Economics of Sorghum Production, Consumption and Trade in Sudan

Elgilany A. Ahmed[1], Fatima Rahma Mohammed[2]

ABSTRACT

This paper focuses on a set of high-potential of sorghum commodity in Sudan. Sorghum is considered as one of the most important calorie source in the Sudanese diet, future key source of sustainable farming systems and the national economy of Sudan. The paper analyzes sorghum by evaluating its production, consumption and trade trends for a 10-years period (term) for the last three decades (1990 to 2021), and indicates the projections for production, consumption and demand up to 2030. The paper depended mainly on secondary data collected from relevant sources such as the annual statistics of the Central Ministries of Agriculture and Forests for various years. The findings have illustrated that the production of sorghum shows a high annual growth rate during the first (1990s) and the third terms (2010s) in the rain-fed sector. It is clear that, total sorghum consumption in the Sudan rose at an average annual rate lower than the production rate for the whole period of the study. Sorghum is mainly grown for local consumption by small scale holders (60% of quantity produced) in main producing areas, particularly in traditional rain-fed farming, in semi-mechanized and in irrigated agriculture. The overall trend of the most exports during 1990 -2020 is fluctuated The period 2000s was the period of oil export from Sudan which was the major source of foreign currency to the government neglecting traditional agricultural exports and the impact was deterioration on agricultural export quantities.

Keywords: Sorghum, Economics, Production, Consumption, Trade, Sudan

Introduction

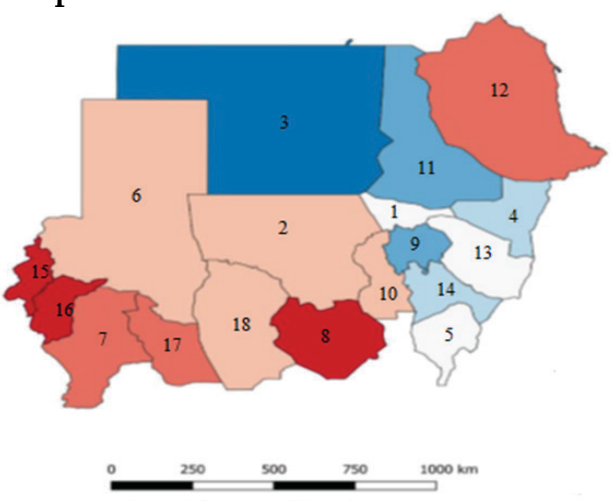
The Republic of Sudan is the third largest country in Africa, covering an area of approximately 1,886,068 km^2 and divided administratively into 18 states (Figure 1). Sudan had a population of 41.8 million inhabitants in 2018, according to the Central Bureau of Statistics of Sudan, and its economy revolves mainly around traditional agriculture and livestock

1. Director, Agricultural Economics and Policy Research Center
Agricultural Research Corporation of Sudan (ARC), Sudan
2. Central Ministries of Agriculture and Forests, Sudan

Corresponding author: elgilanya@yahoo.com
Article Received Date: 13.01.2025 Article Accepted Date: 09.04.2025

husbandry. Sudan has been included in the UN list of Least Developed Countries (LDC) since 1971. In Sudan, agriculture sector is the foundation of livelihoods for the majority of the rural population and considered as an essential pillar for rural development and for many Small and Medium Enterprises (SMEs), because of its importance for food security and household welfare and as a source of export earnings. The agriculture sector is expected to regain its role as a key source of foreign exchange. The loss of oil revenues in 2011 after the separation of South Sudan has been followed by resurgence in agriculture's share in the country's exports, reaching 55% in 2019 as reported by the United Nations International Trade Statistics Database, and helping cushion some of the impact of the loss of oil revenues. This improvement has been mainly led by the good performance of major agricultural export commodities like livestock, sesame, gum Arabic, and cotton. For at least three of Sudan's key exports sheep, goats, and gum Arabic—the ability to export in processed forms presents significant upside potential. Overall, the agricultural trade balance remains negative due to the high food import bill, which mainly goes for imports of wheat and wheat flour, sugar, and oils (World Bank 2015). Compares the performance over the agricultural and the oil eras, as seen, the average value added share of industry has increased by 8.9 percentage points. Humid agro climatic zones are shifting southward, rendering vast arable lands increasingly unsuitable for agriculture production.

