Contact Details:
Tel office: +264 61 379 500
Fax office: +264 61 22 5371
E-mail: nabdesk@nab.com.na
Website: www.nab.com.na

Physical address:
Agricultural Boards' Building
30 David Hosea Meroro Road
Windhoek
Namibia

Postal address:
PO Box 5096
Ausspannplatz
Windhoek
Namibia

NAMIBIAN AGRONOMIC BOARD

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AGRONOMY AND HORTICULTURE MARKET DEVELOPMENT DIVISION

SORGHUM VALUE CHAIN ANALYSIS IN NAMIBIA

January 2023

NAMIBIAN AGRONOMIC BOARD

~ CONTENTS ~

~ LIST OF TABLES ~

~ LIST OF FIGURES ~

List of Acronyms

NAMSIP	The Namibia Agricultural Mechanisation and Seed Improvement Project's
NNFSGC	Northern Namibian Farmers Seed Growers Cooperative
NSA	Namibia Statistic Agency
MAWLR	Minisrty of Agriculture, Water and Land Reform
GAP	Good Agricultural Practices

EXECUTIVE SUMMARY

To develop a sustainable and functional sorghum value chain in Namibia it is expedient to analyse and understand the current status quo of sorghum crop production and marketing activities in Namibia. Thus, this value chain analysis study aimed at defining the production area and quantifying the current status quo of sorghum crop production, storage, value addition, and marketing in Namibia; and identifying sorghum value chain actors and their respective functions.

Quantitative research questionnaire survey method coupled with qualitative questionnaires were used to collect data from sorghum producers, traders, and other value chain actors. A total of 70 respondents comprised producers (57), traders (6), and input suppliers (7). The sorghum study comprehensively covered five (5) Namibian Agronomy and Horticulture production zones namely: Central, Karst, Kavango, Zambezi, and North Central. Out of these five (5) production zones, the study included producers, traders, and input suppliers from nine (9) crop-growing regions of Namibia; Omusati, Oshana, Ohangwena, Kavango West, Kavango East, Zambezi, Oshikoto, Otjozondjupa and part of Kunene Region. At least 8 respondents from each of the selected crop-growing regions were interviewed as a representative sample. Collected data were analysed using the descriptive statistical analysis method in Microsoft Excel and the value chain mapping model was applied to present the overall results of the study.

The study revealed that the Namibian sorghum sector is faced with various challenges which include low production volumes, less area under sorghum cultivation, and lack of improved varieties, lack of value addition and, poor market accessibility. Study results also established that the current existing sorghum value chain in Namibia is incomplete, some critical value chain components and relationship linkage among chain actors are missing. Due to the lack of value-addition components in the Namibian sorghum value chain, high importation of sorghum finished-end products, and or value-added products was observed into the Namibian market. With an average annual sorghum consumption of 4,758 tons, over 56% equivalent to 2,678 tons/annum of sorghum comes from imports. The results further provide sorghum production and marketing baseline information and untapped opportunities enlightening potential investors and policymakers to possibly stimulate sorghum production in Namibia for socioeconomic development. Thus, recommendations on the stimulation of sorghum production and marketing in Namibia are also provided in this report.

1. INTRODUCTION

Sorghum (*Sorghum bicolor /L./ Moench*) crop is an ancient grain that was first domesticated in Africa and then spread to other parts of the world by approximately 3000 BC. It is the fifth most important cereal crop by total world production and is an important cereal food crop as it is tolerant to drought and high temperatures. It is successfully grown in many African countries and other semi-arid countries (Srinivasa *et al,* 2014) such as Namibia. Sorghum, also known as Milo, has a variety of uses including food for human consumption and animal feed. Sorghum is a versatile plant because it can tolerate drought, soil toxicities, a wide range of temperatures, and high altitudes. In many parts of the world, sorghum has traditionally been used in food products, and various food items porridge, unleavened bread, cookies, cakes, couscous, and malted beverages are made from this versatile grain (Deb *et al*, 2004).

Sorghum is an important cereal crop that is grown globally for food and feed purposes. It is most widely grown in the semi-arid tropics where water availability is limited and frequently subjected to drought. About 100 countries grow sorghum, of which 66 cultivate it over more than 1000 ha or produce more than 1000 t. India has the largest sorghum area with 10.06 million ha (Deb *et al*, 2004). The second largest sorghum-cultivating country is Nigeria, followed by Sudan, USA, and Niger. More than 90% of the world's sorghum area lies in developing countries, mainly in Africa and Asia. In terms of annual production, the USA tops the list with 13.38 million tonnes followed by India (8.23 million tonnes), Nigeria (7.65 million tonnes), Mexico (6.09 million tonnes), and Argentina (3.16 million tonnes). The highest sorghum yields were recorded by Israel (13 tonnes per ha), followed by Jordan (12 tonnes per ha), Italy (6.5 tonnes per ha), Algeria (6 tonnes ha), and France (0.6 tonnes per ha) (Deb *et al*, 2004).

The grain is an excellent food source when ground into flour and used to make pancakes, cake, pap, pancake creole, porridge, and flatbreads. Some of the health benefits of sorghum include its ability to prevent certain types of cancer, help control diabetes, offer a dietary option for people with Celiac disease, improve digestive health, build strong bones promote red blood cell development, and boost energy and fuel production (Tuinstra, 2008).

Moreover, sorghum is well adapted to the Namibian weather conditions due to its tolerance ability to drought and high temperatures and its successful cultivation in climates that are too dry for maize production. Although sorghum is not formally marketed at a satisfactory scale in Namibia mainly due to low production, the crop is well cultivated under the Namibian soil and climatic environments. It is believed that given the ability of sorghum crops of withstanding drought, harsh weather conditions, and varieties of end-use diversified food products (Srinivasa *et al,* 2014), sorghum genetically possesses the right traits to be introduced into the Namibian harsh environment and eventually into the Namibian

formal crop market (as a controlled crop). Sorghum is an important cereal food with tolerance and resilience to climate change and responsiveness to climate variability. Therefore, it may be important for food security in the Namibian dry climate and has the potential to be a staple cereal crop in Namibia.

Further, sorghum has many properties such as polyphenolic antioxidants, the potential for slow starch digestibility, and high fiber that makes it a potential staple-future food in Namibia, given the modern healthy eating habits. These properties make sorghum a potential ingredient for the manufacture of foods for those suffering from chronic diseases such as obesity, and cardiovascular diseases. Furthermore, the low starch digestibility of sorghum makes it a desirable food for humans with diabetic conditions (Tuinstra, 2008).

Table 1 shows the annual average local production, local consumption, import, and export of sorghum from 2015 to 2019.

Table 1: Namibia Sorghum production, consumption, import and export – average tonnage, 2015 - 2019

	Years					
Quantity in tonnage	**2015**	**2016**	**2017**	**2018**	**2019**	**Average**
Local production (grains)	1,700	1,500	2,800	4,000	400	***2,080***
Local consumption (grains)	3,124	6,133	4,011	5,794	4,729	***4,758***
Import (products)	1,424	4,633	1,211	1,794	4,329	***2,678***
Export (products)	2.4	0.2	1.8	0	0.3	***1***

Source: NSA, 2019

Despite the good adaptability of the sorghum crop on the Namibian soil, there has been a decline in overall local production during 2015 – 2019, recording an average production of 2,080 tons/annum (Table 1). However, there has been a high demand for sorghum in the Namibian market with an average annual consumption of about 4,758 tons/annum. Table 1 further shows that there has been a very high reliance on the importation of sorghum products, averaging 2,678 tons/annum with a minute of sorghum product exports, averaging 1 ton/annum.

1.1. Problem statement

Namibia heavily relies on the importation of sorghum and sorghum products into the Namibian market at an average of 4,500 tons/annum valued at N$2.2 million annually (NSA, 2019), which is anticipated to increase. This is a clear indication of demand for sorghum in Namibia which prompted the need to analyse the sorghum value chain in Namibia aiming at promoting local production and marketing. The Namibian sorghum sector is faced with various challenges which include low production volumes, less area under sorghum cultivation, and lack of improved varieties, value addition, and, market access

(Wanga et al., 2018). Therefore, this exploratory study defines the production area and quantifies the current status quo for sorghum crop production, storage, value addition, and marketing in Namibia; identifies sorghum value chain actors and their respective functions, and provides sorghum production baseline information for a better understanding that will assist potential investors and policymakers to stimulate sorghum production in Namibia.

1.2. Objectives of the study

- ✓ To quantify the current status quo for sorghum crop production, storage, value addition, and marketing in Namibia.
- ✓ To examine and understand important production constraints and identify opportunities for improving sorghum production, storage, value addition, and marketing.
- ✓ To suggest recommendations on what should be done to stimulate the growth of the sorghum crop industry in Namibia.

1.3. Significance of the study

Organising and developing the sorghum value chain for sustainability in production, storage, processing, and marketing is difficult without first carrying out a detailed value chain analysis. The study will therefore establish a tentative list of sorghum value chain actors (producers, processors, and traders), and estimate volumes and values while explaining the prevailing bottlenecks and opportunities as perceived by these key value chain actors.

Moreover, this study can thus bring about national sorghum value chain competitiveness at both domestic and international markets; promote entrepreneurship; promote both local production and formal market participation by local producers, processors, and traders; reduce reliance on sorghum import; and consequently, contribute to improved livelihoods, national food security, and economic growth. The practical recommendations on how best may sorghum production, storage, processing, and marketing in Namibia be stimulated and can be useful to stakeholders in the crop sector at both domestic and international levels.

2. METHODOLOGY

An effective stakeholder consultation approach was used for this study. A quantitative research questionnaire survey method coupled with qualitative questionnaires was administered to the producers and traders. All relevant stakeholders and lead individuals were engaged through consultations and involvement meetings for broader in-depth interviews and observations.

The telephone interview approach was also used to make follow-up questions with the respondents and also to collect sorghum value chain information that could not be obtainable from the primary study respondents.

2.1. Sample size

Table 2 shows sample population size and sampled number respondents from each production zone.

Table 2: Sampled population size in each production zone

Production Zones	Regions	Sampled respondents			Total
		Producers	Traders	Inputs suppliers	
Karst	Otjozondjupa	7	1	2	10
	Oshikoto	7	0	2	9
Kavango	Kavango East	7	0	1	8
	Kavango West	7	0	0	7
North Central	Ohangwena	7	2	0	9
	Oshana	7	0	0	7
	Omusati	7	1	2	10
Zambezi	Zambezi	7	2	0	9
Kunene	Omakange	1	0	0	1
Grant total number of respondents		**57**	**6**	**7**	**70**

As displayed on Table 2, a total of 70 respondents comprised producers (57), traders (6), and input suppliers (7). Whereby, at least 8 representatives (on average) from each of the selected crop-growing regions were interviewed (Table 2). Furthermore, identification and consequently registration of all sorghum producers and related production data were collected to establish accurate baseline information for necessary future reference use.

2.2. Study area

Figure 1 shows study area illustrating covered production zones on the Namibian map. The mean annual rainfall across the study areas varies from about 650 mm in the Zambezi Region to less than 250 mm in the Kunene Region (Awala *et al*, 2019).

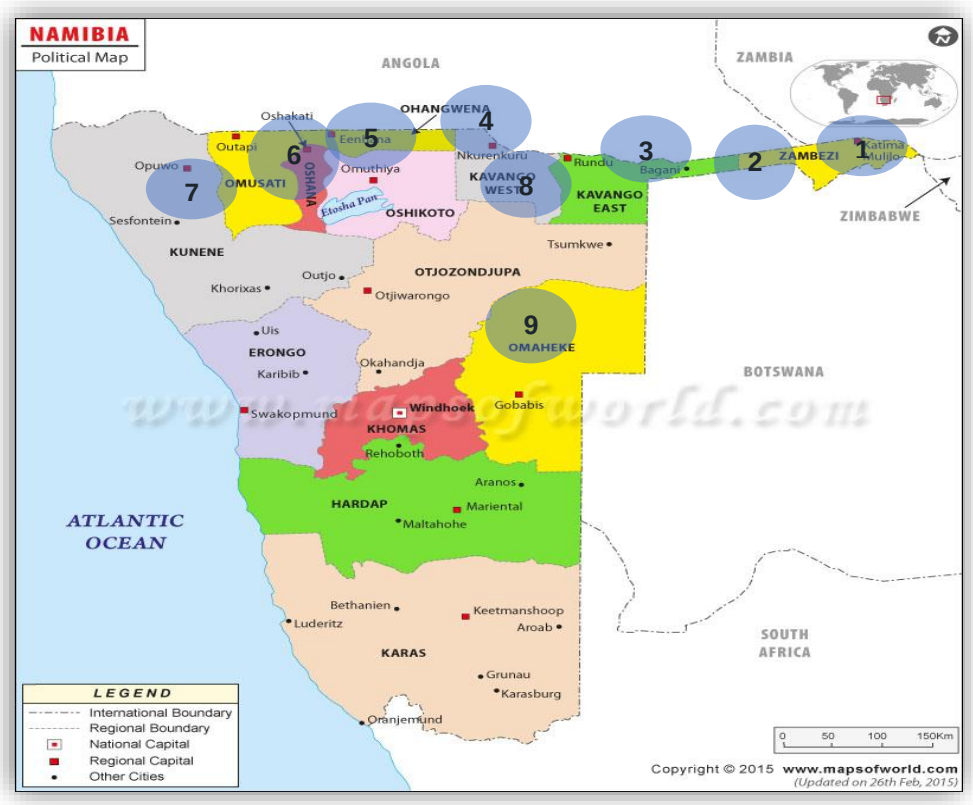


Figure 1: Namibian Map showing the study area (Source: Maps of the World, 2015)

The sorghum value chain analysis study comprehensively covered five (5) Namibian agronomic production zones, namely Central, Karst, Kavango, Zambezi, and North Central. Out of these five (5) production zones, the study included producers, traders, and input suppliers from nine (9) crop-growing regions of Namibia – Omusati, Oshana, Ohangwena, Kavango West, Kavango East, Zambezi, Oshikoto, Kunene and Otjozondjupa (Figure 1).

