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Brewery industry-led seed sector development for sorghum in Tanzania

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Brewery industry-led seed sector development for sorghum in Tanzania

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Acronyms and abbreviations

AVISA	Accelerated Varietal Improvement and Seed Delivery of Legumes and Cereals in Africa
BMGF	Bill & Melinda Gates Foundation
CRP-GLDC	CGIAR Research Program on Grain Legumes and Dryland Cereals
EABL	East African Breweries Limited
FAO	Food and Agriculture Organization of the United Nations
FtMA	Farm to Market Alliance
GDP	Gross Domestic Product
HOPE	Harnessing Opportunities for Productivity Enhancement (HOPE) of Sorghum and Millets in sub-Saharan Africa project
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
KBL	Kenya Breweries Limited
KFS	Kibaigwa Flower Supply
NBL	Namibian Breweries Limited
NBS	National Bureau of Statistics
NGO	Non-Governmental Organization
PICS	Purdue Improved Crop Storage Bags
QDS	Quality Declared Seed
SAB	South African Breweries
SBL	Serengeti Breweries Limited
SPSS	Statistical Package for Social Sciences
TARI	Tanzania Agricultural Research Institute
TASTA	Tanzania Seed Trade Association
TBL	Tanzania Breweries Limited
UBL	Uganda Breweries Limited
USA	United States of America
USDA	United States Department of Agriculture
VIF	Variance Inflation Factor
WFP	World Food Programme

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Executive summary

The use of sorghum improved variety seeds has been low among sorghum farmers in Tanzania. Due to this, stakeholders such as brewing companies have launched various initiatives to expand the use of improved sorghum seeds. In general, this study was undertaken to assess the contribution of brewing industry to the sorghum value chain in Tanzania. Specifically, this study aims to determine the extent of use of sorghum in brewing (by quantifying the amount of sorghum grain sold to brewing companies and grain off-takers), identifying stakeholders in the value chain, and the impact of the brewing industry on use of improved seeds by smallholder farmers. The study was conducted in 11 districts in 6 regions of Tanzania covering sorghum farmers, grain off-takers, brewing companies, extension officers, and seed producers. Purposive and simple random sampling was used to select respondents: 591 individual farmers, 160 farmers from 16 focus groups, 15grain off-takers, 14 extension officers, 4 Quality Declared Seed (QDS) producers, and 2 brewing companies. Data was then analyzed using descriptive analysis statistics, Probit Regression, and cost-benefit analysis.

Findings indicated that sorghum was the most cultivated crop (32.0%) and Bambara nut was the least cultivated crop (0.1%) in Tanzania. Dodoma produced the highest amount of sorghum (266,005 tons) with Songwe being the least sorghum producer (48.86 tons) in the 2019/2020 production season. Furthermore, from the 11 sorghum producing surveyed districts, Kongwa district produced the highest amount of sorghum (141,127 tons under 159.9 hectares of farmsize) and Ikungi the least (12.37 tons under 13.62 ha of farm size). According to NBS 2021, Tanzania produced a total of 514,313 tons of sorghum under 601,496 hectares of land during the 2019/2020 production season. The study reported increased demand of sorghum as raw material by the brewing companies with about 15000 tons purchased in 2020. About 36.9% of farmers used improved sorghum seeds for the 2019/2020 season. Among improved varieties, Macia was the most adopted variety (28.9%), with the highest adopters from Kongwa district (16.1%) and the least from Bunda (0.2%). The report further shows that among sources of improved seeds, most of the interviewed farmers reported obtaining seeds from brewing companies (81.4%). Among farmers obtaining seeds from the brewing companies, only 30% of the farmers were under contractual arrangements with at least one of brewing company .

A cost benefit analysis of sorghum grain produced showed that NACO Mtama 1(313,125 TZS/ha), Macia (228,518 TZS/ha) and Tegemeo (175,613 TZS/ha) had higher gross benefits among other varieties. On the other hand, from a cost benefit analysis of sorghum seed production, it was reported the average positive gross benefits from the research institute (4,256,156 TZS/ha), private seed companies (5,337,827 TZS/ha), and QDS producers (1,339,772 TZS/ha). Furthermore, it was reported from the Probit analysis that access to grain markets, brewery contracts, improved seed price, access to storage, and complementary technologies were the determinants for adoption of improved sorghum seeds among sorghum farmers. Findings also reported that about 41.6% of the sorghum farmers sold grain to brewing companies, with about 81.9% being improved varieties. The most traded grain among farmers was the Macia variety (84.1%) among other varieties, and the highest grain selling price was 550 TZS/kg. About 1375 tons were sold to brewing companies by grain off-takers, with 720 tons being improved grain varieties and 655 tons being local grain varieties.

The study suggests that seed accessibility among sorghum farmers is a critical factor in their adoption of improved varieties and that there is also a need to sensitize farmers on the benefits of contractual sorghum farming. The study clearly indicates that sorghum seed and grain production offer a viable and sustainable value proposition as long as accessibility to improved variety seeds and markets for farmers is provided. Therefore, not only awareness of farmers on the use of improved seeds needs to be increased, stakeholders in the sorghum value chain should also be encouraged in promoting industrial sorghum utilised by beer brewing companies to promote both the seed and grain markets.

CHAPTER 1.

Introduction

1.1 Background information

In most parts of the world, sorghum is largely cultivated in marginal lands. Its production ranks third after maize and rice (NBS, 2021). Approximately 9.5 million tons was produced by the United States, the world's highest producer, followed by Nigeria, the largest producer in Africa with about 6.6 million tons in 2019/2020 (USDA, 2021). In East Africa, Tanzania ranks first in sorghum production (731,877tons) followed by South Sudan (710,000 tons), Uganda (400,000 tons), Kenya (288,000 tons) and Burundi (8,851 tons) (FAOSTAT, 2019). In Tanzania, sorghum production is concentrated in the central and lake zones of the country. These areas contribute about 50% of the total production in the country (FEWS NET, 2018).

In East Africa, sorghum was first introduced for food security purposes, especially for farmers located in semi-arid regions. Literature suggests that sorghum has been termed as an orphan crop, thus farmers consider cultivating the crop only in an emergency especially in the event of a failure of other crops like maize (Orr *et al.* 2017). In recent years, multiple programs have been launched by different stakeholders in developing the value chain in East Africa. In Tanzania, collaborative programs by stakeholders such as ICRISAT, Tanzania Agricultural Research Institution (TARI), NGOs, seed companies and brewing companies have been initiated to promote and disseminate yield enhancing technologies such as improved seeds, fertilizer, pesticides, post-harvest machines, and improving farmer linkages with commercial markets. Despite these efforts, issues of low technology adoption, poor market access and commercialization persist in the country. Therefore, it is necessary that assessment be undertaken to analyze the impact of these initiatives, most importantly, how it impacted the seed systems.

Sorghum uses in Tanzania include human food, animal feed and brewing. About 70% of sorghum production is consumed as human food and animal feed (Demissie *et al*., 2019). Brewing activities in Tanzania comprise local and industrial production value chains with both opaque and clear beer production. In the 90s, before introduction of sorghum clear beer, the opaque sorghum beer was the only industrial beer value chain that existed. It was only in 2007 that sorghum clear beer was introduced in Tanzania which resulted in an increased demand from brewing companies (Makindara *et al*., 2013). In 2010, sorghum utilization for opaque beer and clear beer was estimated to be about 2000 tons each (Makindara *et al*., 2013). In 2018 industrial opaque beer manufacturing was shut down in Tanzania due to supply and quality complications. Therefore, with only the clear beer value chain remaining, its impact and contribution to smallholder farmers and other stakeholders in the sorghum value chain remains an area of interest.

There has been an increase in sorghum demand for clear beer production over years. Brewing companies introduced a contract farming initiative to increase local supply and support sorghum smallholder farmers. The contract farming initiative was launched in 2009 with the expectation of increasing farmers' production, market access, and commercialization (TBL report, 2011). With time, there has been an increase in sourcing sorghum locally by brewing companies aiming to reduce production costs. Local sourcing by brewing companies has increased from 20% in 2011 to about 74% in 2020 (TBL report, 2011; TBL report, 2020). As part of the contract farming initiative, brewing companies supply farmers with improved seeds and complementary technologies in collaboration with other stakeholders for supply of reliable quality grains in return. Since this is the only organized, traceable and measurable initiative, an assessment of the impact brewing industry has had on the entire sorghum value chain gains importance. Furthermore, this study aims to discuss contribution of the brewing industry to specific issues of improved seed production and its adoption, sorghum grain production, market access, market participation and commercialization along the entire value chain.

1.2 Problem statement and justification

Initially, sorghum was produced to enhance food security. With the introduction of clear beer brewing around 2007, increased demand by brewing companies led to increased local sourcing of raw materials from sorghum farmers in Tanzania (SBL, 2019; TBL, 2020). Furthermore, increase in demand from brewing companies in pursuit of minimizing production costs, has expanded opportunities for smallholder sorghum farmers in Tanzania. About 99% of planted sorghum land is by smallholder farmers (NBS, 2021)). Despite the increased demand, sorghum cultivation faces issues such as low adoption of improved seeds, low productivity, and low profitability. This is further exacerbated by the non-participation of farmers in marketing. The seed sector in the country is faced with low production of sorghum improved seeds, along with accessibility and dissemination issues among farming communities. Furthermore, brewing companies have been operating through both contractual arrangements and spot marketing to source for sorghum produced locally by smallholder farmers. This study also aimed to examine and assess the contribution of the brewing industry to sorghum farmers and other stakeholders since there is limited literature available on the subject. Impact assessment studies are necessary to understand whether initiatives taking place in the sorghum value chain have positive and sustainable contributions.