Figure 1: Map of Sudan with 18 Administrative States



Source: Adapted from World Bank 2019

1 Khartoum	5 Blue Nile	9 Al Jazirah	13 Al Qadarif	17 East Darfur
2 North Kordofan	6 North Darfur	10 White Nile	14 Sennar	18 West Kordofan
3 Northern State	7 South Darfur	11 River Nile	15 West Darfur	
4 Kassala	8 South Kordofan	12 Red Sea	16 Central Darfur	

Agriculture is the mainstay of the economy of the Sudan. It contributes about 40 % of GDP and 80 % of the total exports, excluding oil. It provides employment and livelihood to about 65 % of the labor force and their families, as well as it plays a major role in the protection of the environment. The natural vegetative cover helps in inducement of rainfall, absorption of carbon dioxide and release of oxygen. While the rural sector is at a disadvantage compared with the rest of the country, food insecurity-related disparities exist among regions and farming systems. Historically, modern irrigated and the semi-mechanized sectors received more developmental assistance than the traditional rain-fed sector. Infrastructure, public finance, research and social services have been highly in favour of these two sectors. Growth rates of the rain-fed traditional sector and its livestock are by far outweighed by those of the irrigated and semi-mechanized sectors. This is in spite of the reasonable GDP share of the rain-fed traditional sector and the magnificent share of the livestock sector.

While irrigated crops invariably enjoyed rising yield trends, however small they are, trends for traditional rain-fed crops were all negative. Furthermore, variability was notably higher under rain-fed conditions than under irrigation one, subjecting producers in the former system to high risks of crop failure and higher livelihood vulnerability. Notable also is the steeper trend decline in mechanized rain-fed than traditional rain-fed production of both sorghum and sesame, which are produced under both systems. This is highly likely a sign of deterioration of soil productive capacity due to mono-cropping in the absence of conducive policies.

The farming systems of the agricultural sector in Sudan, could be categorized mainly in three farming systems, namely the irrigated farming such as in Central and North regions, traditional rain-fed farming like in Kordofan region and the semi-mechanized rain-fed farming similar to that in Gedarif district. The areas of the rain-fed farming systems have endowed huge sizes of land resources, but they different in their socio-economic and agricultural characteristics. Although the central region applies gravity irrigation farming systems but also the rain-fed one is existed in some areas. The irrigation sub-sector in this region is considered as the prevalent one and it enjoys gravity irrigation system from Sinnar Dam at south of the region. The Gezira state may represent to central region; it has vastly greater human population, somewhat greater per capita income and cultural diversity, and far less farmland than Gadarif. Average farm size is largest in Gadarif state, followed by Gezira, and smaller in Kurdufan of west region. Sorghum (Sorghum bicolor L.) is intensively produced in rain-fed areas of the Sudan in large schemes and in small farms as well. The small-scale farmers whom their farms are scattered nearby villages usually practice sorghum

production for subsistence. Farmers usually start to cultivate their fields when about 100 mm or more of rainfall occurs. They use the conventional machine, the wide level disk (WLD) plow with seeder box, for seedbed preparation and seeding operations. Delayed sowing date and the use of local varieties are common practices. The result of that is low average yield, misuse of resources and economic loss. There is, however, a potential and opportunities to improve the sorghum yield in rain-fed areas through adopt and use of the recommended technical packages and implementation of intelligent economic policies. Many efforts were made by the governmental institutions, NGOs and private sector to change the crop system in rain-fed areas. Sorghum is the world's fifth most important cereal after wheat, rice, maize, and barley in both production and area planted (FAO/ICRISAT, 1996).

Sorghum is one of the main staples for the world's poorest and most food-insecure people (Henry and Kettlewell, 1996).It is a staple food crop for many millions of people in the arid and semi-arid areas of East and Central Africa (ECA). The crop is generally suited to hot and dry areas where it is difficult to grow other food grains. These are also areas subject to frequent drought. In many of these areas, sorghum is truly a dual-purpose crop; both grain and Stover are highly valued outputs. In large parts of the developing world, Stover represents up to 50 percent of the total value of the crop, especially in drought years. Developing countries account for roughly 90 percent of the world's sorghum area and 70 percent of total output (FAO/ICRISAT, 1996). Asia and Africa each account for about 25 to 30 percent of global production. Nigeria and Sudan are the major producers in Africa. Production in Africa remains characterized by low productivity and extensive, low-input cultivation. Generally, sorghum is grown primarily for food in the developing countries and in the developed countries almost all sorghum production is used as animal feed.

Methodology

- **Data collection and analysis**

This paper depends mainly on secondary data from different relevant sources. The secondary data relating to growth performance of sorghum crop is collected from annual reports of the General Directorate of Planning and Agricultural Economics, Department of Agricultural Statistics and Food Security Technical Secretariat (FSTS). To analyze the data collected descriptive statistical analysis was applied, while for examining the growth trends of sorghum commodity statistical tools like Compound Annual Growth Rate (CAGR) and Simple Annual Growth Rate (SAGR) are used. When plotting data in a graph, you may often want to visualize the general trend in your data. This can be done by adding a trend-line to a chart. A trend-line, also referred to as a line of best fit, is a straight

or curved line in a chart that shows the general pattern or overall direction of the data. This analytical tool is most often used to show data movements over a period of time or correlation between two variables. The study applied the Excel power trend-line equation, computing R2 (the nearer R2 is to 1, the better the trend line fits the data) and the formulas as mentioned follow.