2.3. Data collection and analysis

The study collected data from sorghum producers/farmers, sorghum inputs suppliers, processors, and traders/representatives using structured questionnaires to obtain primary data and support activities within Namibia's sorghum value chain. The questionnaire covered matters related to the production, value addition, storage, and marketing of sorghum in Namibia, including constraints and opportunities. Telephone calls and document analysis were used to collect data that could not be obtainable from the study sample. Descriptive analysis was applied using Microsoft Excel and Word to analyse and interpret the field-collected data with figures and tabular presentations. The value chain mapping model was also used to present the overall results of the study.

3. RESULTS AND DISCUSSIONS

This section presents the result findings of the research study with narrative discussions of their implications on the sorghum value chain (production and marketing) in Namibia.

3.1. Demographic

Figure 2 shows producers' gender representation in Namibia.

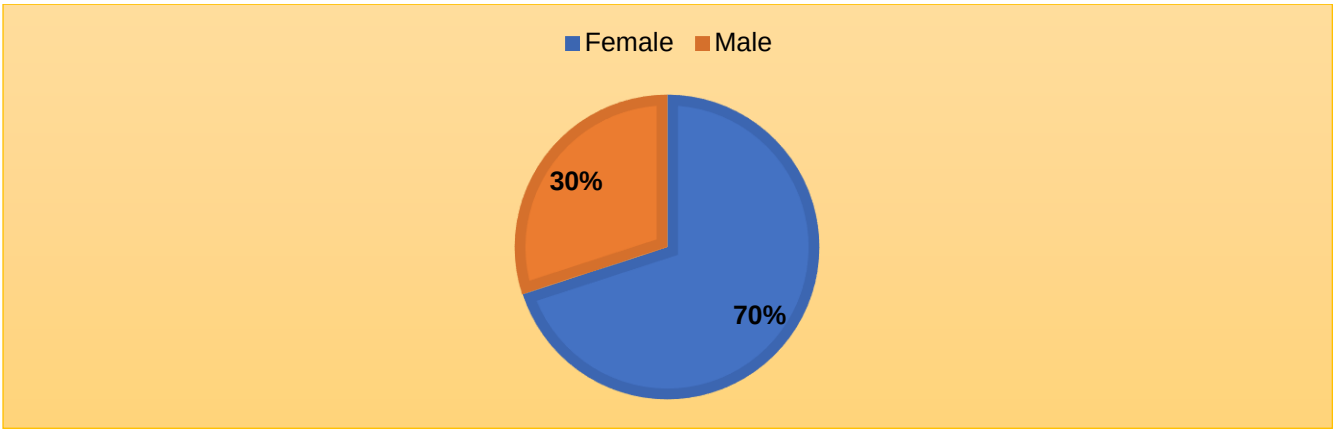


Figure 2: Sorghum producers' gender representation

Sorghum production is predominantly operated by women and the elderly aged group. The results in Figure 2 shows that 70% of sorghum producers are female. Moreover, the majority of sorghum producers in Namibia are above 60 years of age which accounts for 33%, and 28% of producers are aged between 50 to 59 age group while youth under the age of 30 represent 7% only (Figure 2).

Figure 3 shows sorghum producers' age distribution.

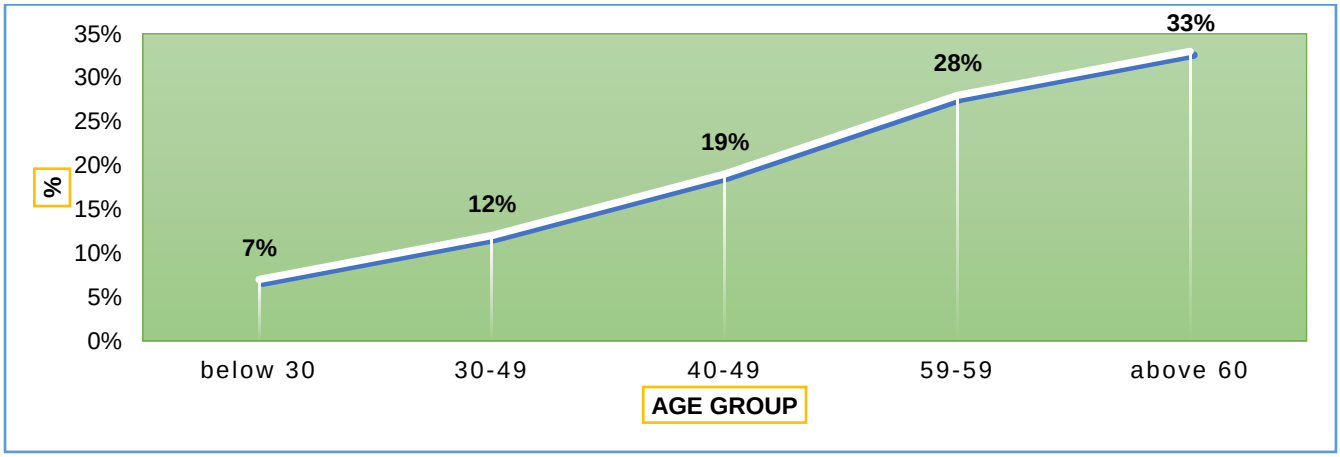


Figure 3: Sorghum producers' age distribution

Figure 3 shows that the age distribution proposition on sorghum production increases with the elderly age group. Very few youths participate in sorghum production and there is a huge gap in the transfer of sorghum production activities from the elderly group to the youth. Evidence reveals that youth engagement in agriculture is declining, this may have implications on food security, unemployment, and undermine the government's efforts to stimulate economic growth through agriculture (Maina & Maina, 2012).

3.2. Sorghum production and output information

An effective sorghum production system is a vital tool for both rural and national development of socioeconomics and food security in a country (Musara *et al*, 2019). Thus, this section focuses on the sorghum production practices, the status quo of sorghum production, hectares planted per production zone, and sorghum productivity in Namibia.

3.2.1. Land under sorghum cultivation

Overall as per the present study findings farmers allocate a total area size ranging from 0.5 ha to 1500 ha for crop production, averaging 33 ha per producer. However, on average farmers allocate land ranging from 1 to 2.5 ha for sorghum cultivation. Figure 4 shows the average area size (ha) allocated for sorghum cultivation per farmer per production zone in Namibia.

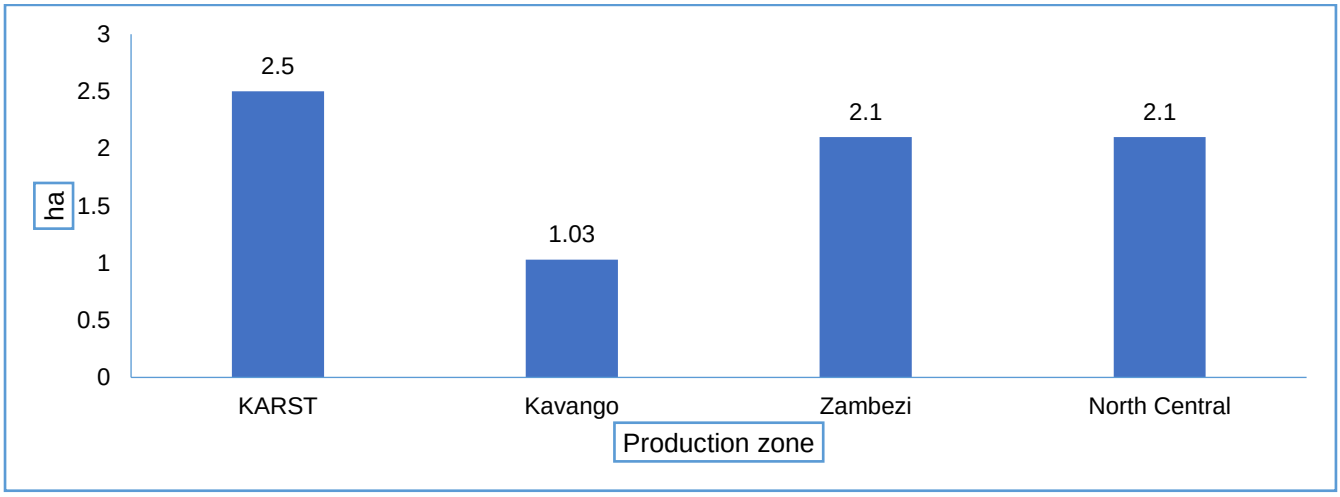


Figure 4: Average area size (ha) under sorghum cultivation per producer in each production zone

Figure 4 depicts that on average producers in the KARST production zone among other production zones, allocate the highest area size of 2.5 ha per farmer for sorghum production followed by Zambezi and North Central with 2.1 ha each while Kavango recorded the lowest land allocation for sorghum cultivation with 1.03 ha per farmer.

3.2.2. Seed production and supply system

This section covers the seed production and supply system in Namibia focusing on the land size under sorghum seed production, the source of seeds, and seeds production in Namibia. The study reveals that the Namibian sorghum seed production and supply system is underdeveloped with few ha, of land devoted to sorghum seed production and low supply output of improved quality sorghum seeds. There are only a few seeds or input suppliers who are accredited and supply certified sorghum seeds. The majority of source seeds are locally dominated by landraces varieties.

Seed supply systems remain the central element to the success of any agricultural commodity value chain development (Almekinders & Louwaars, 2002; Musara *et al*, 2019). Seed security is a precursor to national food security. Therefore, supplying farmers with quality seeds remains critical to ensuring national food security (Dube & Mujaju, 2013). Seed quality can be defined in terms of some of the following characteristics: seed vigour, free from noxious weed seeds and seed-borne diseases, and of no older age (Dube & Mujaju, 2013).

3.2.2.1. Land size under seed production

On average, seed growers devote land size of 2 ha per producer for sorghum seed production with average productivity ranging from 0.5t/ha to 1t/ha. On estimate, a total harvest of 2 tonnes per seed producer can be attained per season. On average estimation, 6 tonnes of seeds are sold per retailer or

input distributor per annum. The only present sorghum seed growers are registered through the Ministry of Agriculture, Water and Land Reform (MAWLR), Northern Namibia Farmers Seed Growers (NNSGC), and Namibia Agricultural Mechanisation and Seed System Improvement Project (NAMSIP) thus, financing mechanisms are through a government subsidy scheme and most of the sorghum seed growers are located in the North Central production zone of Namibia (Table 3).

Table 3 shows the total average hectare planted and yield harvested each season per production zone.

Table 3: Total average hectare planted and yield harvested of sorghum seeds

Production zone	***Total average ha planted***	***Total average yield per season (kg)***
North Central	12	8000
Kavango	2.5	5000
Zambezi	-	-
Karst	-	-
Central	-	-

Table 3 shows that North Central dominates seed production with average of 8000 kg yield per annum as the majority of sorghum seed growers are located in that production zone. It is worth noting that the high production of sorghum seeds comes from government research stations such as Okashana and Omahenene in North Central and Bagani in Kavango.

3.2.2.2. Seed sources and varieties

Planting of high-yielding certified seed varieties sourced from accredited sources could have a valuable contribution to sorghum production in Namibia. However, there are only a few registered sorghum seed growers mostly located in the Northern part of Namibia. The present study results reveal that sorghum seed producers (mainly registered seed growers) source foundation seeds from either the MAWLR, NAMSIP, or NNFSG for sorghum planting. The results demonstrate that there is a need for improvement in sorghum seed production in Namibia as compared to other cereal crops where farmers can easily find numerous improved seed varieties available for cultivation. It can be deduced that there are limited options through which smallholder seed growers could acquire improved sorghum varieties of assured quality.

Seed is a key input for improving agricultural productivity and ensuring food security. Thus, planting improved varieties is vital to sorghum production in Namibia. On the contrary, the commonly planted sorghum varieties in Namibia are the traditional varieties differentiated by colours. Similar sentiments were reported by Wanga *et al.*, (2018) that local sorghum producers continue growing the familiar

landraces which perform well in good rainfall years but fail to produce stable yields with irregular and erratic rainfall.

Common sorghum varieties planted in Namibia are Macia and Red and White sorghum as well as other Landraces. Red sorghum and Macia and local landraces are the most common sorghum varieties planted by local producers at an average seeding rate of 9.6kg/ha, although some producers use few quantities of 2kg/ha while others use more seeds of up to 40kg/ha. Red sorghum is commonly used in traditional beer and beverages. Macia, the white sorghum is mainly popular in flour making at the household level using traditional milling methods.

3.2.2.3. Improved seeds and seed sources

The present study results reveal that only registered sorghum seed growers constituting 42% of the total sorghum producer population, source improved seeds from government suppliers such as MAWLR, NAMSIP, and NNFSGC whilst the majority of sorghum producers use landraces varieties.

Although, planting of high-yielding certified seed varieties from accredited sources has a valuable contribution to sorghum production (Gerrano et al., 2022) in Namibia. According to the study results currently, the majority of sorghum grain producers in Namibia are planting traditional local varieties using their own reserved seeds from the previous harvests, as the majority of sorghum producers attested to face a shortage of certified seeds at planting season. Direct seeding is the commonly practised planting method.

Figure 5 shows sorghum farmers' utilisation of certified seeds in comparison with traditional seed varieties in Namibia.

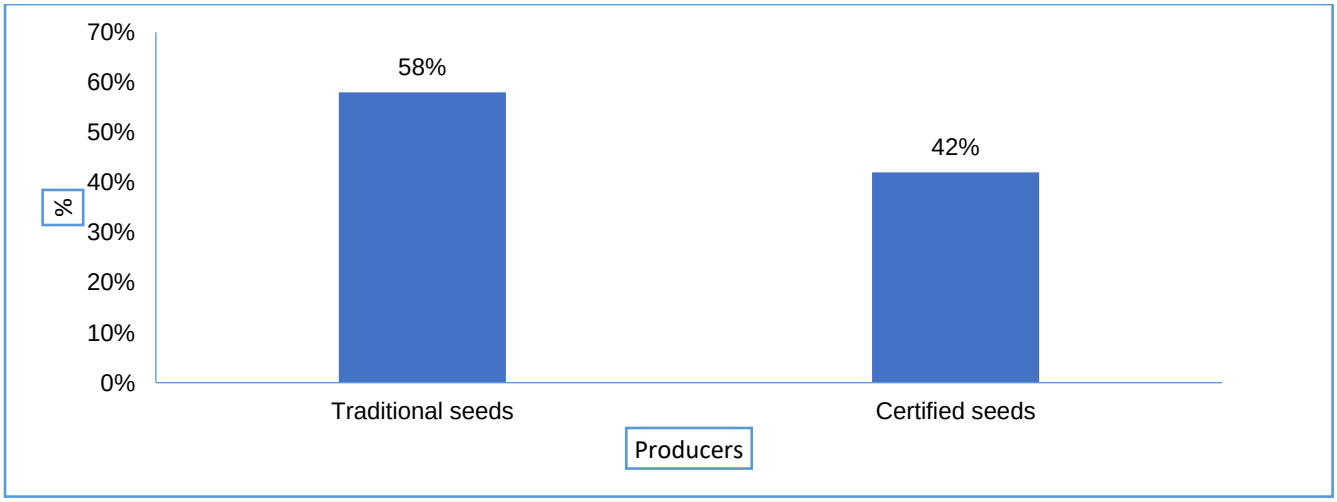


Figure 5: Farmers' proportion on utilisation of certified seeds versus traditional seeds

Figure 5 depicts that 58% of grain producers use uncertified seeds from the informal market or previous harvest for planting. Sorghum production in Namibia is currently limited to household use only, cultivated under rainfed farming.

