholders have led to disparities in information and breakdowns within the market system. To address these issues, the paper proposes adopting policies that prioritize enhancing research and development, extension services, access to funding, and infrastructure development. These initiatives will encourage the development of new ideas and make it easier to establish networks of businesses that add value to products or services. Furthermore, it is imperative to provide ongoing policy support and enhance institutional capacity to ensure the sustainable management and development of the sorghum industry in Ethiopia.

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1. Introduction

A sorghum innovation system refers to the flow of sorghum technologies and information among the organizational and individual actors engaged in Sorghum (Hambloch, Kahwai, & Mugonya, 2021). An innovation system also embraces the nature of the interactions among the actors and the institutions that condition the behavior of the actors involved in the entire sorghum innovation ecosystem. (Mengistu, 2010). It further comprises the structural, functional, capability, infrastructural, and enabling environment dimensions needed to turn available technologies and information associated with Sorghum into a process and product on the market (most developing countries like Ethiopia, 2015). On the other hand, a sorghum value chain can be defined as chains of activities that go into the creation of a sorghum product from its initial stage to its entry into the hands of consumers (Deribe, Kassa, & Agriculture, 2020; Gereffi, Humphrey, Kaplinsky, & Sturgeon). A value chain analysis aims to identify key stages, including technology generation and dissemination,

production, marketing, and processing activities, depending on the socio-technical context. A value-chain analysis aims to enhance value-chain efficiency so that the innovation ecosystem of the commodity can deliver maximum value for the cost incurred in the production process (Akinyi, Karanja Ng'ang'a, Ngigi, Mathenge, & Girvetz, 2022).

Sorghum technological innovations are deployed into a farming system's complex social, economic, cultural, and environmental context. From a systemic policy perspective, pinpointing systemic problems embedded in the various elements of the sectoral social structure is vital. Such analyses enable the design of proper systemic policy instruments so that getting rid of the systemic problems would be possible. This eventually leads to the attainment of sustainable sorghum subsector transformation. Analyzing the overall sorghum innovation system using coupled innovation and value chain analyses may help identify systemic issues, enabling the design of appropriate systemic policy instruments to address systemic constraints and maximize opportunities for sorghum farmers.

This study utilized integrated conceptual frameworks for innovation and value chain analysis. Figure 1 illustrates the proposed study framework. The study will identify the systemic issues that hinder the efficient operation of the sorghum innovation and value chain systems at the district level. To gather additional information beyond the district boundary, appropriate data from federal and regional state bodies were collected to complement the micro-level (home) information, focusing on the innovation system aspects and value chain stages.

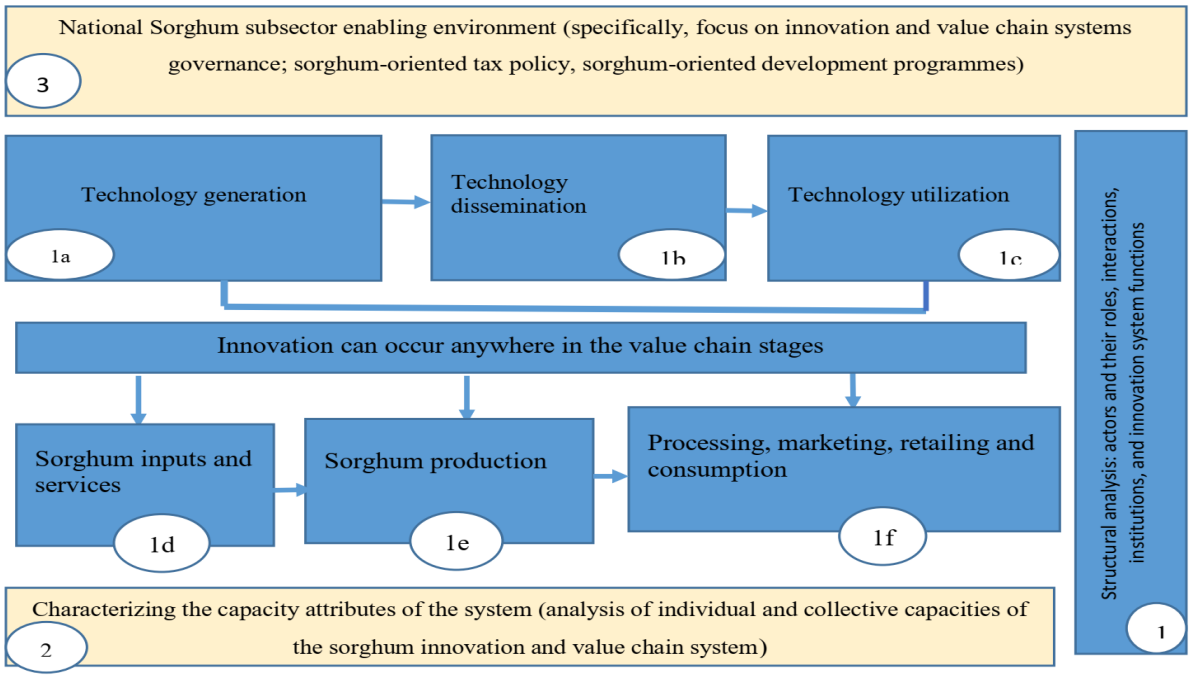

Figure 1: A Proposed Integrated Innovation System and Value Chain Analysis Framework.
Source: own survey

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so that the innovation ecosystem of the commodity can deliver maximum value for the cost incurred in the production process (Akinyi et al., 2022).

Some studies analyzed the bio-physical, socioeconomic, and institutional aspects of the sorghum innovation system in Ethiopia (Sanders, Shapiro, & Ramaswamy; Wubeneh & Sanders, 2006). However, a comprehensive analysis and depiction of the various dimensions of the Ethiopian sorghum innovation system and the features of its value chain have not been well documented. An essential step in identifying significant obstacles inside the innovation system and value chain nodes is to conduct a thorough analysis of the subsector system using suitable analytical methods (Inigo & Albareda, 2016).

Assessing the sorghum technological innovation system involves various study approaches, including structural investigation, functional analysis, capacity analysis, and enabling environmental analysis. This study investigates the sorghum innovation system in the Tehuledere district, situated in the eastern region of the Amhara National Regional State.

2. Literature Review

2.1. Concepts of Innovation Systems and the Agricultural Innovation System

The concept of innovation has been defined differently by various authors in the literature (Lundvall, 2016). As defined by Freeman in 1982, innovation refers to a range of activities involved in creating, manufacturing, managing, and promoting new or improved products. It also includes introducing new or upgraded processes or equipment (Rothwell, 1992). However, Rothwell (1992) highlighted that innovation does not necessarily require radical changes. Rothwell's definition of innovation encompasses the act of introducing substantial advancements in technology to the market, as well as using even minor shifts in technological knowledge. Innovation can be defined at its core as adding a new and original element to an economic or social activity, as stated by the OECD (2018). In research and development (R&D), innovation is the efficient use of new inventions that result in economic prosperity (Bacon & Butler, 1998). In this context, the invention is defined as devising a solution to a specific problem. This enables us to differentiate between knowledge and inventiveness. Transforming a novel concept into a widely embraced solution requires a series of steps, efficient utilization of resources, and continuous problem-solving throughout the rigorous process.