- **Power trend-line equation and formulas**

A power trend-line in Excel is drawn based on this simple equation:

$$y = ax^b$$

Where:

a and b are constants, which can be calculated with these formulas:

a = EXP (INDEX (LINEST (LN (y), LN (x)), 1, 2))

b = INDEX (LINEST (LN (y), LN (x)), 1)

The time series data which is used in this paper analysis is sorghum crop analysis used the Central Ministry of Agriculture reports.

Results and discussion

Agriculture in sub-Saharan Africa suffers from low productivity growth as evidenced by the agricultural Total Factor Productivity (TFP) growth in the region which is lagging behind some countries in the regions because of the performance of new technologies of production is not significantly different from that of old technologies; and the sorghum growers are less efficient in using available technology of production due to weak dissemination and advisory systems coupled with low adoption rates. In Sudan, traditional subsistence agriculture dominates the Sudanese economy with over 70% of the population dependent on crop production and/or livestock husbandry to support their livelihoods. Combined with growing socioeconomic pressures, impacts from climate variability and climate change is intensifying the ongoing process of desertification of arable areas, according to the Intended Nationally Determined Contributions(INDC) (UNFCCC, 2015) .

- **Sorghum Production and development in Sudan**

In Sudan, the productivity of this important crop still remains very low. In recent years, sorghum production has generally expanded mainly due to increase in crop area. However, yield per unit area has failed to increase or even declined because of biotic and abiotic factors. Sorghum in Sudan is considered as the main staple food crop and its uses as food are diverse. Sorghum flour is mainly used to make pancake (kisra), unleavened thick bread, porridge, or gruel. The sorghum plant is also a good feedstock to a number of different

types of animals. It can be chopped for silage or fed directly to livestock. The sorghum grain can also be used as animal feed; the stalk is often used as hay. Sorghum is essentially a crop of the tropics and sub-tropics. It is adapted to high summer temperatures, particularly where soil moisture is adequate. The crop thrives well in the temperature range of 16° to 40° C, though its performance is optimized at a mean temperature of 27° C. It is suited to low or moderate rainfall; sorghum water requirements set the 500 mm-annual isohyet as its northern growing limit (Republic of Sudan, 2003). Over the last few years, sorghum crop attracted a lot of interest for its major role in food security, bio-fuels, feed and other manufactured products. Sudan is the largest producer of sorghum (Sorghum bicolor) in the Arab world, producing about 4.9 million tons in 2018, which is more than 70 percent of sorghum production in Arab world while long term average sorghum production in Sudan showed an average of 3.8 million metric tons over the period 2009/2010 -2018/2019, the main States of sorghum production in the country are Gedaref, Gezira and North Kordofan, they contributed in season 2018/2019 by almost 993 thousand metric tons; 295 thousand and 109 thousand metric tons respectively. This is equivalent to almost 37 percent of the average stable production of sorghum in the country.

The drastic fluctuations in sorghum production and yield threaten food security situation, increase wheat imports in the absence of strategic buffer stocks and increased sorghum losses. However, sorghum production is extremely erratic with variable fluctuations for many climatic, and managerial and financial factors. For instance, average sorghum production over the period 2009-2018 accounted for 3.82 million MT, about 6% of the world production while in season 2016 /2017 production of sorghum accounted for 6.44 million metric tons, far above average by almost 70 percent (CBoS, 2017). Therefore, the potential for sorghum to be the main driver of economic development in Sudan is enormous and there is a clear reason to continue unleashing sorghum's potential capacity in the country to be the cornerstone of food security and other uses as well. Among cereals in Sudan, sorghum comprises almost 77% of cereals' production while pearl millet and wheat share 15% and 8% of total cereals respectively. Most of the sorghum is produced in the semi-mechanized farming system (49%) and traditional rain-fed agriculture (30%) while irrigated agriculture contributes only by 21% (see Table 1).