The results further demonstrate that there is a need for improvement in sorghum seed production in Namibia as compared to other cereal crops where farmers can easily find numerous improved seed varieties available for cultivation. It can be deduced that there are limited options (varieties) through which sorghum smallholders acquire improved sorghum varieties of assured quality. Currently, farmers buy seeds from unaccredited suppliers such as informal markets and vendors, this is a common practice with most 'orphan crops' such as cowpea (Gerrano et al., 2022).

3.2.2.4. Input suppliers on seed production

The study results reveal that seeds and inputs are sourced locally of which seeds are sold at an average price of N$10.25 per kilogram. Few registered seed growers are affiliated with MAWLR/NNSGC and NAMSIP. The registered seed growers receive foundation seeds from accredited sorghum breeders and multiply these seeds to produce certified seeds which are then sold to the public, all sorghum producers. However, due to high demand these citified seeds are always not enough for the majority of sorghum producers.

3.2.3. Sorghum grain production in Namibia

3.2.3.1. Land size under sorghum production

Study findings reveal that land size allocation for crop cultivation and related activities differ from farmer to farmer and region to region. Small-scale producers in communal area set-ups allocate a small portion of land for crop cultivation averaging only 3.5 ha per producer in comparison to large-scale producers in commercial set-ups who on average devote up to 33 ha for crop cultivation per producer. Out of this cropland allocation, sorghum occupies less than 40% of the total cropland per producer. Whereby most crop producers intercrop sorghum with staple crops such as maize or pearl millet. Very few farmers allocate up to 100% of cropland to sorghum cultivation.

Table 4 shows land allocated for crop activities and proportion allocation for sorghum cultivation purposes as per each production zone.

Table 4: Average cropland under sorghum cultivation in each production zone

	Total average area (ha) planted	*Average cropland (ha) under sorghum cultivation*	*Land allocation percentage for sorghum (%)*
Kavango	4	1	25
Zambezi	9	3	33

North Central	7	2	29
Central	758	7	1
KARST	2	0.6	30

Table 4 shows that less than 33% of cropland is allocated to sorghum cultivation. The Zambezi production zone recorded high percentages of cropland allocated to sorghum production while the Central production zone recorded the lowest land allocated for sorghum production. An average sorghum production of 5 160 tonnes per annum is reported on an average area of 30 641 ha (Wanga *et al.*, 2018; Crop Prospects and Food Security Situation Report-MAWLR, 2022), (Table 5). In absence of a well-established market that is accessible by local sorghum producers has negatively attributed to small land size allocation for sorghum cultivation. According to Wanga *et al.*, (2018), numerous issues have been attributed to the declining area under sorghum in the past two decades in Namibia; lack of market for sorghum grain as compared with maize, pearl millet, and wheat (controlled crops).

3.2.3.2. Production tonnage volume and productivity

Present study results established that sorghum productivity per unit area in Namibia is approximately 400 kg per ha, these findings are in line with the study by Deb *et al.,* (2004). However, the lowest sorghum yield of 63 kg per ha and the highest yield of 1000 kg per ha were recorded during the present studies respondents. According to Deb *et al*, (2004), the global sorghum's average yield ranges from 2000 kg to 12 000 kg per ha. Figure 6 shows the sorghum's average yield per ha per production zone in Namibia.

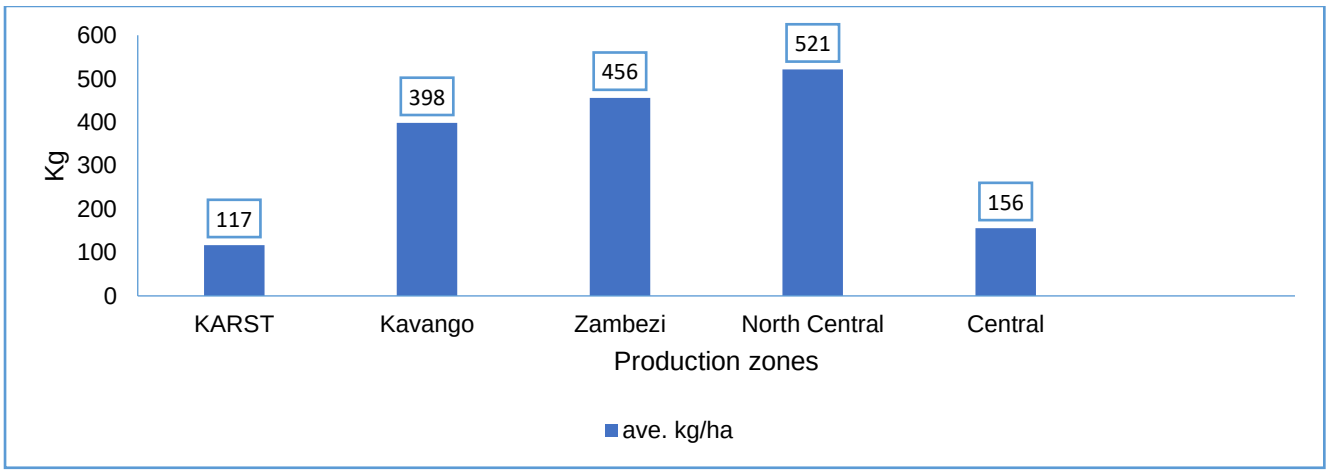


Figure 6: Average sorghum productivity, yield per ha produced per production zone, current study.

Figure 6 results shows that North Central has high average productivity of 521 kg/ha followed by Zambezi with 456 kg/ha while Karst recorded the lowest yield with only 117 kg/ha. A total yield of 970 kg to 2000 kg per farmer per season has been reported.

Table 5 shows national sorghum production and productivity (yield per ha) over 5 years period from 2017/18 to 2021/22.

Table 5. National sorghum productivity average over 5 year period

Year	***2021/22***	***2020/21***	***2019/20***	***2018/19***	***2017/18***	***Average***
Production (t)	6 100	8 200	7 100	400	4 000	**5 160**
Area (ha)	29 402	36 800	22 004	29 000	36 000	**30 641.2**
Yield (t/ha)	0.207	0.222	0.322	0.013	0.111	**0.175**

(Source: Wanga et al., 2018; Crop Prospects and Food Security Situation Report-MAWLR, 2022)

According to the study by Wanga *et al.,* (2018) as displayed on Table 5, on average sorghum grain production of 0.175 t/ha is attained, which is slightly lower than the established average yield of 0.329 t/ha as per the present study. According to Knnoema, 2022 over 1 tonne per ha of sorghum grains can be attained in Namibia.

Figure 7 shows the average total sorghum production produced per farmer per season in each production zone.

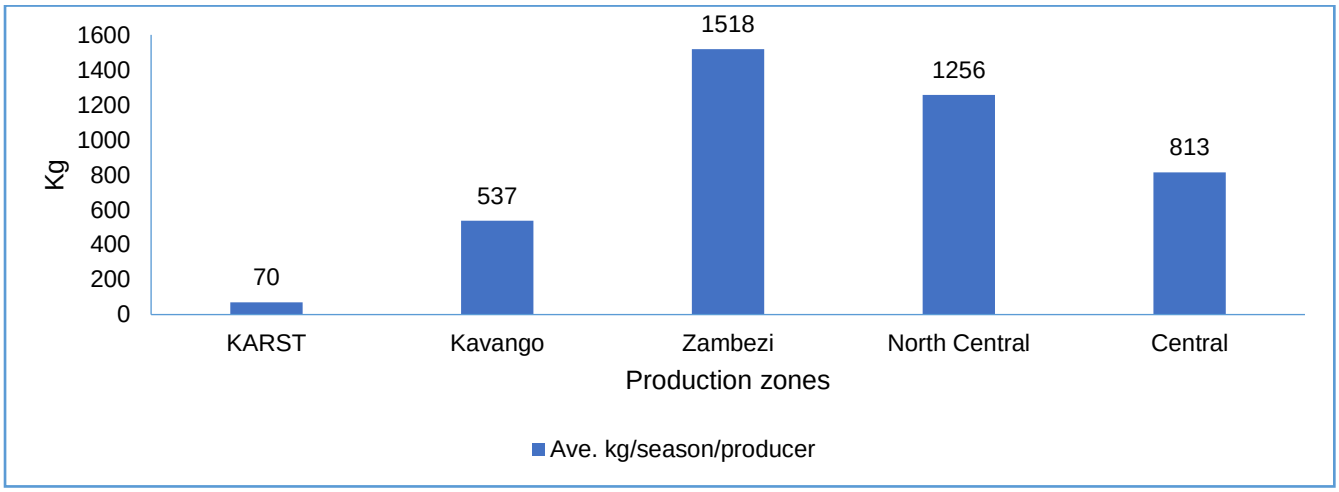


Figure 7: Average total sorghum production produced per season by a single farmer in each production zone

According to the present study results as shown on Figure 7, Zambezi recorded the highest total production per season per farmer with 1 518 kg/ha while Karst recorded the lowest average total production of 70 kg/ha.There are no technological practices currently carried out in Namibian sorghum cultivation as the majority of producers practice traditional cultivation methods. Sorghum is currently produced under rainfed in Namibia. As per the present study results, only 8.7% of the producers practice Conservation Agriculture.

3.2.3.3. Fertiliser application and input supply

Inputs such as fertilisers and others are sourced mostly from MAWLR, local retailers, and informal markets. Farmers reported that they can't afford to buy inorganic fertiliser as the prices are expensive to many farmers even when subsidised. Despite reported poor soil fertility in sorghum production areas (Wanga *et al.*, 2018), farmers do not apply sufficient fertiliser as they only spread available fertiliser thinly to cover the entire crop field (Wanga *et al.*, 2018). Table 6 shows Application of different types of fertilisers by sorghum producers per production zone. Overall fertiliser application rate among Namibian sorghum producers is very low. Organic fertiliser is the most commonly applied fertiliser by the majority of farmers who constitute 73% of the producers' population (Table 6).

Table 6: Application of different types of fertilisers by sorghum producers per production zone

Production Zone	***Type of fertiliser***		
	Organic	**Inorganic**	**Mixed**
North Central	67%	25%	8%
Kavango	69%	19%	12%
Zambezi	91%	9%	0%
Karst	67%	33%	0%
Central	50%	0%	50%

Table 6 shows that inorganic fertiliser is among the least applied types of fertilisers. Only a few local sorghum producers apply inorganic fertilisers in their sorghum crop fields representing 19% of the total sample population. While over 74% of sorghum producers use organic fertiliser mainly kraal manure, and about 7% of sorghum producers apply mixed, both organic and inorganic fertilisers. It is worth noting that overall fertiliser is applied at a very low quantity of insignificant rate. There is limited access to input markets by smallholder, sorghum farmers. The main input suppliers are located in urban setups far from farmers hence, transport expenses with a significant impact on production costs are incurred.

Furthermore, the types of fertiliser applied differ amongst production zones. In Zambezi, Kavango, North Central and Karst production zones organic fertiliser is the most popular applied type of fertiliser with high representation of 91%, 69%, 67%, and 67% respectively while in the Central production zone, only 50% of sampled farmers apply organic fertiliser while the remaining 50% apply mixed fertilisers. Low application of chemical (inorganic) fertiliser could be linked with high fertiliser cost on affordability by farmers while organic fertiliser is readily available and accessible.

3.2.3.4. Cost of Production

Crop production analysis provides useful information for economic cost analysis and assessment of the production process. It provides an appropriate indication for the promotion of that crop in the future, targeting cost reduction and yield at a reasonable capacity (You *et al*, 2008; Ericsson *et al*, 2009). Therefore, in this study production costs were established in terms of the economic compensation required by the farmer to grow sorghum crops and therefore include not only the cost of cultivation but also the transport costs to the nearest market which are often omitted in production cost calculations. However, it was also observed that most of the local sorghum producers do not have proper or updated economics records, thus, the obtained information is per farmers' responses on the cost estimates (including; seed cost, land preparation, fertilizers and application, weeding, harvesting, storage and transport cost).

Table 7 shows farmers' perception of sorghum production affordability and while Figure 8 shows the estimated average sorghum production cost per hectare per production zone in Namibia.

Table 7: Farmers' response to the perception of sorghum production affordability

AFFORDABLE	EXPENSIVE
87.8%	*12.2%*

Table 7 depicts that the majority of farmers (87.8%) believe that sorghum production is affordable. However, 42.8% of sorghum producers don't have production cost records which makes it difficult to determine the exact accurate sorghum production cost. Figure 8 shows the average production cost per ha in each production zone.