1.3 Study limitations

The study has not included individual sorghum consumers, and thus we recommend consumer studies in the future to assess market drivers among individual consumers.

1.4 Objectives

The overall objective of this study is to assess and analyze contribution of the brewing industry to sorghum value chain and the seed sector development in Tanzania.

Specifically, the study intended to determine:

I. Sorghum use in brewing purposes and the stakeholders involved in Tanzania.
II. Extent of use of improved sorghum varieties
III. The role of brewing industry in facilitating improved sorghum seed access and use in Tanzania.
IV. Amount of sorghum grain sold to brewing companies by farmers and grain off-takers in Tanzania.
V. The impact of the brewing industry on different sorghum farming communities in Tanzania.

CHAPTER 2.

Literature review

2.1 Empirical framework

2.1.1 Sorghum as a source of brewing material in brewing industry

Sorghum is among the most explored crop in the world with multiple uses (Dabija *et al.*,2021). It is the fifth most important cereal crop in the world after corn, rice, wheat, and barley. It serves over 750 million people residing in semi-arid tropical regions of Africa and Central and South America (Schnitzenbaumer, and Arendt,2014; Abah *et al.*,2020; Adiamo *et al.*,2018). Sorghum utilizations tend to vary from one country to another. It is used as human food and animal feed for forage and fodder, in alcoholic beverages and biofuels (Prasad and Staggenborg, 2011: Orr *et al.*, 2020). In developing countries, over 78% of grain is used for food ,14% as animal food and 7% for diverse uses (Adebo, 2020). Countries like United states of America, Mexico, Japan, and Former Soviet Union use 80% of the produce for animal feed purpose, while in Africa and Asia, more than 95% of produced is used for human consumption (Kleih *et al.*,2020; Ratnavathi *et al.*, 2013). In Africa, Eastern and Southern parts use most of the sorghum as a source of raw material in brewing industry. For example, Togo uses about 60% of its national production to produce beer namely Tchoukoutou and Tchakpalo (Dabija *et al.*,2021). Nigeria produces over 900 million liters of beer annually and most of it is made from. South Africa uses at least 70,000t of per year in the production of malt. Zimbabwe uses 17,000t of in opaque beer industry and Botswana uses about 4,000t/year for small opaque industry (Dabija *et al.*,2021).

In Africa there are different types of traditional fermented beverages which they have both socio-cultural and nutritional value. These beverages are commonly known as dolo in Burkina Faso, Ikagage in Rwanda, Amgba in Cameroon, Pito or Burukutu in Nigeria and Ghana, Merissa in Sudan, Doro or Chibuku in Zimbabwe, Bilibili in Chad, Mtama in Tanzania, Tchapalo in Ivory Coast, Togo and Benin and Kaffir in South Africa (Dabija *et al.,*2021). These beverages play a central role in their culture and a significant part of the diet due to its gluten free feature. In 2017, sorghum dominated the non-gluten beer market, which accounted for 37.9% of the total volume of non-gluten beer produced (Dabija *et el.*,2021). It is mostly marketed to people with gluten intolerance and consumers who are interested in new drinks and new products (Dabija *et al.*,2021). It is also in high demand amongst women because they are often more concerned about healthy lifestyles and the higher incidence of celiac disease among women (60% of adult patient). (Dabija *et al.,*2021). Sorghum has a high content of vitamin B, such as Riboflavin, Nicotinic acid, and Folic acid. It is also rich in amino acids and in minerals such as calcium, potassium, magnesium, iron, and Zinc (Dabija *et al.,*2021) and that is why sorghum beer is consumed in larger quantities in rural regions (Mawonike *et al.,*2018). Culturally, sorghum beer is generally consumed at festivals, weddings, prayers, rituals, birth ceremonies and funerals (Konfo *et al.*,2020; Dabija *et al.,*2021).

2.1.2 Sorghum attributes (product type) in brewing industry

Sorghum as raw material is used in manufacturing of opaque beer, larger beer, and non-alcoholic malt drinks (Dendy,1995). Some of the industries using sorghum for opaque beer production in Southern Africa include South African brewing industry, Zimbabwe opaque beer industry, Malawi industries, Zambia, and small opaque beer industry in Botswana (Taylor, 2003). Sorghum is preferred for opaque beer production and beer powder since it meets the taste and preferences of consumers (Dabija *et al.,*2021). Also, countries such as Nigeria, Uganda, South Africa, Tanzania, and Rwanda use sorghum in production of larger beer (Taylor, 2003).

White, red, and brown sorghum are most commonly incorporated into opaque beer as malt, (Lyumugabe *et al.,*2012). According to Msangula (1993), white sorghum is used in the production of opaque beer and clear beer. In Rwanda, sorghum has been used as both malt and starch in the manufacture of traditional

beer (Ikigage or Amarwa) (Lyumugabe *et al.*,2012). Also, in Nigeria and Rwanda, white sorghum is used for starch and malt in brewing companies (Rohrbach *et al.*,1992). In Tanzania, Tanzania Brewing Limited (TBL) and Serengeti Breweries Limited (SBL) use white in production of clear beer (Makindara.2012).

2.1.3 Understanding contract farming

Contract farming is a popular institutional tool that ensures the quality and quantity of inputs for processors, exporters, and distributors (Reardon *et al.*,2009; Swinnen, & Maertens 2007). It can be defined as a pre-planting agreement between a farmer and a buyer (Ragasa *et al*,2017). Meemken and Bellemare (2020) defined contract farming as a pre-harvest agreement between farmers and buyers. Many studies analyze the benefits obtained by farmers through contract farming. These studies focus on profits and household income (Khan *et al.*,2019; Miyata *et al.*,2009; Maerterns and Vende Velde,2017). Others explore implications for other dimensions of household welfare (Morgan *et al.*,2020; Hernández-Becerra *et al.*, 2020) and yet others explore how contract farming improves farmers welfare (Bellemare and Bloem, 2018; Wang *et al.*,2014; Otsuka *et al.*,2016; Ton *et al.*,2018). Other studies have been done to explore and explain how contract farming helps farmers overcome uncertainties in labor, input, credit, insurances, and markets (Abebe *et al.*,2013; Key &Runstem.,1999; Bellemare *et al.*,2018; Grosh,1994; Barrett et al,2012; Swinnen and Maertens,2007). It was also empirically evidenced by Eaton and Shepherd (2001); Bijiman (2008); Simmons (2002); Little and Watts (1994); Singh (2002) that contract farming may improve farmer's productivity, reduce production risks and transaction cost, and improve farmers income.

It is estimated that 90% of all agricultural production in Africa, is produced by small-scale farmers (Spencer,2020). Therefore, in the African context, contract farming is seen as a mechanism to alleviate poverty since it has potential to raise the income of these small-scale farmers. It is also believed that contracting farming has a positive impact on agricultural revolution in developing countries improving the chances of farmers in regional and international markets (Eaton and Shephred,2001; Minot,1986) Moreover, it is also used in developed countries such as United states of America (USA) since its benefits outweigh the undesirable effects (Ncube,2019).

2.1.4 Brewing industry and contract farming

There is a growing trend towards contract farming of sorghum to cater to the brewing industry across Africa. In Tanzania, contracts are mostly confined to plantation crops, however, firms such as brewing companies are also extending contracts beyond traditional cash crops (Mwimo et al., 2016). Being a contract farmer for brewing industry offers far better returns than traditional marketing of the grain. Contract farming has helped increase acreage under cultivation, improved farmers' bargaining power, easy access to production inputs, faster skills transfer and widened access to credit for farmer organized groups. It also helps farmers access a wide range of managerial, technical and extension services. Farmers can use the contract agreement as collateral to arrange credit with a commercial bank. When contract farming is efficiently organized and managed, it reduces risks and uncertainty for both parties as compared to buying and selling crop in open market.

2.2 Theoretical framework

2.2.1 Utility maximization theory

The random utility maximization theory is the main theory that underlies this report. The theory postulates that sorghum farmers as unit of production would want to engage in sorghum production activities for gained maximized returns. This is connected to the farmers' urge to participate in adoption of inputs and grain markets. Sorghum farmers would participate in adoption and grain markets for maximum returns. The theory further explains that the farmer may only participate in adoption and market activities if and only if the perceived utility to be accrued by a farmer is greater than the utility of not participating (McFadden, 1973; Herath *et al.*, 1982). This brings out the fact that the decision to participate in the production and market activities is related to a set of socio-economic and institutional factors.

CHAPTER 3.

Methodology

3.1 Study area

The study was conducted in eleven districts namely Kongwa, Mpwapwa, Chamwino, Ikungi, Iramba, Singida DC, Shinyanga, Kishapu, Misungwi, Bunda and Mbozi. Data were collected from farmers who grew sorghum and other crops as well. Grain off-takers were located in Dodoma, Singida and Songwe regions. These off-takers were obtained from marketplaces, companies, and warehouses. Data collection was done in 2021 and information obtained was for 2019/2020 production season. Moreover, secondary data was obtained from Ministry of Agriculture and Government agencies such as NBS.