Innovation was once closely linked to science and technology. Innovation is inherent in the existing economic framework, which determines the goals to be accomplished and the areas where progress will occur. These innovations enhance institutional, organizational, managerial, and service delivery in addition to product and process technology. This further substantiates that agricultural research organizations go beyond providing novel technology and information. Inventors might be successful if they achieve widespread usage and adoption (Chema, Gilbert, & Roseboom, 2003). Innovations refer to novel and economically impactful creations. They entail the generation of novel information or the amalgamation of preexisting data. According to Chema et al. (2003), knowledge is not considered innovation until it is transformed into tangible commodities and processes with practical and commercial value. This intricate change encompasses feedback loops and interconnections among research, technology, education, industry, politics, and consumer demand. "Innovations" encompass the processes of discovering, producing, distributing, adapting, and utilizing new information and methods in technology, institutions, organizations, and management of services (Hall, Lotti, & Mairesse, 2009).

An innovation system comprises organizations and individuals who generate, distribute, modify, and employ novel information. The encompassing environment that impacts these interactions and activities is included. The entities and individuals accountable for producing, distributing, modifying, and utilizing novel information; the collaborative acquisition of knowledge that takes place when organizations participate in these endeavors, resulting in the development of unique products and procedures (innovation); and the systems (official and unofficial regulations, standards, and customs) that oversee these interactions and procedures (Horton, Innovation systems refer to interconnected networks or series of individuals who collaborate on similar subjects, be it within a specific industry,

geographical region, or any other discipline. Innovation systems are national, sectoral, commodity, or intervention-based.

2.2. National Innovation System

Legwaila (2012) defines a national innovation system as a cohesive network of institutions, organizations, and policies that work together to achieve a standard set of social and economic objectives. This concept was given in the framework of the national innovation system. In order to facilitate this transformation process, it is essential to employ innovation. This concept posits that innovation arises from establishing networks of individuals, the interactions among these individuals, and the processes involved in conducting research and utilizing research findings to gain socioeconomic benefits (Roseboom, Minde, & Elliott, 2005). Implementing an NIS notion into an organization will enhance comprehension of governance, resource allocation, and outcomes in the short, medium, and long term.

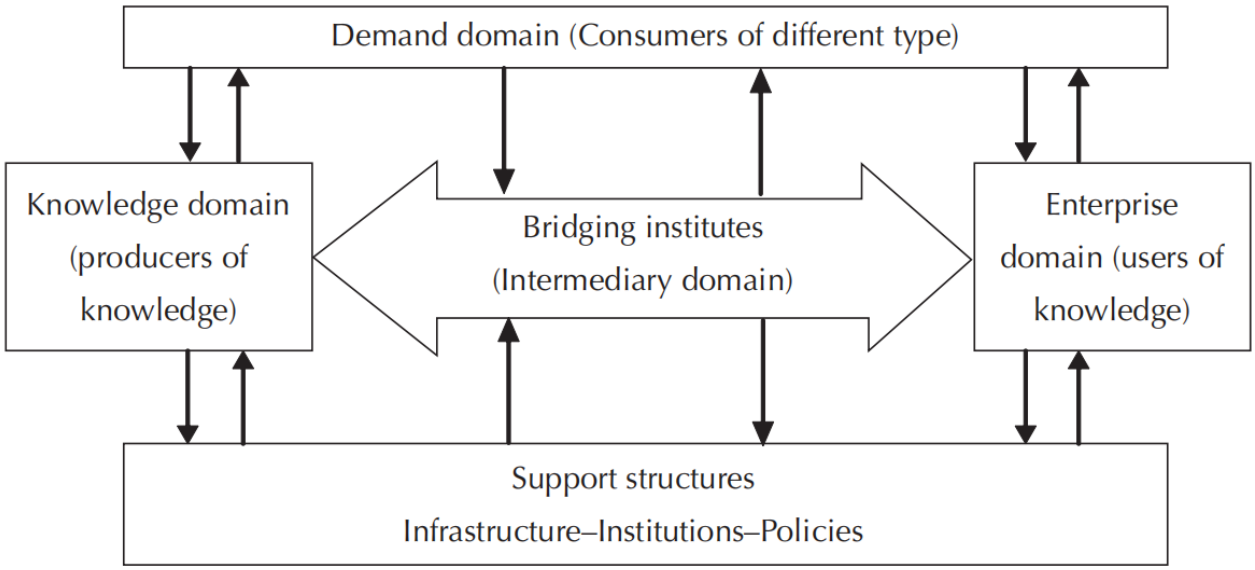

Figure 2: Generic Concept of National System of Innovation, World Bank 2008

The NIS concept is a fundamental notion consisting of three components. The components encompass the knowledge domain, the business domain, and the environment. The notion of NIS was first proposed in the academic literature that discussed industrial innovation in the late 1980s. A thorough and straightforward investigation marked the initial part of the NIS inquiry. This analysis aimed to elucidate the disparities in inventive activity and performance across different nations.

However, the theoretical basis of the NIS technique has been dramatically improved in recent years due to the incorporation of knowledge from several schools of thought. The streams of thought encompassed in this text are institutional thesis, evolutionary economics, systems theory, and earning theories, as discussed by Roseboom in 2004a and 2004b. The NIS primarily functions as an analytical instrument that can enhance innovation by assisting in policymaking and planning.

The Network Information System (NIS) allows actors and stakeholders to understand their connections with other individuals in the system and recognize their specific responsibilities. Patterson, Kerrin, and Zibarras (2013) argue that the result is the possibility of enhanced expression, the recognition of shortcomings and barriers, and a higher level of consensus, at least in principle, on the criteria that will be crucial for the system in the future. Patterson was the subject of inquiry in 2003. The subsequent points outline the distinctive features of NIS and the valuable knowledge that may be obtained from them (Metcalfe, 1995; Pardey & Roseboom, 2004; Roseboom et al., 2005). The references cited are as follows: Hall et al. (2009), Metcalfe (1995), and Arnold and Bell (2001);

- The National Innovation System (NIS) places significant importance on the interconnection and non-linearity of the innovation process and on-demand as a driver of innovation.
- The evolutionary theory has a significant impact on them. At the same time, as there is no singular optimal NIS, dynamic NIS are continuously adjusting and modifying themselves in response to the emergence of new opportunities.
- The National Information System (NIS) assigns excellent weight to institutions' functions regarding the game's rules and participants. The success of innovation is heavily influenced by the 'framework circumstances,' which encompass policies, regulations, rules, cultural features, and the underlying design of the system. The primary determinant of the disparity between individuals who innovate and those who do not is often rooted in the operational dynamics of a particular culture, including the societal emphasis on innovation and entrepreneurship, financial considerations, and the perception of risk.
- The National Information System (NIS) emphasizes the pattern and intensity of interactions among the many actors involved in the system.
- Successful innovation requires both a "supply push" from the research community and a "demand-pull" from individual users of new information. For a system of innovation to be successful, it is essential to have continuous interaction between multiple companies and individuals from both sides.
- Innovation occurs inside a social structure where research and researchers play a minor role. Furthermore, outside of these essential elements, there exist networks of individuals that function as channels of communication between individuals and organizations. These networks might be either formal or informal. Intermediate organizations play a crucial role in successful innovation, primarily when they aim to determine the desires of producers and end users and explore the potential within existing and new knowledge to identify the most satisfying solutions.