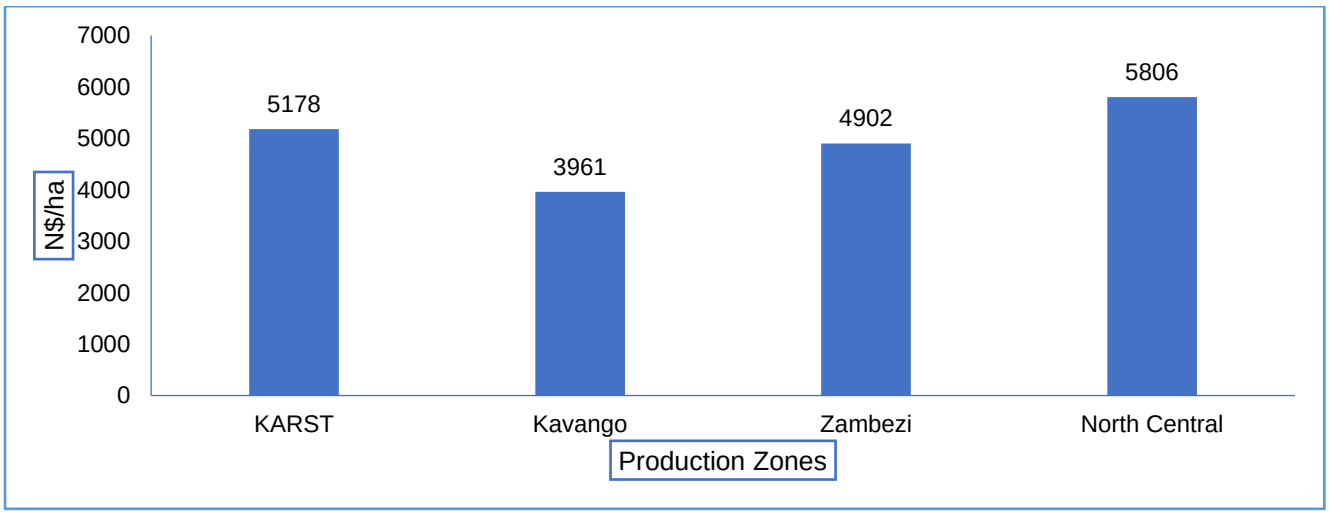


Figure 8: Sorghum average production cost per ha of each production zone

Figure 8 results indicates that the average sorghum production cost per ha ranges from N$3 961/ha to N$5 806/ha, as per the findings on average sorghum production cost is estimated roughly at N$5 046 per ha across all production zones. Kavango production zone recorded the lowest average production cost of N$3 961/ha while North Central recorded the highest average production cost of N$5 806/ha.

3.2.3.5. Transport to the market

Regarding the transport expenses incurred during transportation to the nearest market, it was revealed that over 50% of sorghum producers only sell their end products at the farm gate, thus, buyers travel to the farm and bear the cost. Therefore, sorghum production costs slightly differ per production zone. Figure 9 shows transportation method used by sorghum producers selling products to the nearest market.

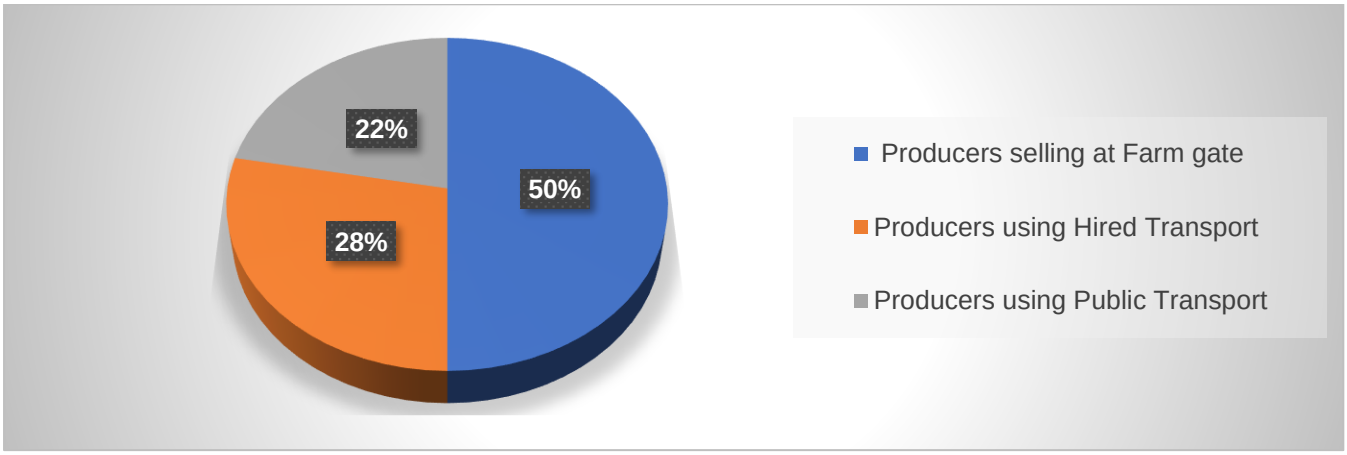


Figure 9: Transportation method used by sorghum producers selling products to the nearest market

Present study results as shown in Figure 9 shows that majority (50%) of sorghum producers only sell at farm gates (at N$7/kg to N$15/kg) remaining 22% and 28% use hired and public transport charged at the rate of N$1.2/kg/trip.

3.3. Regulatory compliance and protection

3.3.1. Registration and usage of certified seeds

The registered seed growers use certified seeds from accredited sorghum seed suppliers while the majority of unregistered sorghum seed producers do not have knowledge or access to certified seeds. Only a few local input suppliers know the Seed and Seed Varieties Act 23 of 2018. Figure 10 shows farmers' awareness of Namibia's Seed and Seed Varieties Act No. 23 of 2018.

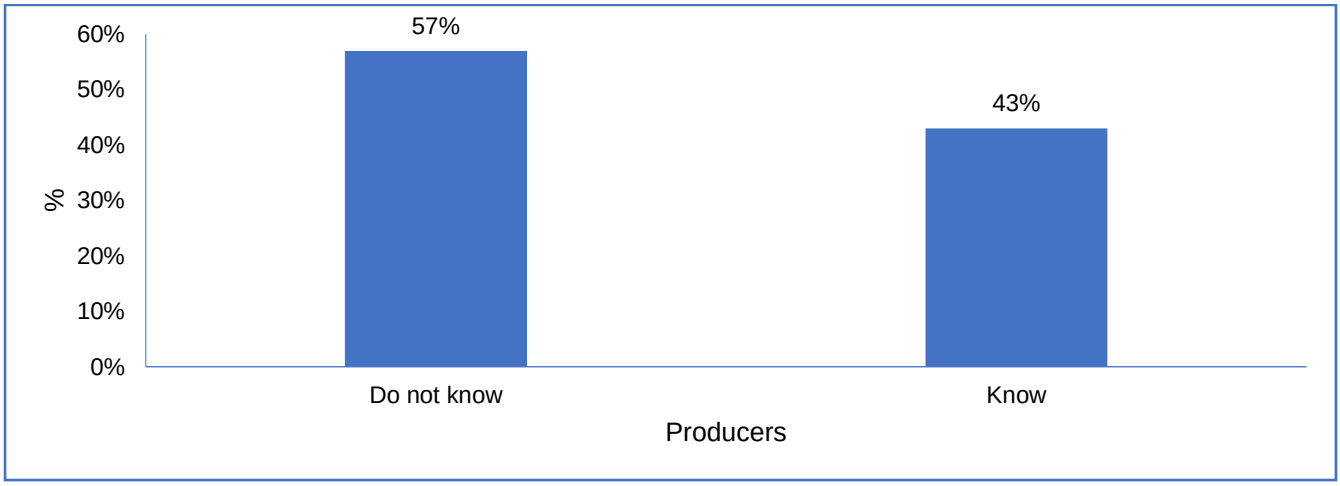


Figure 10: Farmers' Awareness of Namibia's Seed and Seed Varieties Act No. 23 of 2018

Study results as depicted on Figure 10 reveal that the majority of sorghum seed producers are not aware of Namibia's Seed and Seed Varieties Act No. 23 of 2018. Figure 10 shows that 57% of sorghum producers are not aware of Namibia's Seed and Seed Varieties Act and only 43% are aware of the Act. Most input suppliers are agent distributors. Only the Ministry of Agriculture, Water, and Land Reform through the Crop Research Stations namely Omahenene, Okashana, Mannheim, and Bagani with a few participating seed growers who are currently producing certified sorghum seeds and selling to the local farmers through seed cooperatives. Figure 11 shows Seeds/inputs suppliers registration status as per production zone.

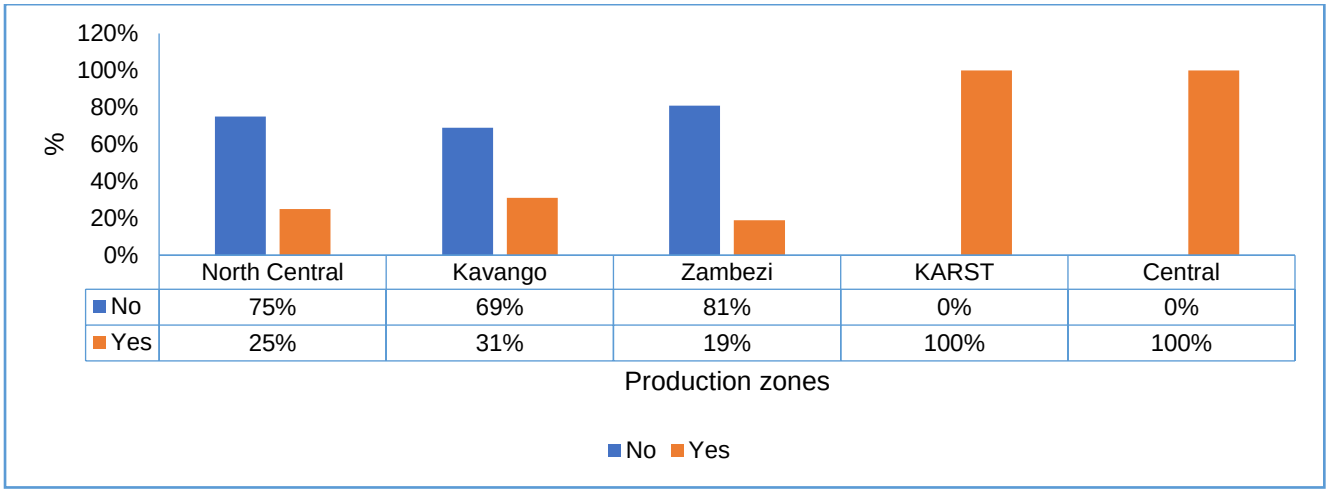


Figure 11: Seeds/inputs suppliers registration status as per production zone

Figure 11 shows inputs suppliers' registration status as per production zone. Results on figure 11 indicates that in the Zambezi production zone inputs/seeds suppliers are not registered sorghum seed suppliers accounting for 81% of the total sampled farmers in that production zone followed by North Central and Kavango with 75% and 69%, respectively. However, 100% of sorghum seed growers in

Karst and Central production zones are registered with NAMSIP, these are the sorghum seed growers under NAMSIP programs through the Ministry of Agriculture, Water and Land Reform. Figure 12 shows certified sorghum system as per production zone.

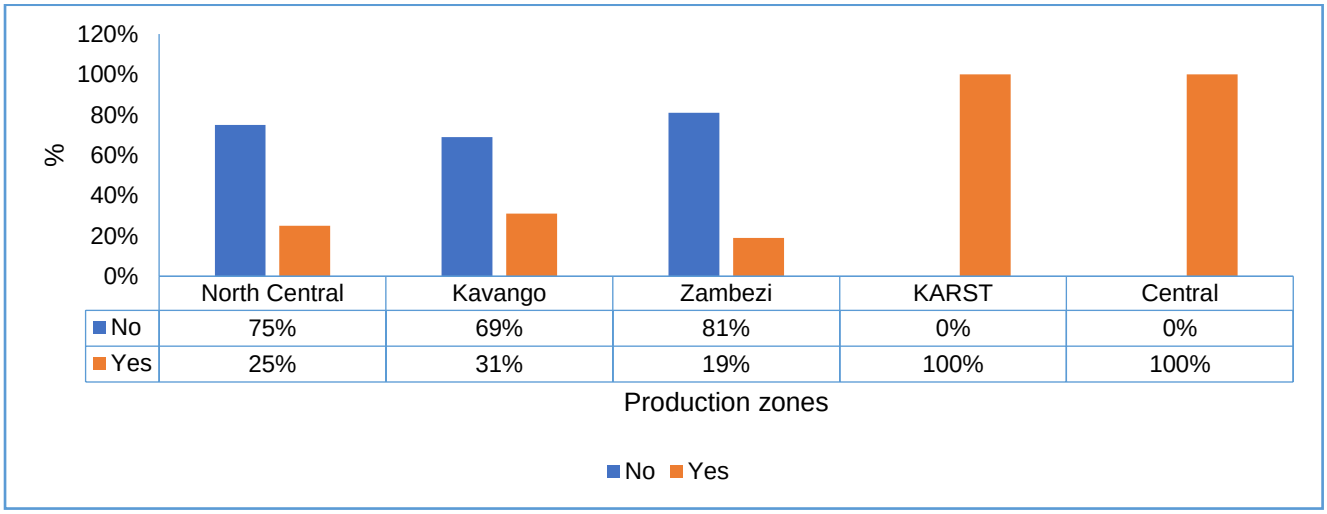


Figure 12: Certified sorghum system as per production zone

Figure 12 shows the seeds certification system application by farmers in each production zone. The figure indicates that in the Zambezi production zone sorghum producers do not use certified sorghum seed accounting for 81% of the total sampled farmers in that production zone followed by North Central and Kavango with 75% and 69%, respectively. However, 100% of sorghum producers in the Karst and Central production zones use certified seeds from NAMSIP programs through the Ministry of Agriculture, Water, and Land Reform.