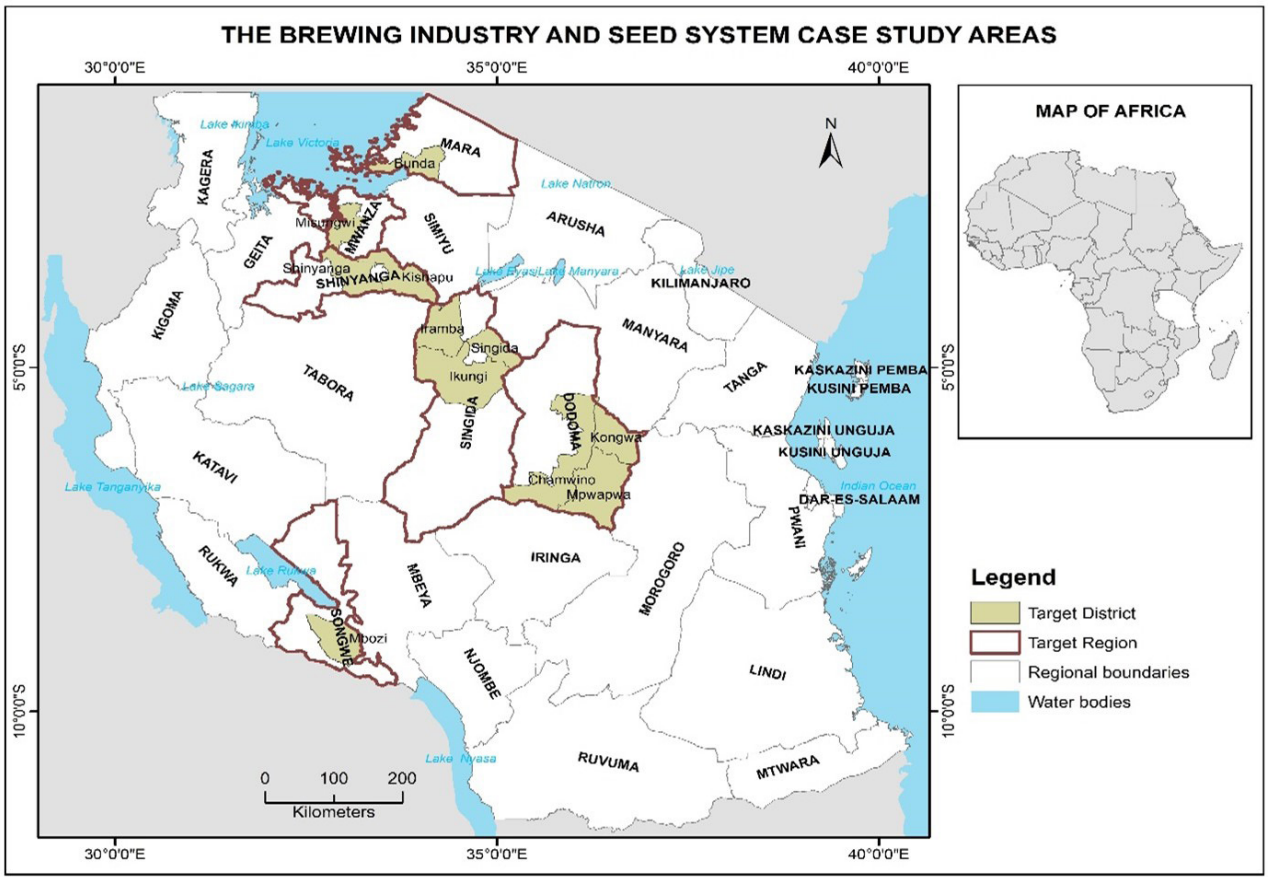

Figure 1: Map showing sorghum production, trading areas and brewing industry involvement in Tanzania.

3.2 Data source and sampling procedures

Primary and secondary data were used. For primary data cross-sectional research design was employed. Data from a representative subset in all districts was collected at a specific point in time. Household surveys, informative interviews and group discussions were the main approaches used to get in-depth information. Secondary data involved the use of materials such as journal papers, government reports and academic dissertations.

Sample frame included individual farmers, extension officers,researchers,seed producers, off-takers,brewing industry and government officials. Two types of sampling designs were used namely purposive sampling and simple random sampling. Purposive sampling was employed to select production

districts and grain off-takers while simple random sampling was used to select the villages, farmers and seed producers. According to Kothari (2004), these methods are recommended since they focus directly on the intended area of study. The sample size consisted of 591 sorghum individual farmers, 160 farmers from 16 focus groups, 15 grain off-takers, 14 extension officers, 4 Quality Declared seed (QDS) producers and 2 brewing companies. The list of respondents was obtained from the village executives and extension officers who helped with the mapping.

3.3 Data processing and analysis

Descriptive statistics was used to analyze and summarize data for this survey. Use of percentages and frequencies were used in summarizing obtained information across different variebles as will be seen in the results section.The probit model was used to analyze determinants of adoption decision by sorghum farmers based on age,sex, household size, years of school, harvested grain, grain market, brewing contracts, seed price, farmsize, grain storage and complementary technologies. The dependent variables of the model are 0, 1 (dummy variables), 1 if a farmer adopted improved varieties and 0 if a farmer did not. The model is an appropriate econometric model for the binary dependent variable and the error term is assumed to be normally distributed (Gujarati 2004).

Furthermore, cost-benefit analysis was used to see the reflection of the profitability analysis of different seed producers as well as farmers who planted different sorghum varieties for the 2019/2020 production season. In the cost and return analysis, production costs included those for land, seed, fertilizer, weeding, ridging, herbicides, insecticides, pesticides, Labor, transportation, security, threshing, winnowing, shelling, grading and packaging. Total production costs were computed for each farmer to get the average production cost for each variety per hectare. However, total costs varied among farmers depending on the location and range of activities performed during production. Total revenue was obtained from yield and the average price (in kg) for each individual farmer; hence:

Gross benefits = Total Revenue–Total Variable Costs

CHAPTER 4

Results

4.1 Social economics characteristics of different respondents

4.1.1. Sorghum farmers' socio-economic characteristics

Findings show that male sorghum farmers comprised about 66% of the interviewed farmers, with about 89% of the households being male headed households. Over 90% households had more than 3 family members (Table 1). Most farmers (52%) were aged between 41 to 60 years old. Years spent in school by 81% farmers was 1 to 7 years. For the sorghum farming experience, most farmers had less than 3 years (3 years about 33%), additionally, most farmers (91%) had less than 5 acres of planted sorghum. About 61% of the farmers were in farmer groups, while most farmers had access to extension officer services. About 63% of farmers did not use seed of improved sorghum varieties while about 52% had access and used other complementary technologies (fertilizer, pesticides, herbicides, machinery) (Table 1).

Table 1: Socio-economic characterization of sorghum farmers in Tanzania.

Household variables	Categories	Farmers (%)
Sex	Male	65.8
	Female	34.2
Gender of household head	Male	89.4
	Female	10.6
Household size	<4	8.3
	4-8	67.6
	9-12	19.0
	>12	5.1
Age	<18	0.2
	18-30	10.0
	31-40	23.5
	41-60	51.9
	>60	14.4
Number of years in school	0	9.9
	1-7	81.0
	8-13	8.8
	>13	0.3
Sorghum farming experience	<3	32.9
	4-8	24.5
	9-19	14.4
	>19	28.2
Total Farm size	< 5	28.5
	5-10	38.4
	11-30	28.9
	>30	4.2
Sorghum farm size	< 5	91.0
	5-10	7.4
	11-30	1.2
	>30	0.4
Group membership	Yes	61.4
	No	38.6
Extension services	Yes	65.8
	No	34.2
Improved sorghum seeds	Yes	37.2
	No	62.8
Complementary technologies	Yes	48.4
	No	51.6
Total		**100.0**

4.1.2 Sorghum grain off-takers characterization

Most of the grain off-takers were male (around 85%), with age between 18 to 40 years (about 54%). All of the grain off-takers were traders with formal education and 77% attended primary and secondary education. Most traders had less than 50% of their grain stock being sorghum in their business profile, with less than 50 tons of sorghum traded during 2019/2020 production season. Furthermore, all farmers were aware of the sorghum use in industrial brewing, and very few (21.4%) acknowledged working with brewing companies (Table 2).

Table 2: Socio-economic characterization of sorghum grain off-takers in Tanzania.

Variable	Categorization	Off-takers (%)
Gender	Male	84.6
	Female	15.4
Age	<18	0.0
	18-40	53.9
	41-60	46.1
	>60	0.0
Education	Primary	38.5
	Secondary	38.5
	Tertiary	23.0
Sorghum proportion business (%)	>50	46.2
	50-70	38.4
	>70	15.4
Sorghum proportion traded (tons)	>50	40.0
	50-100	32.8
	>100	27.2
Awareness of sorghum industrial brewing information	Yes	100.0
	No	0.0
Working with brewing companies	Yes	21.4
	No	78.6
Total		100.0

4.1.3 Extension officers' characterization

Most of the extension officers interviewed were male (61.5%), aged between 18 and 40 years (84.6%). About 15.4% had tertiary as the highest level of education. Most extension officers had information on sorghum use in industrial brewery (69.2%), but only few of these officers worked with brewing companies to facilitate sorghum farmers in sorghum production (38.5%) (Table 3).

Table 3: Socio-economic characterization of extension officers in sorghum producing areas.

Variable	Categorization	Extension officers (%)
Gender	Male	61.5
	Female	38.5
Age	<18	0.0
	18-40	84.6
	41-60	15.4
	>60	0.0
Education	Primary	0.0
	Secondary	84.6
	Tertiary	15.4
Sorghum industrial brewing information	Yes	69.2
	No	30.8
Working with brewing companies	Yes	38.5
	No	61.5
Total		**100.0**

4.2 Grain production in sorghum producing regions in Tanzania

4.2.1 Production of other crops in sorghum producing regions

The major five crops cultivated by sampled sorghum farmers included sorghum (32.0%), maize (23.7%), sunflower (11.1%), groundnut (6.3%) and cotton (5.5%) (Table 4). Crops such as cabbage, soya, Cowpeas and Bambara nut were less cultivated by sorghum farmers, all falling under 1%.

Table 4: Crops production in sorghum producing regions in 2019/2020 production season.