2.3. Agricultural Innovation System

Numerous sources explore the origins of innovation systems and their use in agriculture. The following items are encompassed within this category: Freeman (1987) introduced the National Innovation System in developed economies' industrial sector. Biggs (1989) suggested a model with multiple sources of innovation for agricultural research and technology promotion. The linear model is insufficient in describing the actual innovation process. Existing organizational frameworks do not sufficiently include all participants. There is an increasing need for proven developmental impacts and higher expectations and responsibilities for research and development.

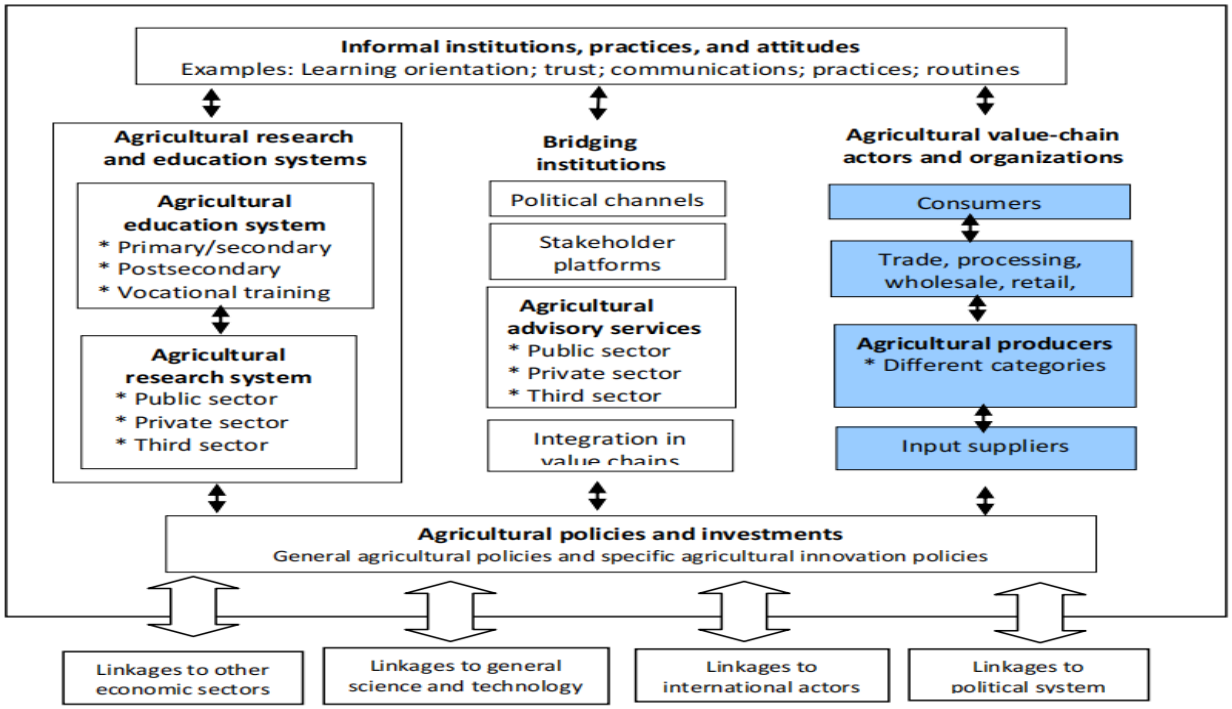

Figure 3 National Agricultural Innovation System Communities (Research for Development).
Source: World Bank, 2007

An "Agricultural Innovation System" refers to a collaborative framework where several entities collaborate to enhance agricultural practices using new management techniques, organizational frameworks, and technological breakthroughs. The system can involve various actors, including local, national, and multinational private sectors, such as agro-industrial firms and entrepreneurs, civil society organizations like NGOs, farmers and consumer groups, and pressure groups. Modern actors like NARIs, IARCs, and advanced research institutions can contribute to this system. Furthermore, the innovation generation and delivery process can be influenced by various institutions such as laws, regulations, beliefs, practices, and norms (Figure 3).

Formal and informal socioeconomic institutions affect a generic AIS's many agents, including NIS. AIS focuses on knowledge production and adoption and considers all parties engaged in economic success and innovation. Market pressures, public policy, non-market institutions, organizational learning, and behavioral change are all captured in the framework (World Bank, 2006). It also emphasizes foundation conditions and connections to other industries and national and worldwide scientific and technology communities. This paradigm explicitly integrates the value chain notion, making it essential. The AIS point of view examines the flow of knowledge and institutional and technical change in society by analyzing the roles and interactions of various agents involved in the research, development, and delivery of innovations relevant to agricultural production and consumption. Agricultural innovation systems are more comprehensive than agricultural research systems. Think about this. Table 2 shows the main traits of agricultural research and innovation systems. Several countries have integrated AIS components into their agricultural R&D systems. This is notable.

Clark (2002) stated that the AIS concept acknowledged the findings of Clarke and Turner (2002).

- Innovating involves scientific research institutions and other organizations as well as non-research activities. How links, contracts, partnerships, and organizational settings affect information exchange.
- As a social process, innovation entails participatory learning through practical experience. New opportunities and ideas might arise from this process, leading to organizational and institutional reforms. Social and economic systems affect agent relationships. Innovation depends on linkages between people and institutions: these links and their political economy matter.
- Innovation depends on the people and institutions in a given time and place who create knowledge.

2.4. Commodity-based Innovation System

A commodity-based innovation system encompasses the range of actors, their actions, and partnerships, as well as the enabling environment, institutions, and services that affect different types of innovation along the value chain of a commodity. This emphasizes that innovation can occur at every stage of the value chain rather than only being restricted to the farm. Hence, broadening the research agenda to encompass bio-physical and socioeconomic research within the R4D portfolio is crucial.