3.3.2. Grain food safety system

Figure 13 shows Sorghum grains safety practices by inputs suppliers and producers

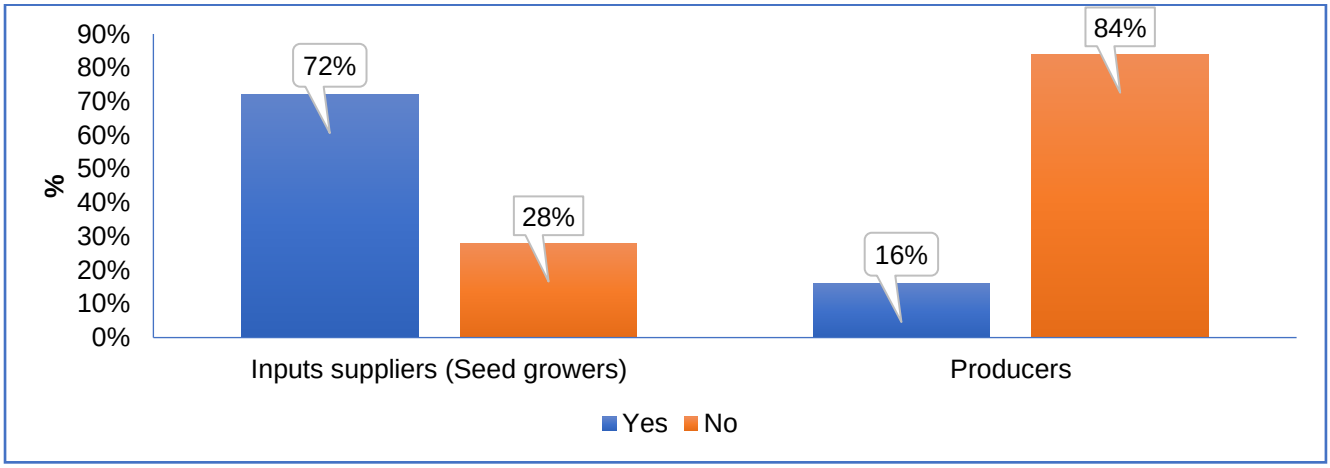


Figure 13: Sorghum grains safety practices by inputs suppliers and producers

Results on Figure 13 shows that the majority of seed suppliers follow certification processes such as Good Agricultural Practices (GAP), phytosanitary and traceability as well as other quality aspects such as screening and grading. Present study results reveal that 72% of seeds/inputs suppliers (seed growers) follow the food safety certification process and only 28% of input suppliers do not practice the food safety certification process. On the other end, the majority of sorghum producers do not practice food safety processes in their production systems, there is no quality standards procedure currently in place. Over 84% of sorghum producers do not have any food safety system, and only 16% are confirmed to have a food safety system in place. Figure 14 shows food safety and certification system as per production zone.

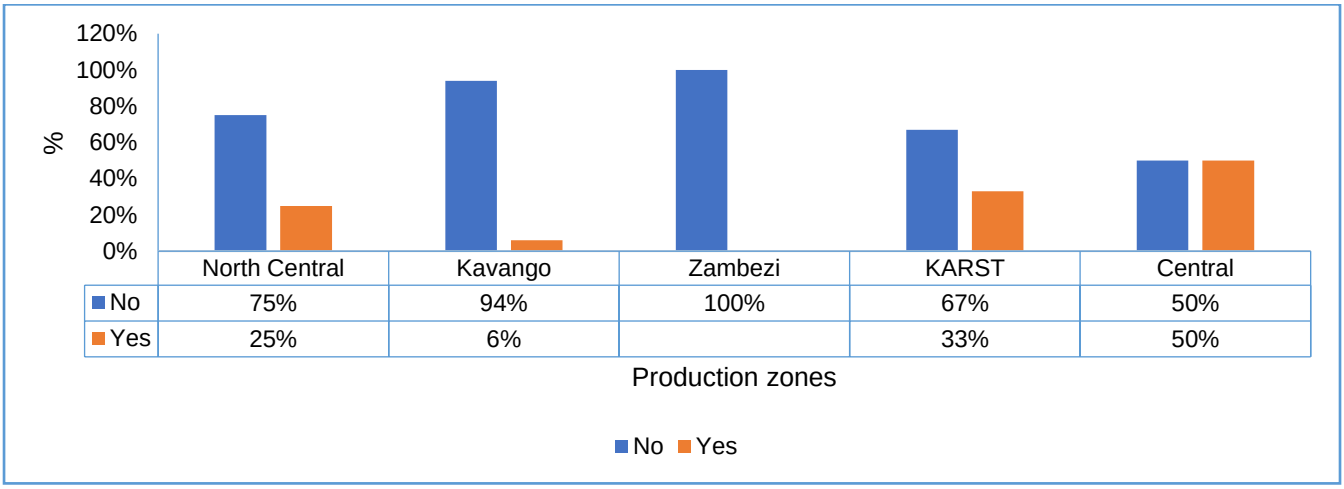


Figure 14: Food safety and certification system as per production zone

Figure 14 shows the food safety and certification system practised by sorghum grain producers per production zone, results depicts that in the Zambezi production zone, all (100%) of the sampled sorghum grain producers do not practice food safety systems or use certified seeds followed by Kavango and North Central with 94% and 75%, respectively. This demonstrates that the food safety and certification process is poorly practised among local sorghum producers in Namibia.

3.3.3. *Government sorghum industry protection*

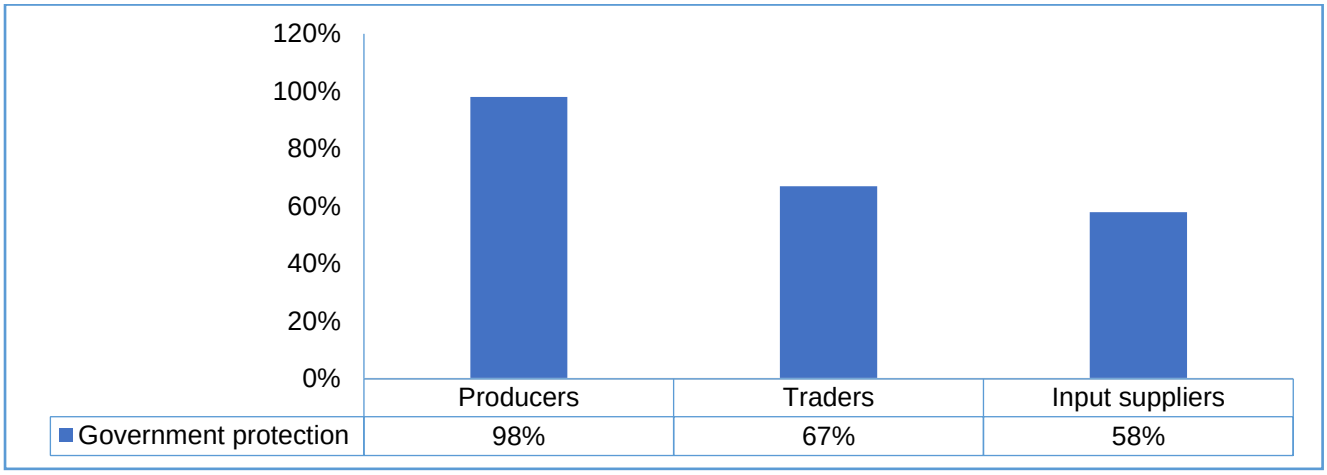


Figure 15: Number of different value chain actor's plea for government sorghum industry protection

As shown in Figure 15, the study revealed that almost at every sorghum value chain stage various actors plea for government sorghum industry protection. Whereby over 98% of the sorghum producers plead to the government for market protection and price regulation mechanisms and over 67% of traders/processors plead for government protection on minimising imports and promoting an organised farming system among local sorghum producers to ensure a consistent and quality supply of sorghum commodities as well as regulation of price within the sorghum value chain stages. On the other hand, 58% of input suppliers plead for government protection on the market, import restriction, and promotion of local farmers' participation in the seed supply chain (Figure 15).

3.4. Marketing and price information

3.4.1. *Market share*

Figure 16 shows number of sorghum producers trading in different markets

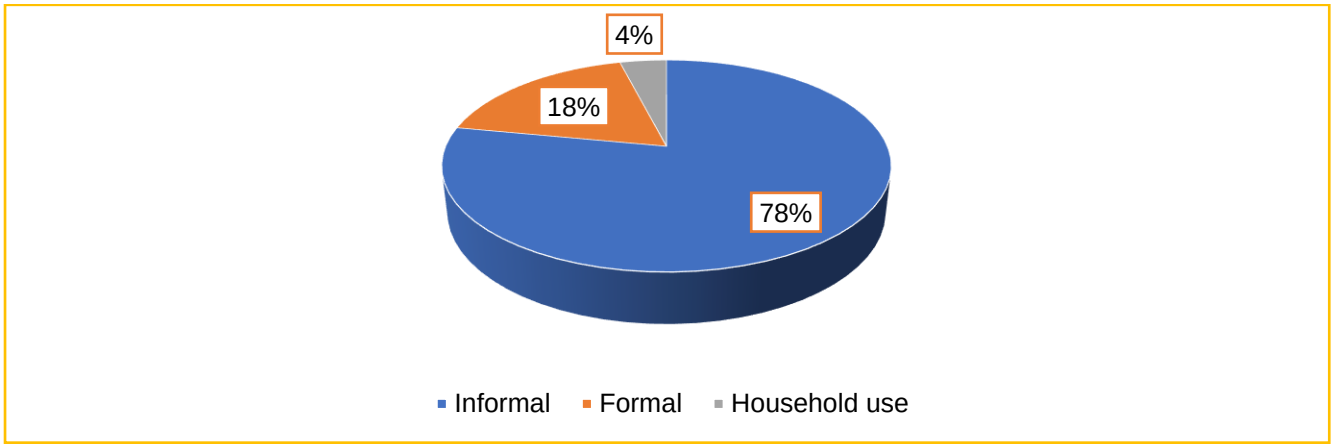


Figure 16: Number of sorghum producers trading in different markets

The study revealed that the majority number of sorghum producers sell their produce through the informal market (Figure 16). Farmers showed a willingness to produce and market sorghum and sorghum products in bulk. However, the lack of a formal market deprives these farmers of partaking in the formal main economy stream. Consequently, producers opt to sell through informal markets. Sometimes smallholder farmers store and sell sorghum grains back to farmers during peak planting season at high prices as seeds. Figure 16 shows that 78% of sorghum producers market through the informal market while 18% are marketed through formal such as local supermarkets like Spar and Choppies and only 4% of sorghum producers use sorghum for household purposes.

During the study, it was observed that most if not all processed sorghum products such as meal flour and beer flour traded in the formal local market are imported from other countries such as Botswana and South Africa. This signal in high notable sorghum product importations into the Namibian market, although current figures are not quantified. In addition, the lack of value addition and the competition against imports deprive local farmers of participating in the main formal economy stream. Although the price is relatively accepted in the informal market, the market security is un-guaranteed throughout all seasons. According to the study findings currently in Namibia, sorghum is not regarded as the main staple food crop by farmers as compared with maize and pearl millet. Table 8 shows sorghum grain market share distribution by tonnage.

Table 8: Sorghum grain market share distribution by tonnage

Market type	**Tonnage sold**	**Market share %**
Informal	*47 331*	*89%*
Formal	*5 850*	*11%*
Total	***53 181***	***100%***

The present study results estimates that out of the sampled size population (of 57 producers) total sorghum harvest of 53 181 tonnes is attained per annum of which 89% (47 331 tonnes) are marketed through the informal market and only 11% (5 850 tonnes) of sorghum marketed through the formal market. Table 8 shows that most sorghum grains produced in Namibia are sold through the informal market. Furthermore, sorghum prices differ in different types of markets; the informal market currently records higher prices per unit quantity than the formal market.

Table 9 shows the average and price ranges of sorghum grain in different markets.

Table 9: Average and price ranges of sorghum grains in different markets

Market type	**Price ranges [N$/kg]**	**Average price [N$/kg]**

Informal	8 - 15	10.10
Formal	4.6 - 11.25	7.29

Table 9 depict that farmers collect better retail/selling prices in the informal market than formal market. This could be another contributing factor for more tonnage volumes being traded through the informal markets than the formal markets in addition to the lack of a well-established formal market.

Table 10 shows the average prices of different sorghum products sold in the informal market.

Table 10: Average prices of different sorghum products sold in the informal market

Product	Price (N$/kg or ltr)
Grain	15
Seed	56
Flour	20
Traditional beverage	21

Results depicts that seed is the highest-priced commodity among all sorghum products, this might be due to high demand during peak planting seasons. Furthermore, value-added commodities are better priced than un-processed, raw products. The competition imposed by imported products makes it difficult for local farmers to penetrate and strive in the local markets. Furthermore, input suppliers confirmed that sorghum seeds are a highly demanded commodity.

3.4.2. Value addition

Value addition is critical for the success of agricultural commodity value chain development (Musara *et al.*, 2019). World Bank report (2006), indicated that many developing countries especially in Africa lose income on agricultural commodities by not adding value or processing these agricultural commodities into finished products. According to the present study, similar results were observed (Table 9), and there is a low level of value-added activities or processing of sorghum into finished products in Namibia. Figure 17 shows proportion of producers selling processed sorghum products.

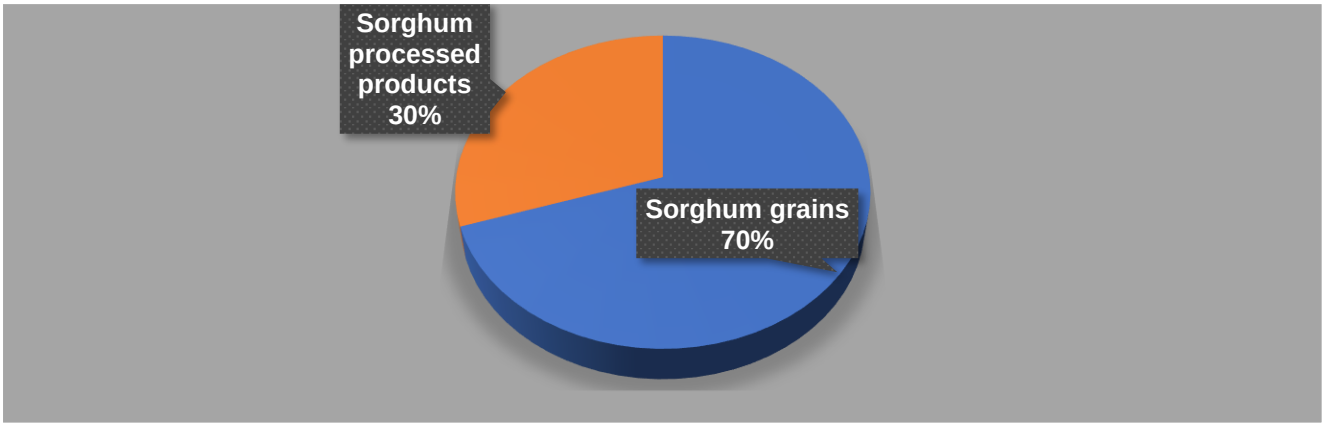


Figure 17: Proportion distribution of producers selling processed sorghum products

The majority of sorghum producers do not process or add value to the sorghum crop instead it is commonly sold as grains which accounts for over 70% of producers selling or consuming sorghum commodities as grains. Only a few producers 30% process sorghum grains but only into traditional beverages or beer and flour mainly for household consumption or family-happy events and ceremonials, see Figure 17.