Crops	Percentage (%)
Sorghum	32.0
Maize	23.7
Sunflower	11.1
Groundnut	6.3
Cotton	5.5
Sesame	3.7
Pearl millet	2.4
Sugarcane	2.3
Tomatoes	2.2
Pigeon pea	2.0
Paddy	1.9
Coffee	1.6
Pigeon peas	1.0
Green gram	0.7
Onion	0.6
Sweet potatoes	0.6
Green pea	0.5
Watermelon	0.4
Finger millet	0.2
Green gram	0.2
Lentils	0.3
Pepper	0.2
Vegetables	0.2
Cabbage	0.1
Soya	0.1
Cowpeas	0.1
Bambara nut	0.1
Total	**100.0**

4.2.2 Sorghum production in sorghum producing regions

Among sorghum producing regions and based on sampled farmers, Dodoma came out as highest sorghum producer (266.005 tons), followed by Shinyanga (99.567 tons) and Singida (56.233 tons) for the 2019/2020 production season. Among the surveyed regions and for the sampled farmers, Mwanza had the lowest sorghum production (31.305 tons) (Table 5). In terms of land used under sorghum production, Dodoma reflects large total farm size (284.1 ha), followed by Shinyanga (137.1 ha) and Singida (76.74 ha) for the sampled farmers.

Table 5: Amount of sorghum produced by producing regions in 2019/2020 season.

Regions	Sorghum farmers (n)	Farm size (ha)	Amount produced (tons)
Dodoma	222	284.1	266.005
Singida	91	76.74	56.233
Shinyanga	109	137.1	99.567
Mwanza	56	33.3	31.305
Mara	46	32.8	43.15
Songwe	67	42.8	48.86
Total	**591**	**606.84**	**545.12**

Among 11 sorghum producing surveyed districts and based on sampled farmers, the leading producing sorghum district was Kongwa (141.127 tons) followed by Chamwino (65.328 tons) and Mpwapwa (59.55 tons), while Ikungi (12.37 tons) had the least sorghum produced (Figure 2).

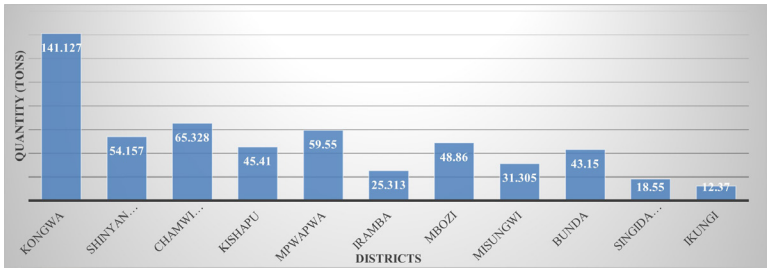

Figure 2: Sorghum production among sorghum producing districts in 2019/2020 production season

With farm size under sorghum production (based on the sampled farmers), Kongwa (159.9 ha) showed the largest total farm sizes, followed by Shinyanga district (73.7 ha) and Chamwino (63.6 ha) while, Ikungi had the smallest farm size (13.62 ha) (Figure 3).

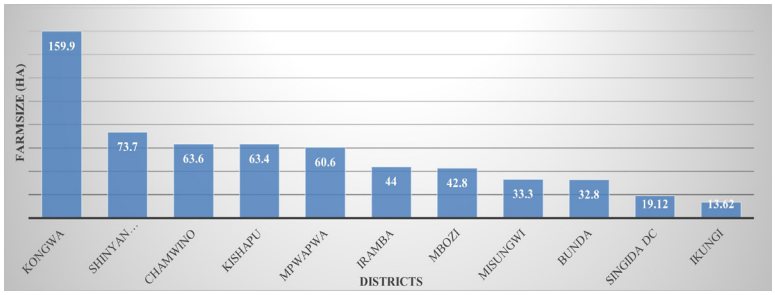

Figure 3: Farm size under sorghum production among sorghum producing districts in 2019/2020 production season

From the overall country data by the NBS for the 2019/2020 production season, the overall total amount of sorghum produced in the country was 601,496 tons with 601,390 tons from smallholder producers and 106 tons from large holder producers. Furthermore, about 514,313 hectares were planted with sorghum during that season, with about 512,767 hectares planted by small holder farmers and 1,546 hectares planted by large holder producers (Table 6).

Table 6: Sorghum planted area (hectares) and amount produced (tons) during 2019/2020 in Tanzania.

Planted area (hectares)		Production (tons)	
Small holders	601,390	Small holders	512,767
Large holders	106	Large holders	1,546
Total	**601,496**	**Total**	**514,313**

Source: NBS, 2021

4.3 Sorghum use by brewing companies and the sorghum clear beer value chain with stakeholders involved in Tanzania

4.3.1 Brewing companies using sorghum in Tanzania and neighboring countries

In Tanzania, TBL and SBL companies are famously known for using sorghum in production of clear beer products. These two companies have different modes of obtaining sorghum grain from sorghum farmers. Various beer products brewed from sorghum by TBL include Eagle lager, Champion and Bia Bingwa; and brewed products by SBL include Senator and Pilsner beers in Tanzania. In Uganda, NBL and UBL companies use sorghum in manufacturing of Eagle and Senator Keg brands, while in Kenya EABL and KBL companies also use sorghum in Senator Keg beer manufacturing. From the findings, the two companies (TBL and SBL) in Tanzania have reported that sorghum demand by their companies to be about 10,000 tons per year for each company. For the last five years, the amount purchased by the two brewing companies is shown in Table 7, with the highest amount purchased in 2019/20 production season.

Table 7: Amount of sorghum purchased by brewing companies for five consecutive years.

TBL company		SBL company	
Year	**Amount purchased (tons)**	**Year**	**Amount purchased (tons)**
2020/2019	9,000	2020/2019	6,000
2019/2018	8,000	2019/2018	9,000
2018/2017	5,000	2018/2017	3,000
2017/2016	8,000	2017/2016	7,000
2016/2015	4,000	2016/2015	6,000

4.3.2 Existing policy incentives to enhance use of local material for brewing

The objective of minimizing production costs through local sourcing of raw materials and the favorable investment environment for the brewing industry has increased the demand for sorghum. Local sourcing by brewing companies in the country is done to:

- support small scale farmers in the country
- minimize production costs for brewing companies in the country
- enhance contribution to the national economy

Furthermore, the brewing company reported about 2-3% of the revenue obtained being the Government's share.

4.3.3 The clear beer value chain in Tanzania

From the findings, the clear beer value chain included the following stakeholders: For the inputs, seeds are supplied by the Kibaigwa Flour Supply (KFS) as an intermediary under TBL. These seeds are

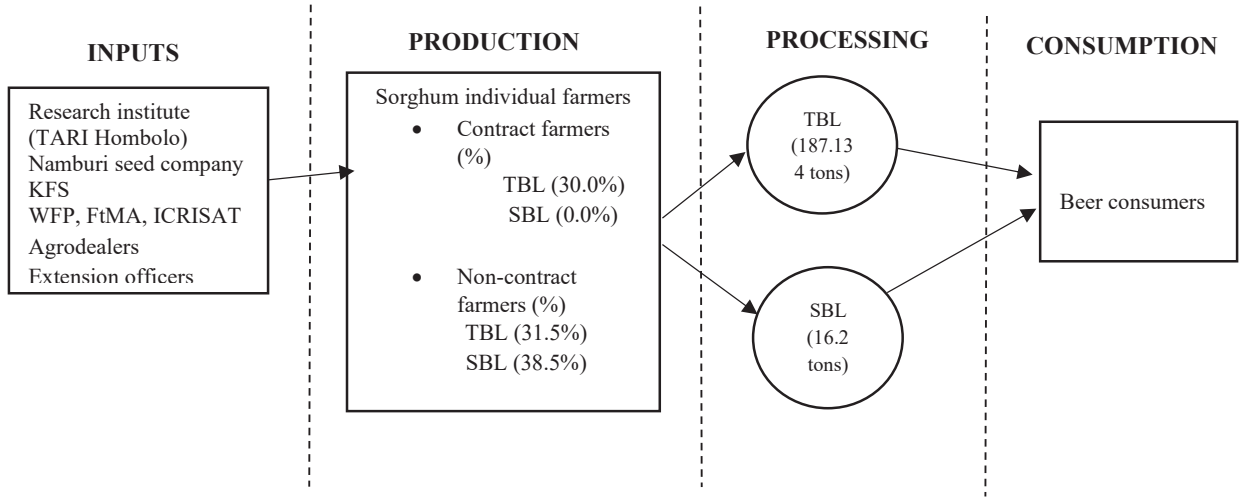

Figure 4: Brewery industry value chain for clear beer production.

collected from TARI Hombolo and private seed companies (one of them being Namburi seed company). In 2019/2020 production season, about 22 tons were supplied to sorghum farmers by KFS. TBL had contractual arrangements with some sorghum farmers while SBL obtained sorghum grain from sorghum farmers without contractual arrangements through traders/agents for the 2019/2020 season. Findings indicated that contract sorghum farmers were trained by extension services (WFP and FtMA), and also through district and village extension officers. Furthermore, sorghum farmers obtained complementary inputs such as fertilizer, pesticides, and herbicides from agro-dealers. From the interviewed sorghum contract farmers, TBL bought about 168 tons while for non-contract farmers TBL bought about 20 tons, and as for SBL, about 16 tons were obtained from farmers through different traders (Figure 4).

4.4 Extent of use of improved sorghum varieties with the role of the brewing industry in facilitating improved sorghum seed access and use in Tanzania

4.4.1 Improved varieties grown by sorghum farmers in target communities

About 37 % of sorghum farmers from the interviewed 591 farmers adopted improved sorghum variety while about 63% planted local sorghum varieties during 2019/2020 production season (Figure 5).

From the improved seed planted, the commonly adopted sorghum varieties by farmers were Macia (about 29%), Tegemeo (about 5%) and NACO Mtama 1 (2%) while Hakika, Serena and Pato were the least adopted varieties (below 1%) among interviewed farmers (Table 8).