In the 1980s, the linear model supported improving national agricultural research systems (NARS). The investments made during this period mainly focused on enhancing the ability to provide technology by offering infrastructure, training, management, and policy assistance at the national level. Since the 1990s, there has been an increased focus on demand-side variables concerning agricultural knowledge and information systems (Iacovidou et al., 2017). The most recent framework on agricultural innovation systems (AIS) offers direction for creating and using knowledge. The essay emphasizes the importance of creating strong institutions and practical linkages between research, extension, and farmers. The text highlights the importance of incorporating supplementary functionalities that

facilitate the cooperation and fulfillment of diverse requirements across players, including expertise, partnership incentives, and enhanced information exchange. Moreover, it emphasizes the significance of establishing a conducive atmosphere that enables innovation among the individuals involved.

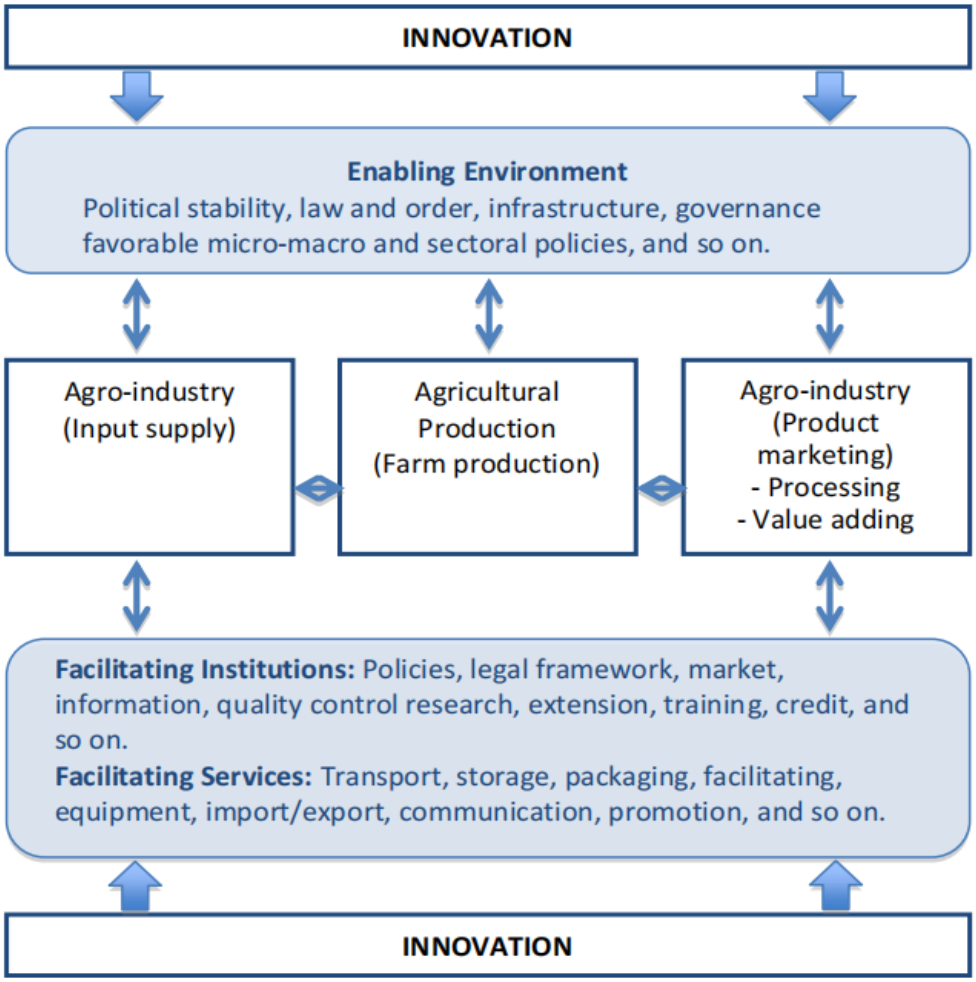

Figure 4: Typical Commodity-based Innovation System

Systems thinking is all about connections, not parts. An innovation system is characterized by the introduction new goods, processes, and organizational forms by a combination of individuals, businesses, and other entities (Hall et al., 2009). Also mentioned are the policies and laws that impact their actions. Members of innovation systems include not only scientists but also others. Knowledge demand and use undergo unique and beneficial transformations due to innovation. According to the World Bank (2006), local, user-new changes drive innovation. The 'National Innovation System' (Legwaila, 2010) describes how all parts of the system work together (Mengistu, 2010), whereas the 'intervention-based innovation system' (Spiers & Maguire, 2008) focuses on the difficulties that are unique to the intervention. "Master and implement the design and production of goods and services that are new to them irrespective of whether they are new to their competitors, their country, or the world" is what it means when businesses innovate (Mytelka, 2000). Innovations boost economies and society through improvements in technology, institutions, and other areas (Bank, 2006). Mytelka (2000) discovered non-linear learning.

This research shows that a highly integrated, mixed–croattle system produces crops and livestock in a compact space. Individuals or families manage crops and cattle. Agricultural and animal operations with positive plant biomass, manure, electricity, and cash flows are more efficient, productive, and sustainable.

Smallholder and commercial farmers in Eastern Amhara utilize both new and current sorghum knowledge and services for both commercial and non-commercial purposes. Interaction and overlapping information flows among players in the sorghum sub-sector and underlying laws and institutions determine the efficacy of innovative products, process, and organizational translation into social and economic use. All sorts of people—livestock-

dependent people, scientists, traders, development workers, legislators, and more—are part of the innovation systems idea, which promotes creativity and uniqueness via player interaction, information sharing, and learning. Innovation and knowledge use are shaped by interaction patterns and the forces acting upon them. This is particularly true concerning the habits and practices of players and institutions, which can be understood as norms and laws (World Bank, 2006).

Traditional economic models that view innovation as a sequential process driven by R&D failed to explain it (Hall et al., 2009). The framework helps understand and improve national, sectoral, and sub-sectoral innovation. Innovation systems are thought to drive sorghum technology. Traditional innovation development methods that focus on innovation system structure fail, according to Hekkert, Suurs, Negro, Kuhlmann, and Smits (2007). Due to this absence, emerging methods for analyzing innovation systems in a specific product subsector focus on critical procedures. Innovative opportunities require resources, skills, and product markets to realize and profit from (Carlsson, Jacobsson, Holmén, & Rickne, 2002).

3. Method

The research makes use of qualitative as well as quantitative information. The sorghum value chain is defined using the quantitative technique by analyzing quantitative data obtained from both primary and secondary sources. Key informant interviews, focus groups, and home surveys provided most of the data. Understanding the Ethiopian sorghum innovation system via the perspectives and ideas of the different individuals engaged is the primary purpose of the qualitative approach. Using the qualitative data produced by diagnostic techniques and actively engaging in the study process are skills that the researcher must possess. The researcher must study and analyze the data produced by the sorghum technological innovation system. Researchers conducting this study should use their senses while simultaneously taking into account the cultural viewpoints of the local sorghum farmers.

A descriptive research design was used to examine data at a macro level. The sorghum innovation system is characterized using a 5-point Likert scale (Wieczorek, 2017) in the macro-level analysis at the national and regional state levels. It evaluates how well the sorghum innovation system is doing in terms of its capabilities, capacity, and enabling environment.