It is therefore, imperative for improvement at this stage of the Namibian sorghum value chain requires effective interventions. Limited value-addition activities on sorghum have deprived local producers of maximising the full potential of sorghum crops among different actors along the value chain. At the same end, high importation of sorghum value-added, processed products enter into the Namibian market from neighbouring countries (Figures 23 & 24).

In comparison, developed countries earn a high value of US$185 (N$3 163.5) by processing one tonne of the agricultural commodity while developing countries only earn US$40 (N$684.0) per tonne (Musara *et al.*, 2019). In developing countries, only 38% of agricultural production undergoes industrial processing while over 98% of agricultural production in developed countries undergoes industrial processing (Musara *et al.*, 2019).

All these variabilities can be attributed to poorly developed agro-value chains in Africa leading to underutilisation of the full potential of agricultural commodities including sorghum (Musara *et al.*, 2019). Thus, value addition in the sorghum value chain is of significant benefit to sorghum producers and traders in Namibia (Figures 23 & 24). The pictures below show some processed, value-added sorghum products.

Sorghum pancakes

Sorghum flour

Sorghum cookies

3.4.3. Supply contract

3.4.3.1. Seeds/input suppliers

Figure 18 shows the number of seed growers with existing supply contracts expressed in percentages.

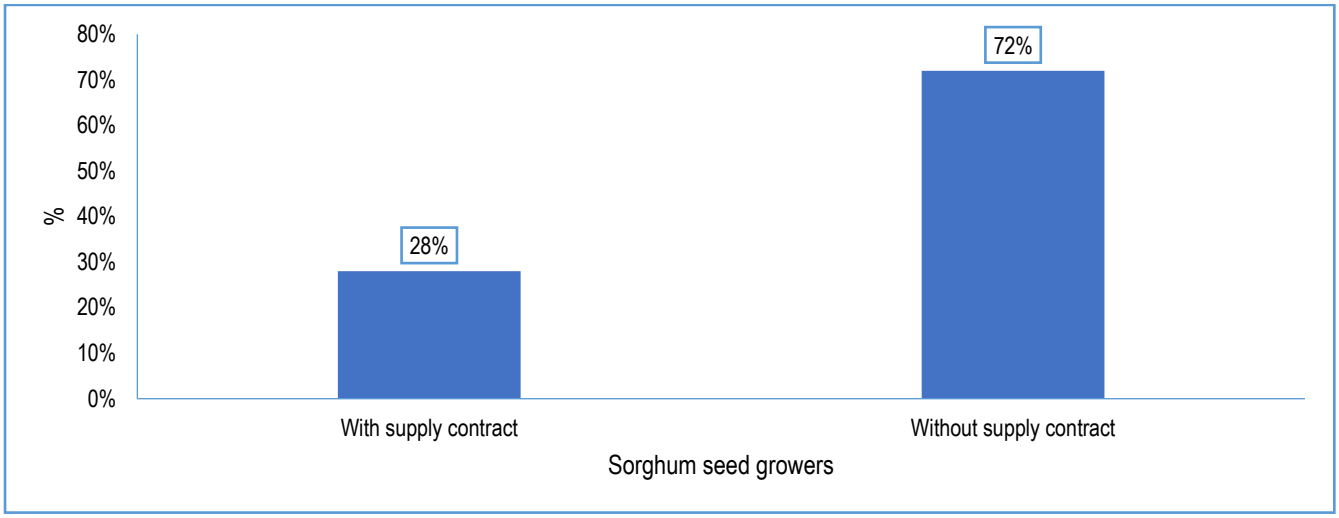


Figure 18: Sorghum seeds growers with existing supply agreement contract

Over 57% of total input suppliers are willing and interested to enter into any supply contract. But currently, among the sampled seed/inputs suppliers, only 28% have an existing supply contract mainly as seed grower members of Northern Namibian Farmers Seed Growers Cooperative (NNSGC) or the Namibia Agricultural Mechanisation and Seed Improvement Project (NAMSIP). While 72% of seed suppliers do not operate on any supply contract. Figure 19 shows sorghum grain producers with existing supply agreement contract.

3.4.3.2. Producers

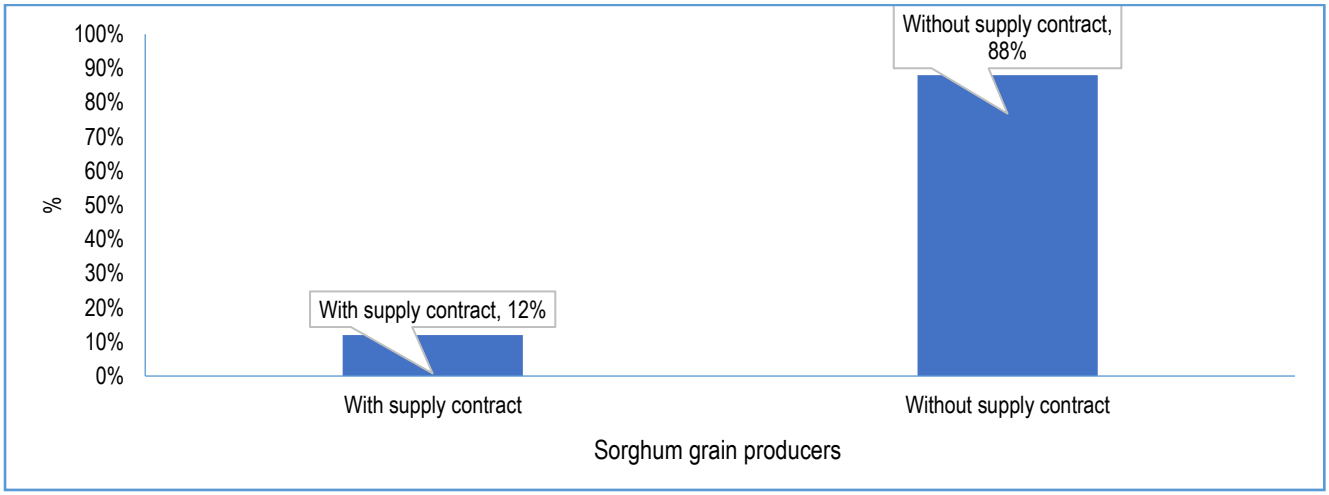


Figure 19: Sorghum grain producers with existing supply agreement contract

Over 95% of local sorghum producers showed a willingness to enter into a supply contract agreement. Despite the displayed high willingness, currently, over 88% of sorghum producers are without supply agreement contracts only 12% of sorghum producers are in supply agreement with local retailers such as Spar Otjiwarongo, and Choppies (Figure 19).

3.4.4. Storage

Proper storage practices (handling) and facilities are among the most important elements in the food supply chain of which grain is a significant nutritional source. Every year, millions of tons of grain losses are caused due to improper storage conditions the situation is worse in developing countries, especially in rural areas. Factors like humidity, heat, pests, and aeration which are effective on storage conditions affect the quality and quantity of grain and shorten the storage period (Nyambo, 1993). The present study reveals that all the sampled sorghum producers do not have a packhouse or cold storage system. Instead, on-farm traditional storage methods are commonly used for storing sorghum grains in Namibia. According to Nyambo, (1993), grains stored in improved granaries suffer less insect attack and less loss than in traditional granaries.

3.4.5. Traders/ processors

Figure 20 shows % distribution of sorghum traders with or without supply contracts.

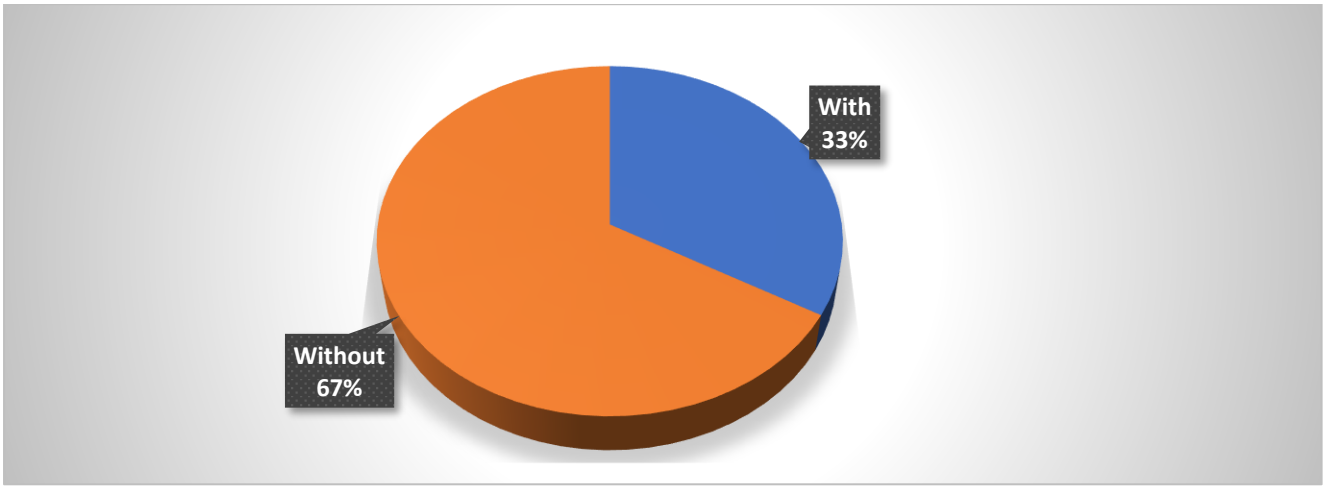


Figure 20: Proportion % distribution of sorghum traders with or without supply contracts

Six (6) traders from the following three production zones; Central (Otjiwarongo) Zambezi and Central North (Okongo and Outapi) were interviewed. The results as shown in Figure 20, indicate that only 33% of traders have existing supply contracts with foreign suppliers from South Africa and Botswana such as Choppies and CIC INDO ATLANTI in Botswana, but over 67% of traders do not have any supply contract or written agreement and they indicated a high willingness to agree with local suppliers. This is a potential gap for local sorghum producers to fill up by entering into supply contracts with traders and consistently supplying the highly demanded and imported sorghum and sorghum products. However, there is a need for value addition or processing of sorghum grains into flour and/or into other finished products for easy marketing. Figure 21 shows average volume of processed sorghum products sold per trader per annum.

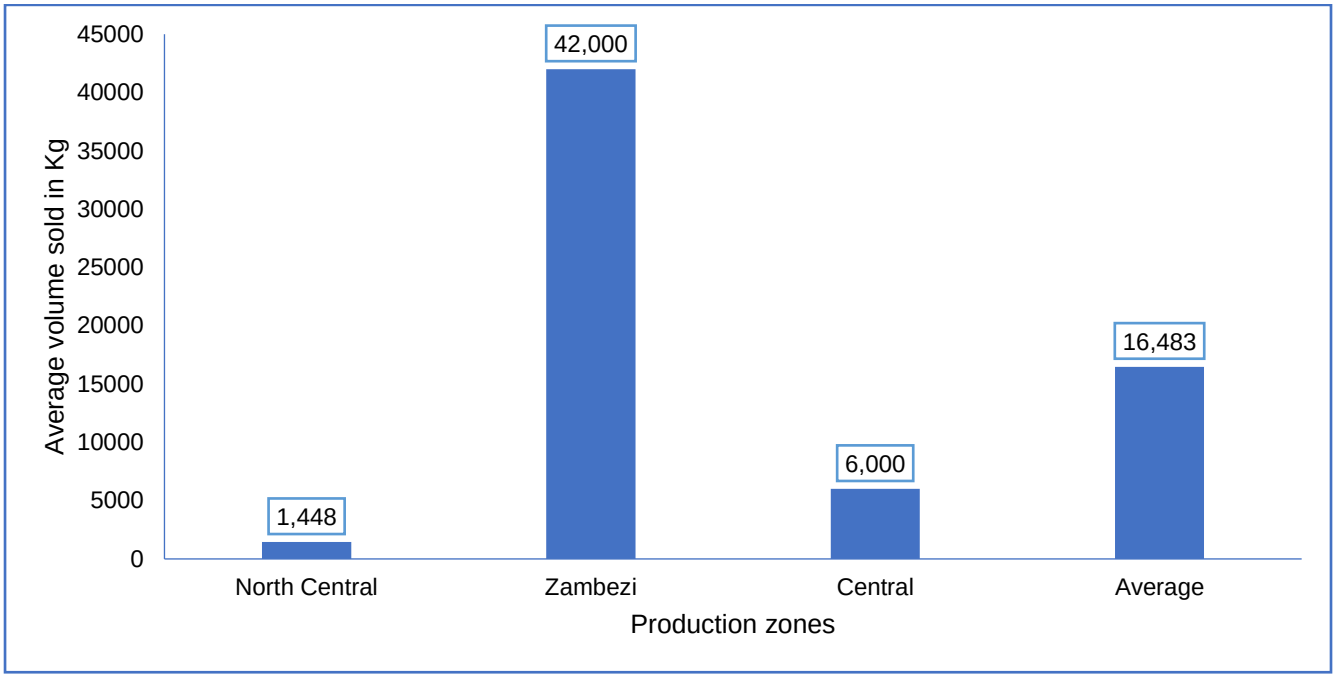


Figure 21: Average volume of processed sorghum products sold per trader per annum

The results in Figure 21 depicts that on average 16 tonnes of processed sorghum products are being sold per trader per annum. Figure 22 shows share (%) of sorghum products sourced from different origins, local and import.