Table 8: Sorghum improved varieties grown in target communities.

Improved varieties	Farmers (n=220)
Macia	28.9
Tegemeo	5.1
NACO Mtama 1	2.0
Hakika	0.7
Serena	0.3
Pato	0.2
Total	**37.2**

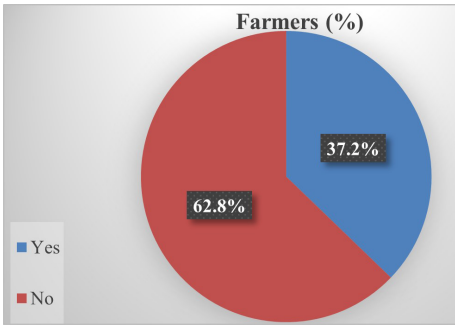

Figure 5: Sorghum seed planted by farmers in 2019/2020 production season

For the non-adopters, the most reported reasons were seed inaccessibility (72.5%), lack of grain markets (8.9%) and lack of information on improved sorghum seeds (8.6%) (Table 9).

Table 9: Reasons to low adoption rates of improved sorghum seeds.

Reasons	Farmers (n=371)
Seed inaccessibility	72.5
Lack of grain markets	8.9
Lack of knowledge/information	8.6
Expensive	4.0
High production costs	3.0
Bird infestation	2.2
Poor grain price	0.8
Total	**100.0**

The adoption of improved varieties per district shows that farmers from Kongwa (16%), Chamwino (about 12%) and Mpwapwa (around 5%) districts highly adopted improved sorghum varieties, while farmers from Singida DC, Ikungi and Bunda (below 1%) districts were the least adopters (Table 10).

Table 10: Sorghum adoption rates per district among farmers.

District	Farmers (n=220)	District	Farmers (n=220)
Kongwa	16.1	Kishapu	0.3
Chamwino	11.7	Singida DC	0.2
Mpwapwa	5.2	Ikungi	0.2
Misungwi	1.6	Bunda	0.2
Mbozi	0.7		
Iramba	0.5		
Shinyanga DC	0.5	**Total**	37.2

4.4.2 Sources of improved sorghum varieties accessed by sorghum farmers

Farmers obtained seeds from different sources (Table 11). Most farmers obtained improved seed from TBL company (about 81%), followed by own saved source (around 7%), extension officers (about 6%), purchased (about 3%) and others obtained from NGOs (1.6%).

Table 11: Different sources of improved sorghum seeds by farmers.

Sources	Farmers (n=220)
Brewing company	81.4
Own saved	7.4
Extension officer	6.4
Purchased	3.2
NGO's	1.6
Total	**100.0**

From the 3.2% of the interviewed farmers who purchased sorghum seeds, these farmers purchased seeds from different sources (Table 12). The table 12 shows the categorization of these sources, but also, the seed prices, including the highest, average, and lowest prices.

Table 12: Sources of purchased seeds and their respective prices.

Source of purchased improved seeds	Farmers (%)	Prices (TZS/kg)	
Market	53.1	Highest price	7 500
		Average price	2 030
		Lowest price	500
Fellow farmers	31.2	Highest price	500
		Average price	300
		Lowest price	200
Seed dealers	12.5	Highest price	3 000
		Average price	1713
		Lowest price	600
Quality Declared Seeds (QDS) producers	3.2	Price	1500

* USD 1 = TZS 2300 during time of data collection

Unfortunately, the willingness of sorghum farmers to pay for improved sorghum seeds was low (Table 13). The overall average willingness to pay price by sorghum farmers was 1700 TZS/kg, while the highest average willingness to pay price was by contract farmers (2528 TZS/kg) and the lowest willingness to pay price was by non-adopters of sorghum improved seeds (1600 TZS/kg).

Table 13: Willingness to pay among sorghum farmers.

Willingness to pay (WTP)	Average price (TZS/kg)
All farmers (n=591)	1700
Adopters (n=220)	2000
Non-adopters (n=371)	1600
Contract farmers (n=176)	2528
Non-contract farmers (n=415)	1700

Farmers reported accessibility (about 37%) as the major reason while good taste (4.5%) was the least factor to consider in the use of improved seed (Table 14).

Table 14: Reasons to preference of improved seeds by farmers.

Reasons	Farmer (n=220)
Accessibility	36.8
High yield	26.9
Grain market	17.3
Good grain price	14.5
Good taste	4.5
Total	**100.0**

From the sorghum farmers in surveyed districts, only about 1% and 25.2% of the farmers had knowledge of sorghum seed dealers inside and outside their villages respectively (Table 15).

Table 15: Knowledge (awareness) of sorghum farmers on improved seed dealers.

Seed dealer's knowledge	Responses	Farmers (%)
Seed dealers inside the villages	Yes	0.9
	No	99.1
Seed dealer outside the villages	Yes	25.2
	No	74.8

4.4.3 Stakeholders support to sorghum farmers in adoption of improved sorghum seeds

About 34% of the sorghum farmers reported receiving support from other stakeholders in different production seasons in accessing improved sorghum seeds, with most of the improved seeds coming from the brewing company (around 67%), TBL to be specific, followed by extension officers (about 23%) and directly from TARI Hombolo (around 5%) (Table 16).

Table 16: Stakeholders support in accessing sorghum improved seeds.

Stakeholders	Farmers (n=591)
Brewing company (TBL)	66.8
Extension officer	23.1
Research institution	4.9
NGO's	4.4
Relative	0.4
Village Executive Officers	0.4
Total	**100.0**

4.4.4 Use of local sorghum seeds by farmers in the target communities

For sorghum farmers who planted local varieties, most of these farmers used seeds they have recycled (89%) while others obtained from other farmers or relatives (5.6%) and some others purchased from the local markets (5.3%) (Table 17).

Table 17: Sources of sorghum local sorghum seeds.

Sources	Farmers (%)
Own saved recycled seeds	89.1
Relative/fellow farmers/neighbors	5.6
Purchased	5.3
Total	**100.0**

Furthermore, for farmers who purchased local sorghum seeds, the highest price was 600 TZS/kg and the lowest price was 300 TZS/kg (Table 18).

Table 18: Prices of purchased local sorghum seeds

Prices of local seeds	TZS/kg
High price	600
Average price	325
Lower price	300

4.4.5 Number of farmers growing sorghum for the breweries

About 30% of the interviewed sorghum farmers (individual farmers) were under contractual agreement with the TBL company (Figure 6).

For sorghum farmers with contractual agreement with TBL company, most of them planted improved sorghum seeds (87%), while a few (13%) planted local sorghum seeds during the 2019/2020 production season (Table 19).

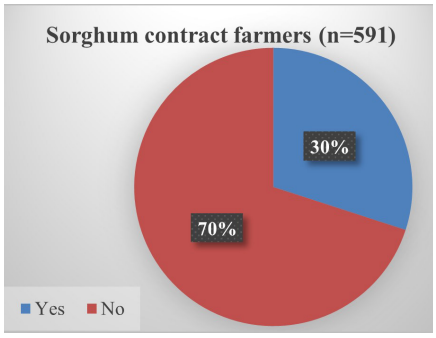

Figure 6: Distribution of brewing contract and non-contract sorghum farmers

These farmers obtained improved seeds from the brewing company (89.5%), NGO's (3.3%), own saved seed (3.3%), extension officers (1.3%) while others purchased seeds from agro-dealers (Table 20).

Table 19: Contract farmers and sorghum seeds planted.

Brewing contract farming	Farmers (n=176)
Planted improved seeds	87.0
Planted local seeds	13.0
Total	**100.0**

Table 20: Sources of improved seeds for brewing contract farmers.

Sources	Farmers (n=153)
Brewing company	89.5
NGOs	3.3
Own saved	3.3
Purchased	2.6
Extension	1.3
Total	**100.0**

4.4.6 Sorghum plot size under sorghum for breweries

Most sorghum farmers under contracts with the brewing company (TBL) grew Macia, Tegemeo and NACO mtama1. Macia was largely produced (132.8 ha), while Pato was the least 0.8 tons (Table 21) within the sampled farmers.

Table 21: Sorghum improved varieties grown by sorghum contract farmers

Improved variety	Land (ha)
Macia	132.8
Tegemeo	16.8
NACO Mtama 1	7.5
Serena	1.6
Pato	0.8

4.4.7 Cost-benefit analysis of sorghum grain production by sorghum farmers

Cost benefit analysis was done to ascertain profitability for sorghum varieties. All varieties had a positive gross benefit with farmers who grew NACO Mtama 1 obtaining the highest gross benefits (313 125 TZS/ha). Farmers who planted NACO Mtama1 obtained higher revenue (839 583 TZS/ha). The highest

average price across varieties was of Macia (545 TZS/kg). Farmers with local varieties incurred high variable costs (594 372 TZS) (Table 22).

Table 22: Cost-benefit analysis of sorghum grain production by farmers.

Seed variety	Average revenue	Average price	Average variable costs	Gross benefit (TZS/ha)
Macia	644 909	545	416 391	228 518
Tegemeo	434 993	537	259 380	175 613
NACO Mtama 1	839 583	538	526 458	313 125
Hakika, Serena and Pato	232 925	525	137 286	95 639
Local	765 140	480	594 372	170 768

For seed producers, the research institute obtained high gross benefit (11 096 540 TZS/ha) from Macia production while negative gross benefits for Tegemeo and NACO Mtama 1, since these varieties were not sold commercially but were for demonstration purposes only. Private seed companies as well obtained a positive gross benefit of 5 337 827 TZS/ha. Furthermore, QDS farmers obtained a positive gross benefit of about 1 339 772 TZS/ha with lowest average variable costs (Table 23).