At the micro level, we are looking at sorghum value chain phases and the factors linked to them, as well as describing the households that grow Sorghum. This micro-level investigation aims to identify the nodes in the value chain by characterizing the sorghum production system at the household level in a few sample kebeles. We utilized a systematic random sampling procedure to select 297 heads of household from the lists of female-headed and male-headed families in each of the three kebeles (Godaguadit, Jari, and Tebisa), which had a total population of 20,807. However, just 108 of the people who participated in the survey met all the requirements for the research.

This work examines the aims and procedures of the sorghum technical innovation system in detail. All the players, their functions, and how they interact make up the structural analysis of a sorghum technological innovation system. Evaluations are based on their presence or absence, roles, and interactions. Interactions are what make up dynamic actor relationships. In several ways, actors engage with the world around them. Various functions inside the sorghum innovation system should be responsible for innovation. Edquist (2004) states that revolutionary innovations are created, disseminated, and utilized by an innovation system. The system's successes, shortcomings, and overall performance are all assessed by functional analysis (Bergek, Jacobsson, Carlsson, Lindmark, & Rickne, 2008). Sorghum innovation system capacity analysis identifies elements that aid or hinder performance. The focus of capacity analysis is on both the abilities of individuals and groups. Sorghum innovation demands specific capacities, as shown by the capacity view. Four functional capacities are highlighted in the Common Framework for innovation system capacity building of the Tropical Agriculture Platform (Cardenas & Los Banos, 2013). Let me list them:

The ability to navigate complexity involves changing perspectives, attitudes, and behavior to understand the more comprehensive system thoroughly.

- The capacity for collaboration entails comprehending different viewpoints, resolving disagreements, handling variety, merging skills and knowledge, and acknowledging complementarity.
- In order to achieve successful reflection and learning, it is necessary to collect stakeholders, develop and promote critical reflection procedures, and implement action and change processes.
- Capability to actively participate in strategic and political procedures, comprehending and exerting influence over power dynamics within individuals, organizations, and society.

In order to reach the innovation potential, these four abilities are necessary for a general ability to adapt and respond, which moves the emphasis from reactively solving problems to co-creating the future (Tropical Agriculture Platform, 2016).

Alternatively, you might use Enabling Environmental Analysis. This section delves into the different policies, infrastructures, and policy tools affecting the sorghum innovation system in the studied area. Some examples of these tools are public-private partnerships and financial incentives for sorghum research and development.

4. Results

4.1. Importance of Different Actors in the Sorghum Innovation System

In addition to interviews and focus group discussions with farmers, institutions, and other stakeholders, the study addressed quantitative data regarding the roles played by different potential actors in the Innovation system. 108 participants responded to the survey questionnaire. The analysis results in Table 1 below identified the importance of the active participation of actors in the innovation, with a 3.63 aggregated average rating on a scale of five.

Table 1
Perception of The Potential Roles to be Played By The Actors Engaged in Sorghum Innovation And Value Chain Systems

S/N	(Perception on the potential roles played by…)	N	Min.	Max.	Mean (M)	Standard Deviation	Significance of the Actor/Role
1	sorghum-producing farmer/farm family	108	1.00	5.00	3.69	0.59	High
2	farmer organizations	108	1.00	5.00	3.62	0.60	High
3	advisory services (private, non-governmental, and public)	108	1.00	5.00	3.72	0.54	High
4	agro-dealers (input suppliers and processing)	108	1.00	5.00	3.32	0.70	Moderate
5	tertiary education institute (colleges and universities)	108	1.00	5.00	3.86	0.63	High
6	researchers (regional state and international)	108	1.00	5.00	3.79	0.61	High
7	policymakers (Regional, national, local level)	108	1.00	5.00	3.49	0.68	High
8	development agencies (donors)	108	1.00	5.00	3.62	0.84	High
9	consumer organizations	108	1.00	5.00	3.53	0.74	High
	Overall Mean Score				3.63		High

The findings suggest that agro-dealers, specifically input suppliers and processors, play a moderately significant role in the value chain analysis (Mean = 3.32). These actors are expected to facilitate the availability of resources for sorghum production and access to markets for selling the products (sometimes accompanied by guidance and financial assistance). Additionally, they possess the capacity to find, test, and promote emerging market opportunities. They are responsible for establishing quality benchmarks for sorghum goods and facilitating connections between agricultural stakeholders and the broader market.

Various actors were identified as having a substantial role (Mean > 3.4) in the value chain as long as they are actively engaged in the value chain system and effectively fulfilling their particular roles. The study found that the Education institute (M=3.86), researchers (M=3.79), and advisory services (M=3.72) are the three most essential actors in ensuring the sorghum value chain operates effectively in the study area.

The primary function of tertiary education institutions, such as colleges and universities, is to enhance the overall educational level of individuals involved in the sorghum industry. These institutions provide education and training opportunities for professionals in the sorghum subsector. These institutions are responsible for enhancing the knowledge and skills of farmers and other individuals involved in sorghum production. They also aim to develop strategies and techniques for experiential and collaborative learning to improve Sorghum's transformation.

The primary purpose of the researchers' tasks was to enhance and refine sorghum technologies, practices, and procedures that apply to local, regional, and national contexts. Their responsibility is to fulfill their accreditation role by conducting tests and validations on sorghum technologies and locally developed processes. They must also document how new sorghum production practices and technologies are adjusted and implemented. They must collaborate with other participants in the value chain and other countries and international organizations regarding matters about Sorghum.

The respondents also emphasized the significance of Advisory Services in the value chain. These entities might be categorized as private, non-governmental, or public advisory. Their role was seen as facilitating the exchange of information between farmers and other stakeholders. Advisory services can provide access to new technology and methods, establish networks, and assist farmers' organizations. They can also help farmers access credit, inputs, and output services, as well as public or private interventions and initiatives related to sorghum innovation. Furthermore, advising services can have a substantial impact in promoting fair and inclusive involvement of farmers in sorghum value chain operations.

The importance of the contributions played by farmers (M=3.69) and farmers' organizations (M=3.62) was duly acknowledged. The primary objective was for the sorghum-producing farmers to proficiently utilize newly developed sorghum technologies generated by the research system. Additionally, these farmers were expected to serve as a valuable source of knowledge in developing further sorghum technologies while also playing a crucial role in identifying difficulties, challenges, and possibilities. The primary role of Farmer Organizations/Associations is to advocate for the interests, needs, and opportunities of farmers in sorghum value chains, as well as in the community and policy arenas. Additionally, they act as intermediaries, helping farmers gain access to agricultural inputs, credit, and markets. They also engage in lobbying activities to further support farmers. In addition, they facilitate targeted innovation through cooperative research and offer consulting services.