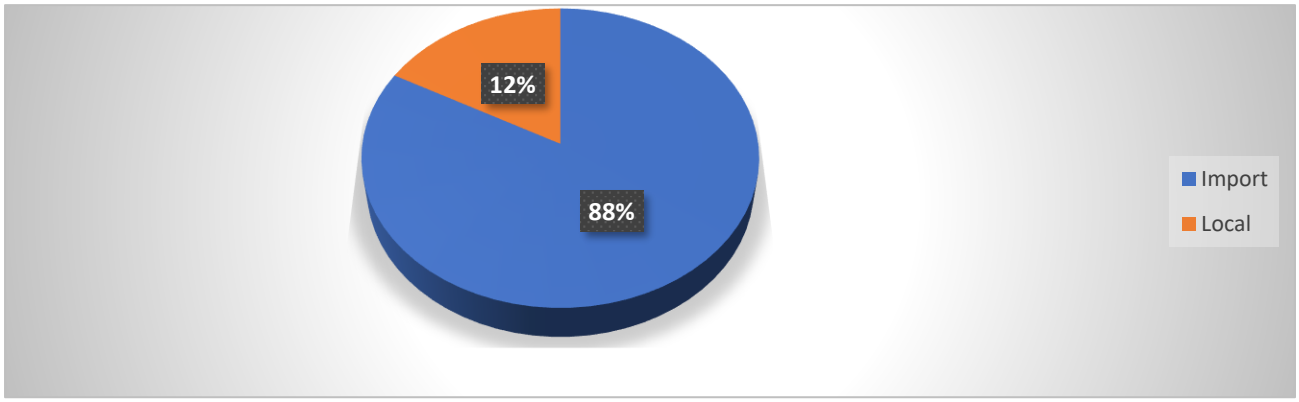


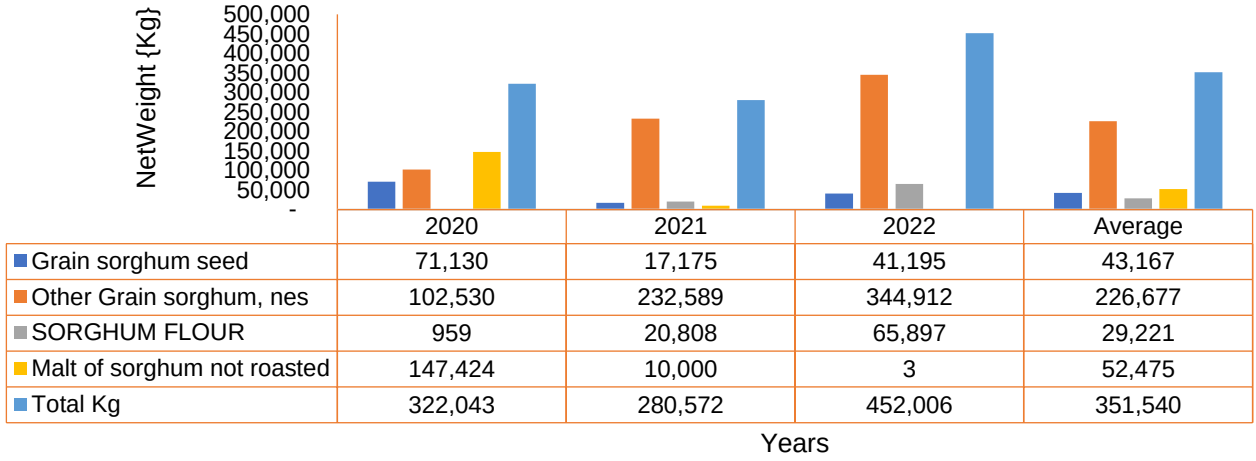
Figure 22: Share (%) of sorghum products sourced from different origins, local and import

This study reveals that only 12% of the total volume of sorghum products is sourced locally while over 88% of traders are importing sorghum products from other countries mainly from Botswana and South Africa (figure 22) Botswana accounts for the largest volume of 37,448 tonnes of sorghum imports (Table 11). Currently, there is no processing nor value addition carried out at the local traders' level in Namibia as all the imported sorghum products are already processed into sorghum flour for beverage and sorghum meal flour respectively.

Table 11: Sorghum products volume and share (%) sourced from different markets, local, Botswana, and South Africa.

Country	Tonnage	Share {%}
Local	6,000	12%
South Africa	6,000	12%
Botswana	37,448	76%
Total	49,448	100%

Figure 23 shows sorghum and sorghum product import net weight over three years period from 2020 to 2022.

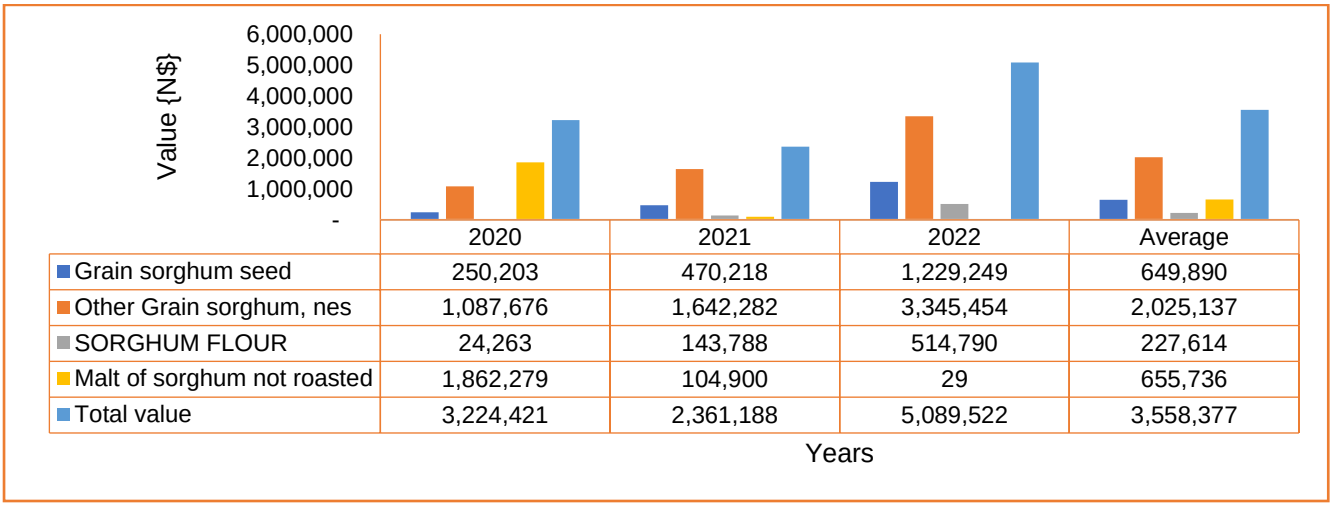


	2020	2021	2022	Average
Grain sorghum seed	71,130	17,175	41,195	43,167
Other Grain sorghum, nes	102,530	232,589	344,912	226,677
SORGHUM FLOUR	959	20,808	65,897	29,221
Malt of sorghum not roasted	147,424	10,000	3	52,475
Total Kg	322,043	280,572	452,006	351,540

Figure 23: Sorghum and sorghum products import net weight (kg) since 2020 (NSA, 2023)

According to NSA (2023), Namibia recorded a total annual average of sorghum and sorghum products of 351,540 kg. As per average volumes of different sorghum products imports, sorghum grain constitutes the largest import volume with an annual average of 226,677 kg followed by malt of sorghum with 52,475 kg, and sorghum flour recorded the lowest volume of 29,221 kg annual average (NSA, 2023). The highest total import volumes were recorded in 2022 with 452,006 kg while the least volumes were recorded in 2021 with 280,572 kg.

Figure 24 shows sorghum and sorghum product import value over three years period from 2020 to 2022.



	2020	2021	2022	Average
Grain sorghum seed	250,203	470,218	1,229,249	649,890
Other Grain sorghum, nes	1,087,676	1,642,282	3,345,454	2,025,137
SORGHUM FLOUR	24,263	143,788	514,790	227,614
Malt of sorghum not roasted	1,862,279	104,900	29	655,736
Total value	3,224,421	2,361,188	5,089,522	3,558,377

Figure 24: Sorghum and sorghum products import value (N$) since 2020 (NSA, 2023)

According to NSA (2023), Namibia recorded a total annual average import value of N$3,558,377. Sorghum grain constitutes the largest import value of N$2,025,137 followed by malt of sorghum with N$655,736 and sorghum flour recorded the lowest value of N$227,614 annual average (NSA, 2023). The highest total import value was recorded in 2022 with N$5,089,522 while the lowest value of N$2,361,188 was recorded in 2021.

3.4.6. Consumption

Despite the huge sorghum production potential in Namibia, the current records by MAWLR, (2022), national sorghum consumption tonnage relies also on import volumes. Local production tonnage is not completely matching demand, creating a constant annual deficit of around 15 740 tonnes per annum on average. Table 12 shows domestic sorghum/millet production and consumption or demanded tonnage over the past five (5) years from 2018/19 – 2022/23 (MAWLR, 2022). According to MAWLR, (2022).

Table 12: National sorghum sorghum/millet production and consumption tonnage over the past 5 years

Year	***Domestic supply***	***Consumption***	***Surplus/Deficit***
2022/23	51 500	86 000	-34 500
2021/22	64 100	87 900	-18 900
2020/21	100 700	78 400	+22 300
2019/20	10 000	77 500	-67 500
2018/19	88 700	86 700	+1 600
Average	***61 000***	***83 300***	***-22 300***

(Source: Crop Prospects and Food Security Situation Report, MAWLR, 2022)

As depicted in Table 12, it shows that on an annual average, there is national sorghum/millet consumption demand of 83,300 tonnes while 61 000 tonnes of local sorghum production is being formally marketed leaving a deficit of 22 300 tonnes on an annual basis which is currently filled through

imports. However, surplus volumes of 22 300 and 1 600 tonnes were recorded in 2022/21 and 2018/19 respectively. Henceforth, local sorghum producers and value chain actors are required to increase local production consistently and add value or process sorghum grains into finished products as demanded in the formal market and meet local sorghum demand to eventually reduce sorghum import reliance or deficits.

3.5. Financing Information, training, and industry affiliation

3.5.1. Financing Information

In the present study, it is revealed that all sorghum producers finance their sorghum production activities with money from their own savings without receiving a loan or financial assistance from financial institutions. Traders could not dwell much on the financing aspect.

3.5.2. Training and industry affiliation

Group farming and organization affiliation among farmers and other value chain actors is characterised by jointly using lands and agricultural inputs such as group purchasing and group sales, it has numerous benefits in comparsion to individual farming (Engindeniz & Yercan, 2002). Organised group farming promotes efficient utilisation of scarce resources which might be land, labour, capital, etc. It is generally accepted that group farming increases productivity, financing, and credit possibilities among farmers (Engindeniz & Yercan, 2002). Figure 25 shows sorghum value chain actors industry affiliation.

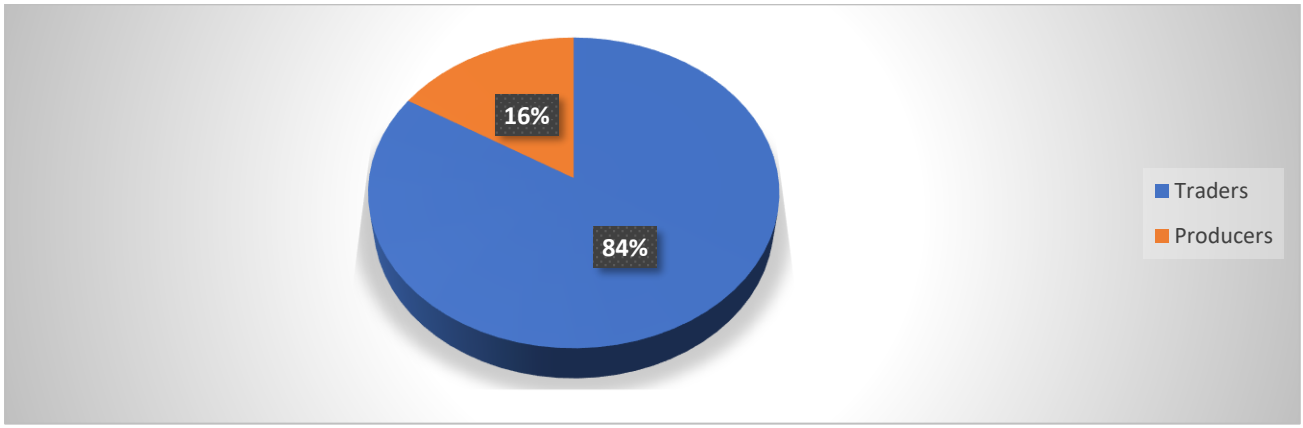


Figure 25: Sorghum value chain actors industry affiliation

On the contrary, group farming is not a commonly practised production system in Namibia, only 16% of total sorghum producers are affiliated or registered with farmers' associations or organisations (Figure 25). Therefore, group farming should be introduced to the smallholder farmers in Namibia to benefit them. Group farming can promote more efficient use of resources in terms of greater farmers, participation, and effectiveness (Engindeniz & Yercan, 2002). There is a need for organized group farming and awareness creation for the benefit of farmers' associations. However, over 84% of sorghum

traders are industry-affiliated with certain organisations or associations (figure 25). Figure 26 shows sorghum producers who received training on sorghum cultivation techniques.