Table 23: Cost-benefit analysis of sorghum seed production by seed producers.

Seed producers	Seed variety	Average revenue	Average price	Average variable costs	Gross benefit (TZS/ha)
Research institute	Macia	12 000 000	3500	903 460	11 096 540
	Tegemeo	-	-	869 547	869 547
	NACO Mtama 1	-	-	802 380	802 380
Private seed companies	Macia	13 370 000	4000	8 032 173	5 337 827
QDS producers	Macia	1 727 280	1500	387 508	1 339 772

4.4.8 Grain storage among sorghum farmers

Most of the interviewed farmer stored sorghum grain (96%) for the 2019/2020 production season for various purposes (Figure 7).

Most sorghum farmers stored grain for food (59.5%), for planting purposes (26.5%), while few others stored grain waiting for the market (1.7%) (Table 24).

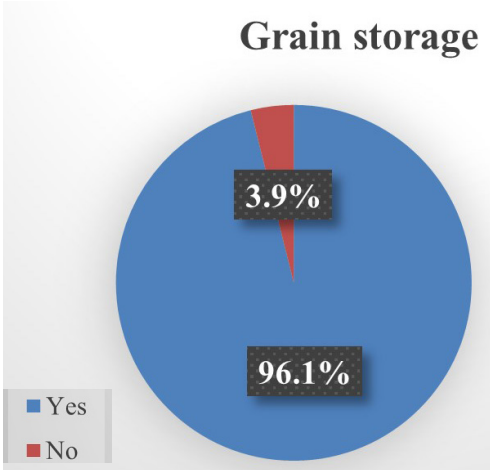

Figure 7:Grain storage among sorghum farmers 2019/2020

Table 24: Reasons for grain storage among sorghum farmers

Reasons for storage	Farmers (%)
Food	59.5
Seed	26.5
Better price anticipation	9.8
Lack of market	2.2
Waiting for TBL's market	1.7
Brewing purpose	0.3
Total	**100.0**

Different practices were used by sorghum farmers during storage (Table 25). About 62% stored in polythene bags, 0.6% stored in storerooms, 0.6% in metal silo and 0.2% in wooden store.

Table 25: Different storage practices by sorghum farmers.

Storage practices	Farmers
Polythene bags	62.2
Normal backing bags	12.0
Purdue Improved Crop Storage Bags (PICS)	10.3
Traditional granary	6.9
Traditional crib	6.0
Plastic container	1.2
Resident store(house)	0.6
Metal silo	0.6
Wooden store	0.2
Total	**100.0**

Moreover, for farmers who stored grain, about (13.7%) reported grain losses
(Figure 8) because of pests, threshing, moisture, rotting and theft issues as shown in table 26.

The main cause for loss reported among sorghum farmers was pests (86%), while theft was the least reported reason for farmers storage loss (Table 26).

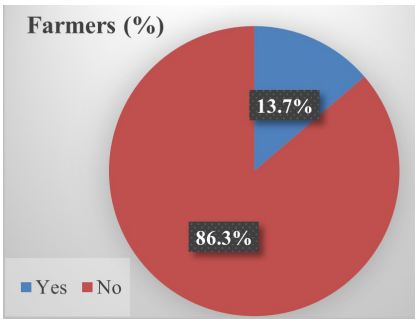

Figure 8: Grain storage loss among sorghum farmers

Table 26: Causes for sorghum grain storage losses.

Causes of loss	Farmers (%)
Pest	86.2
Threshing	6.1
Moisture	4.3
Rotting	1.7
Theft	1.7
Total	**100.0**

Different control measures were taken by farmers to avoid loss. About 57% did nothing to control the loss, 28.6% applied chemical preservative, 10.7% ashes, 0.3% PICS, 0.3% local preservative and 0.1% applied animal dung. (Table 27).

Table 27: Control measures to prevent storage losses by farmers.

Control measure	Percentage
Nothing	56.7
Chemical preservation	28.6
Ashes	10.7
Did not store	1.3
Store for short time	1.0
Smoking	0.6
Traditional medicine	0.4
Use of PICS	0.3
Matumbaka	0.3
Use of animal dung	0.1
Total	**100.0**

4.4.9 Determinants of adoption of improved seeds among sorghum farmers

The probit analysis was undertaken to identify determinants of adoption among sorghum farmers. Multi-collinearity test was performed and the Variance Inflation Factor (VIF) of these variables was less than 10, thus indicating no multi-collinearity. Estimated results are presented in Table 28 indicating that Probit model is highly significant at 1%, which is explanatory strong. Access to Sorghum grain market, brewing contracts, seeds price, grain storage and use of complementary farm technologies were the significant factors in adoption (Table 28).

Table 28: Probit analysis of determinants of adoption among sorghum farmers.

Variables	Coefficient	P|z|	Marginal effect
Age	0.0041889	0.458	
Sex	-0.1275961	0.407	
Household size	-0.0348777	0.143	
Years of school	0.0164575	0.551	
Grain harvested	-0.0001944	0.893	
Grain market	0.7050007	0.000	0.4063568***
Brewing contracts	1.632689	0.000	0.684153***
Seed price	-0.0002583	0.001	0.3449161***
Sorghum farm size	0.022311	0.369	
Grain storage	-0.9531707	0.000	0.2639678***
Complementary technologies	0.270766	0074	0.3809608*

*** Significant at 1% level, ** significant at 5% level, * significant at 10% level.

From Table 28, it is understood that as access to grain markets increases the probability of a farmer adopting an improved variety increases by 40.6%. Brewing contracts increased the probability of a farmer adopting improved sorghum variety by 68.4%. Moreover, the price of improved variety seed negatively affects adoption, meaning an increase in price of improved variety seeds by one unit (TZS) decreased the probability of sorghum farmers in adopting improved variety by 34.5%. Access to grain storage equipment increased chances of adoption by farmers by 26.4%. Furthermore, a unit increase in use of complementary technologies increased probability of improved varieties by 38.1% (Table 28).

4.5 Amount of sorghum grain sold to brewing companies by farmers and grain-off takers in Tanzania

4.5.1 Proportion of sold grain and their respective prices

About 41.6% of sampled farmers sold their grain to brewing companies while 58.4% sold elsewhere (Table 29). The highest grain price offered in the 2019/2020 season was 550 TZS/kg for all varieties, while the lowest price was observed for Macia and NACO varieties (400 TZS/kg)

Table 29: Proportion of sorghum farmers selling grain to brewing companies.

Sold	Farmers (n=246)
Yes	41.6
No	58.4
Total	**100.0**

With grain that was sold to brewing companies, most of the grain was from improved varieties (81.9%), followed by grain from local variety (11.3%) (Table 30).

Table 30: Sorghum grain varieties sold to brewing companies.

Varieties	Farmers (%)
Improved variety	81.9
Local variety	11.3
Both improved and local variety	6.8
Total	**100.0**

Among the improved varieties Macia (84.1%) sold the most, while Pato and Serena varieties (0.6% each) sold the least (Table 31).

Table 31: Sorghum grain sold from improved sorghum varieties.

Improved varieties	Farmers (%)
Macia	84.1
Tegemeo	9.6
NACO Mtama 1	5.1
Pato	0.6
Serena	0.6
Total	**100.0**

Table 32 shows the categorization of grain selling prices for each variety that was sold to brewing companies during 2019/ 2020 production season.

Table 32: Prices for sorghum grain from improved varieties sold to brewing companies.

Improved varieties	Pricing	Actual grain price (TZS/kg)
Macia	Higher price	550
	Average price	520
	Lower price	400
Tegemeo	Higher price	550
	Average price	520
	Lower price	500
NACO Mtama 1	Higher price	550
	Average price	512.5
	Lower price	400
Pato	Higher price	550
	Average price	525
	Lower price	500
Serena	Higher price	550
	Average price	525
	Lower price	500

Some farmers (both contract and non-contract) sold grain of different local varieties to brewing companies (Table 33). These varieties were mentioned by sorghum farmers in their native languages as seen in Table 33. Among these varieties, *Lugugu* and *Sandala* varieties being very white, were preferred to *Mtama mwekundu* and *hupemba* which are red.

Table 33: Grain of local variety sold to brewing companies.

Local variety	Farmers (%)
Lugugu	48.4
Sandala	38.7
Langalanga	6.5
Mtama mwekundu	3.2
Hupemba	3.2
Total	**100.0**

Lugugu variety was sold at the highest (1200 TZSs/kg) while *Sandala* variety was sold the least (400 TZS/kg) (Table 34).

Table 34: Price offered to sorghum farmers on respective sorghum local varieties.

Local variety	Grain price (TZS/kg)	
Lugugu	Higher price	1200
	Average price	687.5
	Lower price	550
Sandala	Higher price	600
	Average price	537.5
	Lower price	400
Langalanga	Price	550
Mtama mwekundu	Price	800
Hupemba	Price	550

The total amount of grain from improved varieties sold to the brewing company under contractual arrangement was about 161 tons with Macia variety selling the highest volumes (about 142 tons) withing the sample farmers (Table 35).

Table 35: Amount of grain of improved varieties sold to brewing company under contracts.

Improved variety	Amount (tons)
Macia	142.0
Tegemeo	9.8
NACO Mtama 1	7.7
Pato	1.2

4.5.2 Quality issues and value addition among sorghum farmers

The most demanded quality attribute was cleanliness of the grain (about 51%) that comprises non-mixed grain, graded grain and pure variety while the least demanded quality was maturity (1.1%) (Table 36).

Table 36: Sorghum quality requirements demanded by brewing companies.

Quality demanded	Farmers (%)
Clean grain	50.8
Color	43.2
Standard moisture content	3.8
Improved grain seed	1.1
Well matured grain	1.1
Total	**100.0**

White sorghum was preferred by the brewing company as opposed to red and tan (Table 37).