Development agencies with a mean score of 3.62 were also acknowledged for their significant role in enabling access to finances for sorghum research projects and programs and allocating resources for sorghum development initiatives. The significance of engaging consumers and/or their organizations in the value chain was strongly emphasized (M=3.53). Their involvement is believed to impact demand-driven sorghum research priorities and innovation practices, act as intermediaries for information on new sorghum products and processes, and facilitate consumer acceptance of sorghum products.

Furthermore, the inclusion of policymakers (M=3.49) was essential in order to enhance the efficacy of the value chain. The responsibility is to develop, administer, and enforce strategies, policies, and laws regarding Sorghum policymakers. They provide strategic guidance for the development of Sorghum at the regional, national, and local levels. Their responsibility involved prioritizing policies that concentrate on devoting resources to sorghum research and developing human resources, fostering innovation and collaboration in the context of Sorghum, and encouraging the establishment of networks and partnerships.

4.2. Capacity Analysis

The focus of the innovation system capacity analysis was on examining individual and collective capacities to determine the elements linked to capacity that impacted the performance of the sorghum innovation and value chain systems. Sorghum innovation and value chain activities were highlighted as requiring specific capacities. It was necessary to evaluate four system capacities, and the research followed the Tropical Agriculture Platform's

(TAP) Common Framework on Capacity Development for Innovation and Value Chain Systems (Dahlberg, 2022).

Table 2
Capacity Analysis of Attributes

S/N	Statements	N	Mean	Std. dev	Decision	Attitude /Perception
1	Capacity to navigate complexity	108	3.38	0.87	Neutral e	Normal
2	Capacity to collaborate	108	3.45	0.93	Agree	+
3	Capacity to reflect and learn	108	3.62	0.80	Agree	+
4	Capacity to engage in strategic and political processes	108	3.50	0.923	Agree	+
	Overall Mean Score		3.49		Agree	

The assessment of these capabilities in the Ethiopian Sorghum Innovation system was done using descriptive statistics that indicated how agreeable these capabilities are. The result in Table 2 indicated the mean agreement values for each of the four capabilities on a Likert scale of five.

The capacity to navigate complexity assumes that the Ethiopian sorghum innovation system actors can shift their mindsets, attitudes, and behaviors to comprehend the broader and multifaceted sorghum innovation system well and create an understanding of the entire macro-system. The state of capability in navigating complexity was assessed with aggregated M=3.38, which was in the range of 2.6-3.4, indicating moderate level availability of the required capacity at the national level.

However, the other three capabilities were rated in the range of 3.4-4.2 to agree that these capabilities were possessed by different actors in the Ethiopian sorghum innovation system. The capacity to collaborate is attributed to the sorghum innovation system actors' ability to understand each other's perspectives, manage conflicts, and manage diversity to combine individual skills and knowledge and create an awareness of their complementarity. The average agreement to this required capability was M=3.45, indicating that actors can collaborate.

Different actors were found to have acquired the capacity to reflect and learn, assessed with an average rating of M=3.62. The result showed that the Ethiopian sorghum innovation system actors can bring stakeholders together, design and lead critical reflection processes, and follow a learning process that leads to action and positive change in sorghum innovation and value chain systems.

Regarding the capacity to engage in strategic and political processes, the actor's readiness was assessed with aggregated M=3.50. Hence, the actors in the Ethiopian sorghum innovation system can understand and influence political and power relations between individuals, within organizations, and in society regarding sorghum subsector transformation.

In general, in all four measures of the capability framework, the actors were found to have considerable capability potential. Although these capacities were attained satisfactorily, the need for improved capabilities cannot be denied. In particular, the actors' potential capacity to navigate complexity must be developed to understand the entire macro-system concerning the Ethiopian Sorghum innovation system.

4.3. Functional Analysis: Performance of the Innovation System

In addition to the above list of actors and their potential roles, the significance of involving other potential actors' and functions in the value chain was assessed (Table 5). The result is the significance of the roles that entrepreneurs could play. The assessment result with M=3.32 indicated moderate level agreement, which implied that entrepreneurs in the sorghum innovation and value chain system would have a considerably positive impact, otherwise hindering realizing the innovation system sustainably fully. In the existing innovation, the respondents highly opined the availability of potential entrepreneurs at an adequate level (M=3.82). Hence, actively involving entrepreneurs will facilitate the application of new sorghum technologies and services to tangible economic outcomes.

Table 3
Assessment of the Status of the Functions of the Ethiopian Sorghum Innovation and Value Chain Systems

S/N	Statements	N	Mean (M)	Standard Dev,	Decision	Attitude /Perception
1	Without entrepreneurs, the sorghum innovation and value chain system cannot be realized, and the innovation system will not even exist	108	3.32	1.05	Neutral	Normal
2	Entrepreneurs turn the potential of new sorghum technologies and services into tangible economic outcomes	108	3.82	0.72	Agree	+
3	It is assumed that such entrepreneurs exist in Ethiopia's sorghum innovation and value chain system	108	3.47	0.89	Agree	+
4	Sorghum technologies are at the heart/core of the global transformation of the sorghum sub-sector	108	4.07	0.71	Agree	+
5	The most fundamental resource in the modern economy is knowledge. Therefore, sorghum research is a fundamental task to enhance the overall transformation of the sorghum sub-sector.	108	3.97	0.89	Agree	+
6	These activities are considered to be carried out satisfactorily in the Ethiopian sorghum production system.	108	3.46	0.97	Agree	+
7	Technology Diffusion – Technology and knowledge exchange through a network of actors is critical to developing sorghum innovation.	108	3.13	0.98	Neutral	Normal
8	Resource mobilization to support research and development activities -	108	3.05	1.04	Neutral	Normal
9	Market-Information	108	3.04	1.03	Neutral	Normal
10	Demand-Articulation or Forecasting	108	3.08	0.99	Neutral	Normal
11	Lowering resistance to sorghum technology	108	3.22	0.87	Neutral	Normal
	Overall Mean Score		3.42		Agree	

Ethiopian Sorgohm Innovation system considers Sorghum technologies to be at the heart/core of the global transformation of the sorghum sub-sector, which is consistent with the missions and vision of the sorghum improvement program and practiced to the satisfactory level (M=4.07). In line with this, the most fundamental resource in the modern economy is knowledge, and thus, sorghum research is a fundamental activity that enhances sorghum subsector transformation. This function comprises research works aimed at sorghum technology generation or adaptation activities through 'learning by doing.' In the Ethiopian sorghum innovation system context, these functions were reported to have been carried out satisfactorily (M=3.97). Hence, exchanging technologies and knowledge through the network of actors is vital for progress in sorghum innovation. This function can be regarded as a precondition to 'learning by interacting,' which can be undertaken by formal public extension systems at various levels or through the roles of non-public technology piloting actors in the sorghum innovation system. However, the assessment by respondents identified a moderate level of such practice (mean=3.13). Hence, in the existing innovation system, however, the system exhibited gaps in technology diffusion where technology and knowledge exchange through a network of actors were not dealt with adequately.