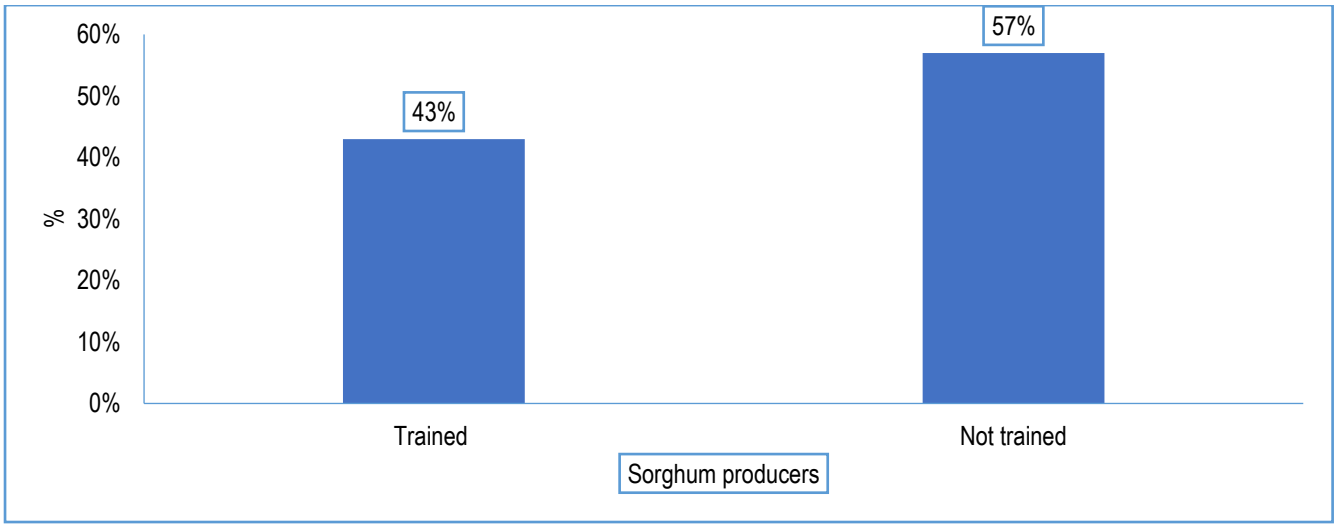


Figure 26: Sorghum producers who received training on sorghum cultivation techniques

Majority (57%) of sorghum producers have not received any training on sorghum cultivation techniques or related skills and knowledge (figure 26). Only a few (43%) farmers, mostly seed growers received training on sorghum seed multiplication and Conservation Agriculture from MAWLR and GIZ through their respective farmers' associations (Figure 26). Thus, farmers are currently relying on old traditional indigenous knowledge only, given new dynamics and challenges in crop cultivation there is a need for training on sorghum cultivation skills in Namibia.

3.6. Sorghum constraints and opportunities

This section focuses on challenges encountered by sorghum producers, processors, and traders and the untapped potential opportunities in sorghum production in Namibia. The study revealed that input suppliers/seed growers, producers, and traders encounter several challenges as alluded to in Table 13.

Table 13: Opportunities and Challenges encountered by sorghum input suppliers, producers and traders.

Value chain actor	Challenges	Opportunities
Producers	• Due to the lack of a formal market and the absence of a price regulation mechanism, price fluctuation and volatility, it is further stimulated. • High competition by imports	✓ Sorghum is a drought-resistant crop well adapted to different Namibian ecological zones. ✓ Sorghum has a low production cost in comparison to other cereal crops such as maize and pearl millet.

	• Lack of improved seed varieties and poor rainfall/drought. • Lack of technology cultivation techniques in sorghum farming. • Lack of value addition. • Lack of support services such as sufficient ploughing services. • High input costs such as fertilisers. • Lack of training and awareness on the consumption health benefits of sorghum products. • Lack of proper storage facilities.	✓ Sorghum consumption has health-diet benefits, many ends use and ensure food security at both household and national levels. ✓ An opportunity for income generation, livelihood improvement, and women empowerment. ✓ Promotion of sorghum production will ensure reduced reliance and dependence on pearl millet and maize as these two crops do not perform optimally during below-average rainfall or drought seasons.
Traders	• Sorghum products are always out of stock. • Lack of local sorghum producers' participation in the supply chain. • Lack of pricing regulations on the local supply chain. • Lack of consistent supply by local sorghum producers.	✓ Sorghum commodities possess a high economic return on sales as the product is in high demand. This might be due to the scarcity of the commodity and the health benefits attributed to sorghum consumption. ✓ Good business opportunities for local farmers, food security, income generation, and livelihood improvement. ✓ Sorghum is demanded throughout the year.
Input suppliers	• Low selling prices, high transport cost to the market, poor rainfall, and pest and diseases all hinders sorghum seed production and inputs supply business operation.	✓ Revenue generation, health balance-diet consumption, and varietal use on end products such as beverages, flour, fodder, and animal feed.

3.7. Summary of the sorghum value chain in Namibia

Value chains are an important catalyst for the development of economies and agricultural commodities in a country (Musara *et al.*, 2019). Thus, this section focuses on the sorghum value chain, the status quo of sorghum production, and marketing in Namibia covering all stages.

3.7.1. Sorghum value chain

According to (Minten *et al,* 2016), there is increasing adoption of modern inputs and new varieties, especially by those farmers living close to cities, this led to higher land productivity, improved processing costs, and increasing willingness by consumers to pay for convenient quality. This transformation has important implications for the country's food security and efficient performance of agricultural commodity value chains. A well-established and functional value chain with value-added components has increased economic benefit to all chain actors (Minten *et al,* 2016). Figure 25 shows the existing sorghum value chain in Namibia and the current relationship linkage among chain actors in comparison to the ideal sorghum value chain. The figure depicts that there are some missing components and relationships such as traders' assemblers, wholesale traders and processing or value addition components, and local distributors in the existing Namibian sorghum value chain.

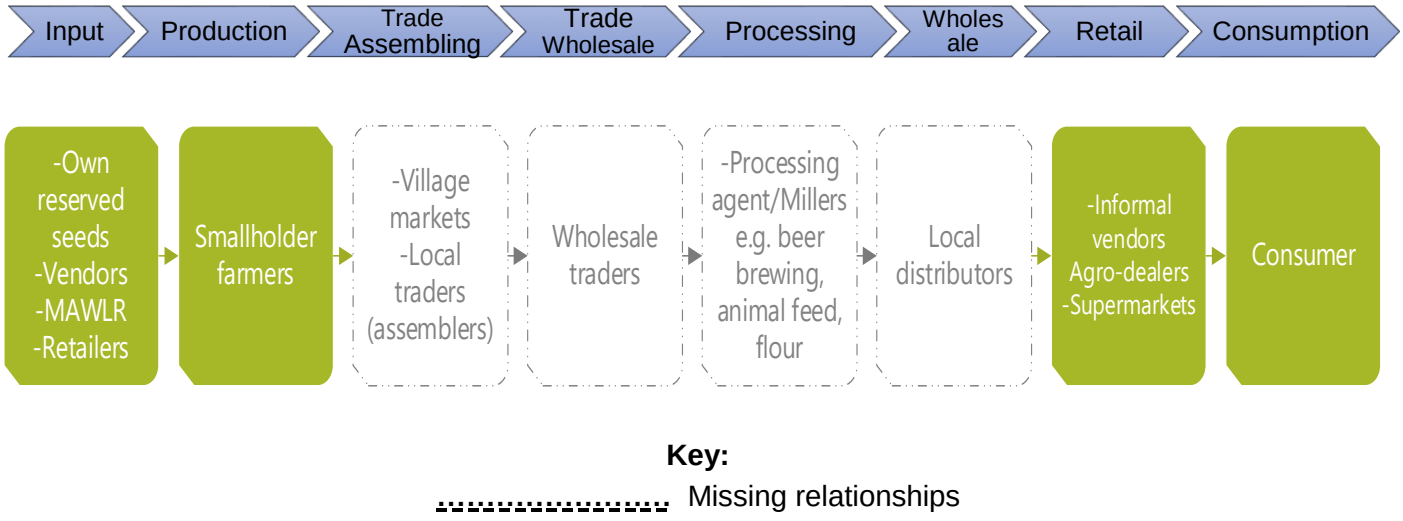


Figure 27: Sorghum value chain map in Namibia showing missing relationships and components (Musara et al., 2019) (Source: Survey data)

According to the study by Musara *et al.*, (2019), the agricultural commodity value chain with missing components affects the functionality of that value chain. Therefore, as per the study observation, the existing Namibian sorghum value chain requires several developments and relationship linkage to promote and establish a functional sorghum value chain in Namibia. Components such as village

markets, local traders, value addition and wholesale, assembling traders, and distributors should be developed and linked up with smallholder farmers in rural areas, markets, vendors, and consumers.

3.7.2. Seeds and inputs

Seed supply systems remain the central element to the success of any agricultural commodity value chain development (Almekinders & Louwaars, 2002; Musara *et al.*, 2019). Seed is a key input for improving agricultural productivity and ensuring food security. Seed security is a precursor to national food security as the availability of high-quality seed sets the limits to crop production and productivity. Therefore, providing farmers with quality seeds remains critical to ensuring national food security in the country (Dube & Mujaju, 2013).

Thus, the planting of high-yielding certified seed varieties from accredited sources has a valuable contribution to sorghum production in Namibia. However, according to the study results currently, the majority of sorghum grain producers in Namibia are planting traditional local varieties using their own reserved seeds from the previous harvests. Shortage of certified seeds at planting season is commonly experienced in sorghum producers in Namibia. The majority of sorghum producers are not aware of Namibia's Seed and Seed Varieties Act No. 23 of 2018, thus, awareness campaign programs are recommendable.

3.7.3. Production

In the absence of a well-established market that is accessible by local sorghum producers and limited marketing mechanisms, sorghum production in Namibia is currently limited to household use only, cultivated under rainfed farming in the reduced areas under cultivation. Red and macia sorghum and other local landraces are the most common sorghum varieties planted by local producers at an average seeding rate of 9.6kg/ha. Poor record keeping among other aspects was observed among other aspect and negatively affected the calculation of production cost estimates.

3.7.4. Storage

Improper on-farm storage facilities such as traditional storage methods which are commonly used for storing sorghum grains in Namibia might have negative implications on grains quality and storage period. According to Nyambo, (1993), grains stored in improved granaries suffer fewer insect attacks and less loss than in traditional granaries.

3.7.5. Value addition

A low level of value-added activities or processing of sorghum into finished products in Namibia was observed. Value addition is critical for the success of agricultural commodity value chain development (Musara *et al.*, 2019). World Bank report of 2006 indicated that many developing countries especially in

Africa lose income on agricultural commodities by not adding value or processing these agricultural commodities into finished products. Limited value-addition activities in the sorghum production system have deprived local producers of maximizing the full potential of the sorghum crops and promoted high importation of sorghum value-added products from neighbouring countries. Therefore, improvements in value addition are critically required as this act will carry significant benefits to sorghum producers and traders in Namibia.

3.7.6. Traders/processors

Traders displayed a high willingness to source local sorghum products and promote of organized farming system among local sorghum producers to ensure a consistent and quality supply of sorghum commodities as well as regulation of price within the sorghum value chain. Over 83% of sorghum traders are industry-affiliated with certain organizations or associations. The traders further indicated a willingness to enter into a supply agreement with local supply.

3.7.7. Marketing

The majority of sorghum producers are willing and prepared to produce and market sorghum and sorghum products in bulk, however lack of a formal market deprives these farmers of partaking in the formal main economy stream. Consequently, producers opt to produce and sell at informal markets and use it for household purposes only. Sometimes smallholder farmers store and sell sorghum back to farmers during peak planting season at high prices as seeds. This act promoted high importation of sorghum products, in addition, lack of value addition and competition against imports deprived local farmers of participating in the main formal economy stream. It was concluded that value-added commodities are better priced than un-processed, raw products.

3.7.8. Consumption

According to MAWLR, (2022), national sorghum consumption tonnage is mainly from imports, and local production tonnage is not matching demand, creating a constant annual deficit.

4. CONCLUSION

The commercialisation prospect of sorghum crops in Namibia is feasible. However, present study results reveal that there is inadequate and erratic supply or low availability of local sorghum and sorghum products in local and regional markets, most sorghum products in local markets are through imports. This might have continuously affected local sorghum producers from participation in formal production, processing, marketing, and consumption domains. This study indicated that the current sorghum value chain is underdeveloped, of which the value addition component is lacking. This study's results further illustrate that sorghum production is commonly popular in smallholder farming setups and the infrastructural inadequacies that characterise small-scale farming have reduced value extraction from the sorghum value chain at each nodal link in Namibia. Landrace sorghum varieties with low yield are the most used varieties in Namibia. The study found that there is a noticeable importation of sorghum products especially sorghum meal flour and beverage flour which can easily be replaced by local supply. The imported products are vividly seen in both formal and informal markets.

Although the sorghum value chain in Namibia faces various challenges such as the lack of an established formal market, poor regulation of prices and lack of storage facilities, and competition by imports, sorghum production possesses huge potential opportunities for local producers, traders, and consumers. Sorghum is a climate-resilient crop, well adapted to Namibia's agroecological zones. Sorghum crop offers sustainable food, feed, and fodder sources. Results show that currently, sorghum consumption demand is waning because of gaps in processing and poor linkages to markets which can easily be improved. The health benefits of sorghum such as the reduction of diabetes, cardiovascular, and celiac diseases are not properly exploited in Namibia.

Therefore, to increase sorghum consumption and full utilization in Namibia, processing interventions and the introduction of improved seed varieties with high yield potentials are recommendable. Sorghum consumption health benefits awareness is required in Namibia. Developing products, diversifying technologies, and standardized processing machines at the farm level will be of significant benefit to the sorghum sector in Namibia. However, the successful realisations of this study's outcomes will solely rely on stakeholders as well as the value chain actors' willingness to partake in the establishment of a functional sorghum value chain in Namibia.

5. RECOMMENDATIONS

The study gives the following recommendations based on the findings:

- ✓ Namibian Agronomic Board should facilitate the national identification and consequent registration of all sorghum producers, traders/processors, and input suppliers nationwide, and related production and marketing data should be collected to establish accurate baseline information for necessary socio-economic development purposes.
- ✓ Ministry of Agriculture, Water and Land Reform through extension officers with other relevant stakeholders such as the Namibian Agronomic Board, Producers Association, and Regional Agronomy Association should promote sorghum production and consumer awareness to ensure consistent supply and a sustainable market chain.
- ✓ Namibian Agronomic Board should facilitate the creation of a conducive enabling business environment for the sorghum sector which promotes both horizontal and vertical linkage among value chain actors and promotion of organised group and contract farming and coordination among sorghum producers, processors, and traders.
- ✓ Namibian government and policymakers with other relevant stakeholders both public and private sectors should create an effective and adequate infrastructure at all farming system setups to increase value extraction from the sorghum value chain at each stage.
- ✓ Value addition, price regulation, and market protection by the government against imports are critically required in sorghum production and marketing in Namibia.
- ✓ Northern Namibia Farmers Seed Growers Cooperative and other seed cooperatives and the Ministry of Agriculture, Water and Land Reform through the Directorate of Agriculture Research and Development, should introduce and promote the utilisation of improved high-yielding sorghum varieties of significant benefit to sorghum producers and seed growers in Namibia.
- ✓ All stakeholders and farmers' associations should encourage contractual supply agreements between farmers and traders and a consistent supply of sorghum products to create sustainable and profitable sorghum farming in Namibia.

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