Most of the farmers do not add value before selling their grain to brewing companies (83.1%) (Table 38), whereby most of them packaged (44.7%), cleaned (34.2%) and graded their grain (21.1%) as shown in Figure 9.

Table 37: Sorghum attributes (product type) sold to brewing company by farmers.

Attribute type	Farmers (%)
White	87.6
Red	11.9
Tan	0.5
Total	**100.0**

Table 38: Value addition by sorghum farmers

Value addition	Farmers (%)
No	83.1
Yes	16.9
Total	**100.0**

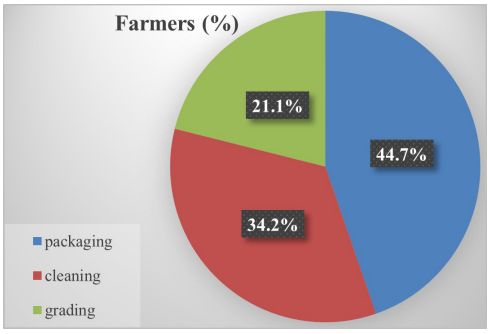

Figure 9: Distribution of value addition activities done by sorghum farmers

4.5.3 Districts which brewing company offered contracts to farmers

In 2019/2020 production season TBL offered contract farming agreements to farmers in three districts. Within sampled farmers, the highest number of contract agreements were offered to farmers in Kongwa (about 66%), followed by Chamwino (around 26%) and Mpwapwa (8.0%) had the least farmers contracted (Table 39).

Table 39: Districts which TBL provided contracts to the farmers in 2019/2020.

District	Farmers (%)
Kongwa	66.3
Chamwino	25.7
Mpwapwa	8.0
Total	**100.0**

4.5.4 Incentives provided to sorghum farmers under contractual arrangement

Among inputs, provision of improved seed was considered the most preferred incentive to contract farming (47%) followed by training 36.5% while herbicides (0.9%) and Fertilizer (0.6%) were considered the least incentivizing (Table 40).

Table 40: Incentives provided by TBL to sorghum contract farmers.

Incentives	Farmers (%)
Seeds	47.2
Training	36.5
Financial aid	9.6
Crop insurance	3.2
Pesticides/insecticides	2.0
Herbicides	0.9
Fertilizer	0.6
Total	**100.0**

Improved seeds were given annually to the contract farmers (about 95%) (Table 41). The only method of reimbursement of seed and other incentives was through selling grain produced to the brewing company under contractual arrangements.

Table 41: Improved sorghum seeds annually distribution to contract farmers.

Annual seed distribution	Farmers (%)
Yes	94.9
No	5.1
Total	**100.0**

4.5.5 Seed inaccessibility challenges among sorghum contract farmers

Most of the farmers in contractual agreements did not face challenges while accessing seed, except few of them (33%) (Table 42). Delay of improved seeds (about 53%), followed by getting mixed seeds (37.5%), lack of enough seeds (8%) and high prices (1.8%) were the reasons mentioned as contributing to seed inaccessibility (Table 43).

Table 42: Sorghum farmers facing seed inaccessibility

Seed inaccessibility	Farmers (%)
No	66.9
Yes	33.1
Total	100.0

Table 43: Reasons for seed inaccessibility among sorghum contract farmers.

Reasons	Farmers (%)
Delay of the seeds	52.7
Mixed seed (different varieties and color)	37.5
Lack of enough seeds	8.0
High seed price	1.8
Total	**100.0**

The amount of grain traded to brewing companies by sampled farmer with off-takers was about 1375 tons (improved varieties being 720 tons and local varieties being 655 tons) (Table 44). High tax levy imposition (about 44%), lack of contracts (36%) and lack of knowledge on marketing regulations and policies on sorghum industrial use (about 20%) were some of the challenges that grain off-takers raised (Figure 10).

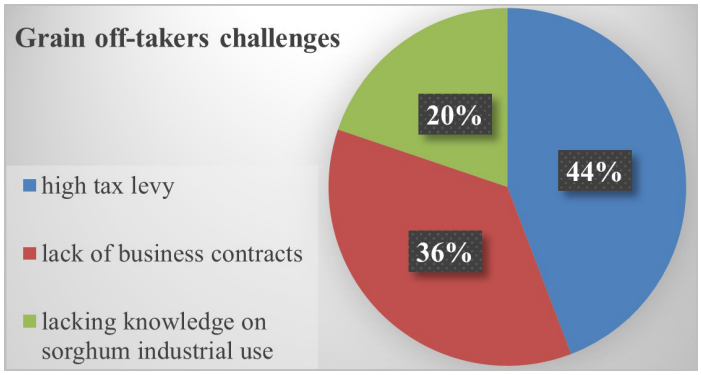

Figure 10: Challenges reported by sorghum grain off-takers

Table 44: Sorghum amount traded by grain off-takers in 2019/2020 season.

Purchased variety	Amount (tons)	Sold variety	Amount (tons)	Sold variety to brewers	Amount (tons)
Improved	7555	Improved	6235	Improved	720
Local	9781	Local	7664	Local	655
Total	**17336**	**Total**	**13899**	**Total**	**1375**

4.6 The impact of the brewing industry on different sorghum farming communities in Tanzania

There was change in some livelihood indicators of the sorghum farmers in producing communities (Table 45). All livelihood indicators assessed had positive changes except for education, livestock ownership and transportation accessibility. Major changes were observed for toilet facilities (72%), house type (68%), housing roof (63%) and children's education (25%). Minor shift was observed for income, food, access to mobile phones and health insurance.

Table 45: Livelihood improvement after sorghum farmers involvement with brewing companies

Contract farming with brewing companies'	Before (%)	After (%)
Income	28.8	34.0
Food secured	25.4	30.6
Education	31.0	26.0
Livestock ownership (most owned)	20.1	12.9
House type (improved)	21.3	89.7
House roof (improved)	36.7	99.7
Toilet facilities (improved)	13.7	85.6
Health facilities (insured)	10.2	11.0
Transportation	17.4	14.4
Mobile phones	31.8	36.9
Education (improved)	21.2	46.1

4.6.1 Impact of the brewing industry to different livelihood indicators for sorghum farmers

Positive change was reported for some livelihood indicators among sorghum farmers. Indicators assessed include income, access to enough food, quality education to children, electricity, livestock ownership, housing conditions, access to health facilities, access to transportation and mobile phones.

4.6.1.1 Impact on income

Before entering into a farming contract agreement with the brewing companies, about 63% of farmers reported farm income to be the major source of their income, followed by non-farm agribusiness activities (about 18%) (Table 46). After contract agreement with brewing companies, about 64% of the sorghum farmers now reported farm income to be the major source of their income, followed by non-farm agribusiness activities (about 21%) (Table 46).

Table 46: Impact of the brewing industry to sorghum farmers' income.

Before sorghum farming contract	Farmers (%)	After sorghum farming contract	Farmers (%)
Farm income	62.6	Farm income	64.1
Non-farm agribusiness net income	17.7	Non-farm agribusiness net income	20.7
Other business net income	15.6	Other business net income	9.6
Other rented property	0.4	Other rented property	3.6
Rented out land	3.0	Rented out land	1.6
Rented out oxen	0.7	Rented out oxen	0.4
Total	**100.0**	**Total**	**100.0**

4.6.1.2 Impact on children's education

With education, about 0.8% of the farmers sent their children to quality improved schools after involvement with brewing companies while about 1.5% of the farmers sent their children to quality improved schools before involvement with the brewing companies (Table 47). Parents education was dropped in favor of children being used as farm labor.

Table 47: Impact of the brewing industry to access to children's education.

Before involvement	Farmers (%)	After involvement	Farmers (%)
Private schools	1.5	Private schools	0.8
Local government	29.5	Local government	25.2
None	69.0	None	73.9
Total	**100.0**	**Total**	**100.0**

4.6.1.3 Impact on livestock ownership

About 56% of farmers owned cows compared to other livestock before their involvement with the brewing companies. After their involvement with the brewing companies, many farmers (33%) shifted to chicken farming compared to earlier (21,5%). Around 38% of sorghum farmers still owned cows at the time of the study (Table 48).

Table 48: Impact of the brewing industry to livestock ownership

Before involvement	Farmers (%)	After involvement	Farmers (%)
Cows	55.6	Cows	38.2
Goats	16.9	Goats	19.1
Pigs	3.0	Pigs	7.4
Sheep	3.0	Sheep	2.2
Chicken	21.5	Chicken	33.1
Total	**100.0**	**Total**	**100.0**

4.6.1.4 Impact on housing materials

With housing facilities, about 19% of the farmers had cemented house, while 2.5% had local brick houses and majority 78.7% had mud houses before involvement with brewing companies. After the involvement with the brewing companies about 88.5% of the farmers had cemented houses, about 1% of them had brick houses while around 10% had mud houses (Table 49).

Table 49: Impact of the brewing industry to improved housing type.

Before involvement	Farmers (%)	After involvement	Farmers (%)
Cemented	18.8	Cemented	88.5
Local bricked	2.5	Local bricked	1.2
Muddy	78.7	Muddy	10.3
Total	**100.0**	**Total**	**100.0**

About 63% of the farmers had grass-roofed houses and close to 37% had iron sheets before their involvement with brewing companies. After the involvement with brewing companies 100% owned iron sheet houses (Table 50).

Table 50: Impact of the brewing industry to improved housing roof.

Before involvement	Farmers (%)	After involvement	Farmers (%)
Iron sheets	36.7	Iron sheets	99.7
Grass roofed	63.3	Grass roofed	0.3
Total	**100.0**	**Total**	**100.0**

Most farmers had mud toilets (86.5%) before involvement with brewing companies, but after the involvement with the brewing companies, majority of the farmers (about 76%) have local brick toilets (Table 51).