Mobilizing monetary and non-monetary resources is necessary to ensure that transformative sorghum innovation activities are carried out efficiently. Allocation of adequate financial resources is necessary to ensure the production of adequate sorghum seed, strengthen research and extension, and develop physical and knowledge infrastructures that facilitate sorghum subsector transformation endeavors. The need for Resource mobilization to support research and development activities was an essential function in the value chain. However, this function was not fully addressed (M=3.05) in the existing sorghum value chain. Hence, it cannot be assumed that adequate resources are available for sorghum innovation and the value chain to transform well.

An interactive and cumulative process of exchanging ideas between sorghum technology developers, users, and other actors engaged in the sorghum innovation system and communicating success stories would stimulate demands for sorghum technology and

pave the way for further innovation. In this regard, demand articulation/forecasting in the innovation system was not highly practiced and was found to be moderate (M=3.08).

New technologies and innovations often face resistance compared to already existing ones that are well-promoted. Thus, creating favorable conditions for sorghum technologies would lead to better use. To stimulate sorghum innovation progress, it is vital to facilitate the creation of (niche) markets where new sorghum technologies get the chance of broader application. In this regard, the availability of favorable market information was assessed to a moderate level (M=3.04). Moreover, to benefit from newly developed sorghum technologies, the technologies must be made part of the existing technological choices or even replace the existing technologies. Rigorous promotional activities can catalyze legitimacy creation efforts to counteract resistance to new technologies, leading to improved adoption. The efforts to lower resistance to sorghum technologies were also addressed to a moderate level (M=3.22) in the sorghum innovation and value chain system.

4.4. Functional Analysis: Systemic Failure

However, contrary to the available potentials, the Ethiopian Sorghum Innovation System was attributed to its systemic failures in engaging different actors towards a comprehensive understanding of the macro-system. This was examined by the extent of failures in the existing innovation system. The mean values in Table 2 indicated the average system failure rating regarding each potential value-chain actor. The mean values range from the smallest, 3.60, to the highest, 3.88, indicating significantly high-level failure with all actors and functions in the innovation system.

Table 4
Analysis of Systemic Failures in the Ethiopian Sorghum Innovation Systems

S/N	Failure Type	N	Min.	Max.	Mean (M)	Std. Dev.	Degree of failure
1	Actors' capability failures	108	1.00	5.00	3.67	0.73	High
2	formal institutional failures	108	1.00	5.00	3.60	0.88	High
3	informal institutional failures	108	1.00	5.00	3.69	0.84	High
4	strong interaction failure	108	1.00	5.00	3.82	0.74	High
5	weak interaction failure	108	1.00	5.00	3.78	0.73	High
6	directionality failures	108	1.00	5.00	3.74	0.87	High
7	infrastructural failures	108	1.00	5.00	3.85	0.84	High
8	demand articulation failures	108	1.00	5.00	3.82	0.75	High
9	policy coordination failures	108	1.00	5.00	3.88	0.72	High
10	reflexivity failures	108	1.00	5.00	3.88	0.78	High
11	market failures	108	1.00	5.00	3.76	0.78	High
					3.77		High

Regarding the actors' capability, which was rated with a failure level of M=3.67, the innovation system suffered from a lack of suitable competencies and resources at both the actor and firm level. This hindered their ability to access new sorghum knowledge and technologies and resulted in their failure to adapt to evolving innovation and value chain circumstances that could have presented new opportunities.

The value chain system was limited by the current formal government policies, rules, and regulations, which impede the advancement of sorghum innovation and the value chain system. This limitation was confirmed by a high failure rate, with an agreement rating of M=3.60. While formal and informal institutions have the potential to contribute positively to the innovation system, the current system is hindered by their presence. This was confirmed by the notable prevalence of failure, with a mean score of 3.69, which indicated that informal institutions such as social norms and values, culture, entrepreneurial spirit, trust, and risk-taking had impeded sorghum innovation and value chain operations.

The system also shows excessive and unnecessary strong interactions among densely interconnected networks while simultaneously displaying restricted interactions and knowledge sharing with other actors. These limitations hinder the utilization of other sources of sorghum-related knowledge and impede interactive learning processes. The profound engagement and collaboration result in a state of being locked into established trajectories and a dearth of infusion of novel concepts owing to excessively introspective conduct. The prevalence of failure in the existing innovation system was high, with a mean value of 82. An

equally significant aspect is the unnecessary weak interaction within the value chain. The low interaction observed in the sorghum innovation and value chain system (M=3.8) can be attributed to a lack of shared vision about goals and direction and a lack of coordination among the individuals involved. The system was further characterized by inadequate regulation or standards to effectively guide and unify the direction of change in sorghum innovation and value chain systems. Additionally, there was a lack of targeted funding for generating and disseminating sorghum technology and a lack of infrastructure to establish acceptable paths for sorghum development. Overall, the directional failure was evaluated as having a significant level of system failure (M=3.74).

There were also several infrastructure failures (M=3.85) in the innovation system. This failure was caused by inadequate physical, knowledge, and financial infrastructure. Private investors may not participate in sorghum innovation and value chain systems due to low ROI and extended operation times.

Innovation should be demand-driven. Lack of spaces for anticipating and learning about user needs to enable user uptake of sorghum technical innovations, absence of orienting and stimulating signals from public demand, and lack of demand articulating capabilities led to high system failure (M=3.82).

Lack of multi-level policy coordination across systemic levels causes strategic aims to deviate from operational implementation. A lack of cooperation between ministries and implementing agencies, public policies, and private sector institutions caused similar effects. Incoordination across interrelated sectors could cause the failure of the innovation system. The Ethiopian Sorghum innovation system has severe policy failure, with an average agreement level of 3.88.

Insufficient monitoring, anticipation, and involvement of players in self-governance processes and the absence of distributed reflexive frameworks to connect discursive realms plagued the sorghum innovation system. The reflexive failure (M=3.88) was a lack of adaptive policy portfolios to manage uncertainty and choices.

The main system limitations include information asymmetries, knowledge spillover, cost externalization, and common overexploitation. This caused market failure (M=3.76).

4.5. Environmental Analysis

The impact with regard to the enabling environment of the Ethiopian sorghum innovation system was assessed, as well as the required policies and strategies and research laboratories. The results in the table identified thirteen favorable conditions for sorghum innovation, where their level of availability was rated from the smallest mean=2.53 to the highest mean=3.46, where most of the required enabling environments were either moderately available or below. Among other dimensions, the sorghum innovation development strategies were assessed with a mean=3.46, indicating that the strategy favored the initiation of sorghum business start-ups. It was assessed that there was a moderate extent of favorable policy environment (M=3.13) that fosters, promotes, and facilitates sorghum innovations to occur (3.17) and positively affects the structures, functions, and capacities of sorghum innovation systems (3.32). However, it was indicated that moderately low level of proficiency (M=2.77) in the implementation of sorghum innovation policies. Moreover, the policy update (M=2.85) indicated that sorghum innovation policies failed to be reviewed regularly.

The effectiveness of implemented sorghum innovation enhancement strategies was rated with a moderately low level of effectiveness, M=2.85. Other sorghum innovations impeding the environment were inadequate public financial investment (M=2.61) and inadequate private investment (2.53) in developing sorghum innovation and value chain systems. Low levels of standard tools used (M=2.66), inadequate research laboratories (M=2.64), inclusive for women, youth, and marginalized groups (M=3.10), and absence of regular capacity-building training events (courses, workshops, etc.) provided for sorghum innovation systems actors (M=2.84).

Table 5
Assessment of the Enabling Environment Dimensions of the Ethiopian Sorghum Innovation Systems

S/N	Statements	N	Min.	Max.	Mean(M)	Std. dev.	Degree of Available Enabler
1	Favorable sorghum innovation policies exist	108	1.00	5.00	3.13	0.97	Moderate
2	The existing sorghum innovation policies effectively	108	1.00	5.00	3.17	0.93	Moderate
3	Existing sorghum innovation policies positively affect the structures, functions, and capacities of sorghum innovation systems	108	1.00	5.00	3.32	0.90	Moderate
4	Sorghum innovation policies are proficiently implemented in Ethiopia	108	2.00	5.00	2.77	1.03	Moderate
5	Sorghum innovation policies are regularly updated in Ethiopia	108	1.00	5.00	2.85	0.91	Moderate
6	In Ethiopia, sorghum innovation enhancement strategies are being implemented effectively	108	1.00	5.00	2.81	0.99	Moderate
7	There is adequate public financial investment	108	1.00	5.00	2.61	1.04	Moderate
8	There is adequate private investment in sorghum innovation and value chain system development	108	1.00	5.00	2.53	1.04	Low
9	tools are commonly used in Ethiopian sorghum innovation efforts	108	1.00	5.00	2.66	1.04	Moderate
10	There are adequate research laboratories to enable sorghum innovation in Ethiopia	108	1.00	5.00	2.64	1.15	Moderate
11	Sorghum innovation system interventions are inclusive for women,	108	1.00	5.00	3.10	0.97	Moderate
12	Sorghum innovation development strategies favor the initiation of sorghum business start-ups	108	1.00	5.00	3.46	0.81	High
13	Capacity building training	108	1.00	5.00	2.84	0.87	Moderate
	Overall Mean Score				2.91		Moderate

5. Conclusions

At a national level, different actors can serve in the value chain to ensure the effectiveness of sorghum innovation improvement. Value chain analyses identified that Education institutes, researchers, and advisory services were found to have significant roles to be played at national and regional levels. Among different contributions, these actors will help improve the general education level of all Sorghum actors, where sorghum subsector professionals can get education and training and develop and improve sorghum technologies, practices, and processes relevant to local/regional/national contexts. These Advisory services can make new technology and practices available, forge networks, and support farmers' organizations.

This study assessed the problems, challenges, and bottlenecks that could hinder the Ethiopian Sorghum Improvement System, in general, and the study area in particular. The study used qualitative and quantitative data from interviews, discussions, and survey questionnaires.

Regarding the enabling environment of the Ethiopian sorghum innovation system, specific challenges were identified: lack of working policies and strategies, which amounts to insufficient regulation or standards to guide and consolidate the direction of change in sorghum innovation and value chain systems. As a result, the weak interaction is attributed to a lack of shared vision on the goals and direction and an absence of coordination among actors involved in sorghum innovation and value chain systems. The existing policy was not fully implemented, monitored, or reviewed. Accordingly, the innovation system may not fit changes in the environment. This was highly asserted in the survey result that the innovation

system experienced reflexive failure due to a lack of adaptive policy portfolios to keep options open and deal with uncertainty.

Strong interaction was also found to have existed, limiting the potential roles played by certain actors. As a result, these actors may not have access to the exploitation of complementary sources of Sorghum-related knowledge and interactive learning processes. Similarly, the system was assessed for the prevalence of information asymmetries, knowledge spillover, externalization of costs, and over-exploitation of commons, which were significant limitations in the system and had direct consequences on the failure of the market system.

The respondents opined that the innovation system faced infrastructural failure related to physical, knowledge, and financial infrastructures. Moreover, the perception of a return that is too low takes a long time to operate, which significantly limits private investors from partaking in sorghum innovation and value chain systems.

Overall, the Ethiopian Sorghum Innovation System was assessed positively in all its four capability dimensions. At the same time, the innovation system experienced high-level system failure, indicating low functional performance. Although the innovation system was found to have a moderate level of enabling environment, it was not adequate for the effective functioning of the innovation system.

Other sorghum innovation impeding environment was found in the innovation system. This includes inadequate public financial investment, absence of inclusiveness to marginalized groups, and absence of regular capacity-building training events for sorghum innovation systems actors. The quantitative analyses, therefore, found multiple challenges and problems related to the sorghum innovation system's structural, environmental, and functional aspects.

6. Recommendations

Ultimately, analyzing the Sorghum improvement project in the Eastern Amhara region underscores the need for holistic approaches considering agricultural development's socioeconomic, environmental, and technological dimensions. The research called to action all stakeholders, policymakers, and practitioners to work closely together in addressing and overcoming challenges and exploring and tapping the best opportunities in Sorghum cultivation, thereby contributing to the overall advancement of Agricultural productivity and resilience in the Amhara region of Ethiopia.

To take advantage of the innovation, it is necessary to make extension and outreach efforts to distribute information about the ideal sorghum genotypes that may be cultivated independently or in combination with other crops. In addition, it is necessary to disseminate information concerning the possible advantages that the invention may bring to smallholders' livestock systems. Through the use of public and private extension and advisory services, planting materials will need to be made accessible to those who have the potential to adopt the plant in the target locations. However, the semiarid agroecological zones are particularly suitable for the application of the innovation because of the adaptable nature of Sorghum, which allows it to be utilized in various production systems and geographical locations (World Bank, 2006).

In conclusion, the analysis of sorghum improvement practices in the Eastern part of the Amhara region of Ethiopia has provided valuable insights into the agricultural landscape and potential pathways for sorghum production enhancement.

The research identified the importance of supportive policies and institutional frameworks in promoting sorghum innovation and value chain development. It is recommended that policies focusing on research and development, extension services, access to finance and markets, and infrastructure development be established to play a significant role in encouraging innovation and fostering a conducive environment for value chain actors' involvement growth. Advocating for continued policy support and institutional strengthening in the sorghum sector is recommended. This involves active engagement with policymakers, organizations, and institutions to ensure favorable policies, resource allocation, and

coordination mechanisms that support sustainable sorghum innovation and value chain development.

By designing a policy to support Sorghum cultivation in Ethiopia, It is critically recommended that different incentive packages like tax leverages, input price subsidies, supporting the business with research and development as well as marketing linkage have to be supported for both foreign direct investors and domestic investors on Sorghum producers in the region.

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.

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

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