Table 51: Impact of the brewing industry on improved toilet facilities.

Before involvement	Farmers (%)	After involvement	Farmers (%)
Cemented flushing	8.1	Cemented flushing	9.8
Local brick	5.6	Local brick	75.8
Muddy	86.5	Muddy	14.4
Total	**100.0**	**Total**	**100.0**

4.6.1.5 Impact on health facilities

Before the involvement with the brewing companies, most farmers were not insured but attended to at Government hospitals (about 90%), while about 10% were attended at government hospitals with insurance and very few were attended at private hospitals with insurance. After involvement with brewing companies, 89.0% were still not insured and attended at government hospitals, about 9.6% attended to government hospitals and had insurance while 1.4% were insured and could afford private hospitals (Table 52).

Table 52: Impact of the brewing industry to access to health facilities.

Before involvement	Farmers (%)	After involvement	Farmers (%)
Government not insured	89.8	Government not insured	89.0
Government-insured	10.1	Government-insured	9.6
Private insured	0.1	Private insured	1.4
Total	**100.0**	**Total**	**100.0**

4.6.2 Impact of the brewing industry to different services for sorghum farmers

The brewing industry positively impacted the accessibility of financial services, group dynamics, complementary technologies, and information accessibility among farmers. Major positive changes were observed for farmers joining farmer groups (about 61%), access to complementary technologies (around 23%), information services (around 18%) and financial services (about 12%) as shown in Table 53.

Table 53: Impact of brewing companies to accessibility of different services

Brewing companies' involvement	Before (%)	After (%)
Financial services	3.9	15.6
Farmer groups	20.1	81.3
Complementary technologies	4.9	27.7
Information services	12.7	31.1

Farmers reported need to access financial services for different purposes. Farmers needed money to buy farm inputs (seeds, fertilizer, pesticides/insecticides and herbicides), buy/rent farm implements, oxen, other livestock, buy food, children's education, family health and non-farm business (Table 54). Positive change was observed for farm inputs (6.1%), farm implements (5.4%), family health (1.8%), livestock (1.0%), oxen (0.3%) and food (0.1%) while negative change was observed for non-farm business.

Table 54: Access to financial services among sorghum farmers.

Purposes	Before (%)	Purposes	After (%)
Farm inputs	4.7	Farm inputs	10.8
Farm implements	2.2	Farm implements	7.6
Oxen	0.0	Oxen	0.3
Other livestock	0.2	Other livestock	1.2
Food	0.7	Food	0.8
Children's education	0.8	Children's education	0.8
Family health	0.2	Family health	2.0
Non-farm business	2.5	Non-farm business	2.0

As 81% of sorghum farmers had joined farmer groups after their involvement with brewing companies, about 92% of these farmers belonged to formal groups while around 8% were in informal farmer groups (Table 55).

Table 55: Belonging to each type of farmer groups by sorghum farmers.

Farmer groups	Farmers (%)
Formal	91.6
Informal	**8.4**
Total	**100.0**

For the institutional roles, sorghum farmers reported to belong to crop specific farmers groups (about 88%), general farmers association (around 10%) and saving and credit group (about 2%) (Table 56).

Table 56: Institutional roles of farmer groups for sorghum farmers.

Institutional roles	Farmers (%)
Crops specific farmer groups	87.9
General farmers' association	10.3
Saving and Credit group	1.8
Total	**100.0**

Source: Brewing industry business case, 2020

Farmers who had contract arrangements with the brewing company (TBL) belonged in different farmer groups according to their allocated districts as shown in Table 57.

Table 57: Farmer groups under contract farming by sorghum farmers.

Districts	Farmers group	Farmers (%)
Kongwa	Amani visumi	13.2
Kongwa	Weupe	12.0
Chamwino	Tumaini	9.7
Kongwa	Tumaini Mtama	9.1
Kongwa	Juhudi	8.0
Chamwino	Umoja	6.9
Kongwa	Upendo	6.9
Kongwa	Kazania	6.3
Chamwino	Mgunga	5.1
Mpwapwa	Mkombozi	4.0
Kongwa	Ikowa	3.4
Chamwino	Jitihada	2.9
Kongwa	Muungano	2.9
Mpwapwa	Tuwezeshane	2.3
Kongwa	Nguvu kazi	1.7
Kongwa	Muungano Iramba	1.1
Mpwapwa	Uwajibikaji	0.7
Mpwapwa	Uzalendo	0.7
Mpwapwa	Wafugaji	0.7
Chamwino	Kimoufusa	0.7
Mpwapwa	Jiwezeshe	0.7
Chamwino	Bank mazao	0.7
Total		**100.0**

The use of complementary technologies among sorghum farmers before and after involvement with brewing companies is presented in Table 58. There have been positive changes in use of different technologies with use of improved sorghum seeds having the highest change (23.4%), followed by use of tractor (around 7%), pesticides/insecticide (about 6%), fertilizer (1.3%), herbicides (0.6%), storage equipment (PICS) (0.3%), while there was no change in use of plough among sorghum farmers (Table 58).

Table 58: Use of complementary technologies by sorghum farmers.

Technologies	Before (%)	Technologies	After (%)
Improved seeds	2.0	Improved seeds	25.4
Pesticides/insecticides	0.3	Pesticides/insecticides	6.4
Tractor	3.2	Tractor	10.1
Plough	4.6	Plough	4.6
Herbicides	0.2	Herbicides	0.8
Fertilizer	0.2	Fertilizer	1.5
Storage equipment	0.2	Storage equipment	0.5

For information services, positive changes were observed for information on improved sorghum seeds (about 18%), inputs and outputs markets and prices (11%) and pests and diseases (around 2%) (Table 59).

Table 59: Information services among sorghum farmers.

Information	Before (%)	Information	After (%)
Climatic change	3.6	Climatic change	0.5
Collective group/farmer group	9.8	Collective group/farmer group	9.5
Family health	14.6	Family health	7.8
Improved sorghum seeds	10.5	Improved sorghum seeds	28.8
Markets and prices	12.5	Markets and prices	23.5
Irrigation	0.7	Irrigation	0.7
Pests and diseases	7.3	Pests and diseases	9.6
Sanitation	9.1	Sanitation	6.0
Soil and water management	0.2	Soil and water management	0.3
Storage	3.4	Storage	1.2

CHAPTER 5

Conclusion and recommendations

5.1 Conclusion

There is still low adoption of improved varieties among sorghum farmers (about 37%); with three major constraints of adoption being seed inaccessibility (72.5%), lack of available grain markets (around 9%) and lack of knowledge or information on improved sorghum seed varieties (8.6%). The most adopted varieties are Macia (about 29%), Tegemeo (about 5%) and NACO Mtama 1 (2%), whereby the least adopted variety was Pato (below 1%). Furthermore, Kongwa (about 16%), Chamwino (about 12%) and Mpwapwa (around 5%) districts in Dodoma had higher adoption rates compared to the rest of the districts.

The probit analysis indicates that among variables, grain market accessibility, brewing contracts, seed price, storage accessibility and accessibility to use of complementary technologies by sorghum farmers affected their adoption decision to improved sorghum seeds. For the cost-benefit analysis, seed producers displayed positive gross benefits, except for Tegemeo and NACO Mtama 1 varieties produced by the research institute, since the institute did not produce these varieties for sale but for dissemination and demonstrations for sorghum farmers. For sorghum farmers, all varieties displayed positive gross benefits, with NACO Mtama 1 farmers displaying the highest gross benefits (313 125 TZS/kg) than the others. Furthermore, it was challenging in obtaining quality declared seed producers farmers during the field survey, since most of them have stopped producing following phasing out of most project works.

The brewing companies reported low quantities obtained directly from farmers, and poor quality when obtained from traders as their main challenges. Grain off-takers reported high tax levy imposition (around 44%), lack of contracts (36%) and lack of knowledge on marketing regulations and policies on sorghum industrial use (about 20%) as their main challenges. In conclusion, the brewing industry is seen as a potential unit driving both the use of improved sorghum seeds, and improving the livelihood of sorghum farmers

5.2 Recommendations

Seed accessibility in terms of time and affordability is critical especially in remote sorghum producing areas, even for farmers under contracts. Policies for seeds and other inputs subsidy need to be further reformed. Sensitizing the farmers on the need and benefits of contract farming to sorghum farmers should be actively pursued. Government support to brewing companies to expand their reach to different sorghum growing communities is considered a key factor in improving adoption of improved varieties of sorghum in the country. There is a need for sensitizing the sorghum farmers to attend trainings and demonstrations of improved sorghum seeds. Sorghum farmers can be QDS producers, if they are supported and managed, and also if they see prospects of obtaining benefits from it through high adoption levels. There is an opportunity for seed producers to invest in seed production and distribution to farmers, following the brewing industry opportunity, with a reflection of profitability from the cost-benefit analysis. Improving working conditions for extension officers will translate into better service delivery. A conducive business environment for grain traders (low tax levy imposition and engaging business contracts with brewing companies) will enhance the grain value chain. Furthermore, the public and private sector should also engage more on advertising and promoting information on sorghum industrial use in clear beer brewing purposes.

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ICRISAT
INTERNATIONAL CROPS RESEARCH INSTITUTE FOR THE SEMI-ARID TROPICS

About

The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) is a pioneering, international non-profit scientific research for development organization, specializing in improving dryland farming and agri-food systems. The Institute was established in 1972, by a consortium led by the Ford Foundation and the Rockefeller Foundation and with the support from the Government of India. ICRISAT works with global partners to develop innovative science-backed solutions to overcoming hunger, malnutrition, poverty and environmental degradation on behalf of the 2.1 billion people who reside in the drylands of Asia, Sub-Saharan Africa and beyond.

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