Table 1: Summary of area, production and yield of Sorghum by farming system (199- 2021)

Crop	Farming system	Area Planted (000 ha)	Harvested (000 ha)	Production (000 MT)	Yield MT/ ha
Sorghum	Irrigated	1014	926	742	0.801
	Rain-fed (Traditional & Semi mechanized)	17201	13530	2922	0.216
Total sorghum			**18215**	**14456**	**3664**

Source: Central Ministry of Agriculture, 2021

However, sorghum productivity is substantially lower than any neighboring countries mainly attributable to low use of technology inputs. Though growth rate for production is above the population growth rate still there are hard droughts times that reduce production substantially since yields are still at low pace. Sorghum is mainly grown for local consumption by small scale holders (60% of quantity produced) in the main producing areas, particularly in traditional rain-fed farming, semi-mechanized and irrigated agriculture. In figure terms, the total sum of sorghum industry in Sudan is close to one billion USD other than the related activities. For the majority, it is considered as a main source of livelihoods and generates income for producers, traders and processors as well as a source of nutritional diet and caloric value for consumers. In the Sorghum supply chain, it worth to note that, about 60% of the small holders' total produce was mastered by male farmers, while female farmers contribute by 40% of this total product. However, the crop produced represents a small amount (only 10%) to the male small holders' total income. This may be due to the argument that most of the product used to cover the cost of production, a considerable portion for family consumption and small proportion is marketed. However, small holder's female farmers usually consider the marketing process as the responsibility of the male household for they look to the farm as a whole family asset, even if the farm is her own.

Average cultivated area of sorghum: This paper revealed the area cultivated under sorghum crop, in Sudan as presented in Table (2). The required data regarding trends of the sorghum planted area in Sudan from 1990/91to 2020/21 were collected from relevant sources. The total average planted area of sorghum was found as 16,009 thousand feddan during 1990/91 to 1999/00, only 6.6% of it under irrigation sector and the rest under rain-fed. The total average cultivated area decreased to 15,469 during 2000/01 to 2009/10 but with increase in irrigated sector up to 1,088 thousand feddan, with significant jump during 2010/11 to

2020/21 up to 22,717 thousand feddans but with slight decrease in irrigated sector to 971thousand feddans and overall period of 18,215 thousand feddans, 5.6% under irrigated sector.

Annual growth rate of sorghum cultivated area: As shown in Table (2) the annual growth rate during the first term was found as 1.6%, with significant annual growth in rain-fed sector of about 4.9% during the same term, and a negative annual growth rate of -2.1% in the irrigated sector. The second term witnessed a decrease in the cultivated area, and a negative growth rate of -1.5% was observed and a negative growth rate for irrigated sector of -5.3, while in the third term the annual growth rate improved to 1% with overall period 1.7%. The total average planted area of sorghum has shown a mixed trend with an average annual growth rate of 1.6% during the first term, -1.5% during the second term and 1% during the third term.

Average harvested area: The paper also unveiled the size of area harvested under sorghum in Sudan as presented in Table (2). The total average harvested area of sorghum was about 12,482 thousand feddan during the period 1990/91 to 1999/00, and only 7.7% of the total harvested area was under irrigation sector, while the rest of the harvested area was under rain-fed. The total average harvested area has increased to 13,661 during 2000/01 to 2009/10 but with decrease in irrigated sector to 934 thousand feddan, with significant jump during 2010/2011 to 2020/2021 up to 16,975 thousand feddans but with decrease in the irrigated sector to 885 thousand feddans with average total harvested area for the overall the period was about 14,456 thousand feddans.

Annual growth rate of sorghum harvested area: The study also evaluates the annual growth rate during the first term, it was found as 4% as shown in Table (2), with significant annual growth in rain-fed sector of about 4.9% during the same term and a negative annual growth rate of -4% in irrigated sector. The second term witnessed a growth rate of 2% for the average total harvested area and a negative growth rate for irrigated sector of -6.8, while in the third term the annual growth rate observed as 1.3 % with overall growth of about 1.7%. The total average harvested area of sorghum has shown a positive trend with a decreasing rate, with an average annual growth rate of 4% during the first term. The study emphasizes on the growth performance of sorghum production in Sudan.

Table (2): Sorghum Production under Different Farming Systems of Sudan (1990 - 2021)

Items	First term (1990-2000)	Second term (2000 - 2010)	Third term (2010-021)	Whole period (1990 - 2021)
a. Average cultivated area	1055	1088	971	1014
- Irrigated (000 fedd)	14954	1088	21746	17201
- Rain-fed (000 fedd)	16009	15469	22717	18215
Total (000fedd)				
b. Annual growth rate of sorghum cultiv. area	-2.1	-5.3	-2.7	-0.7
- Irrigated Sorghum	4.9	2.7	-2.7	1.9
- Rain-fed Sorghum	1.6	-1.5	1	1.7
Total Sorghum				
c. Average harvested area	963	934	885	926
- Irrigated (000 fedd)	11518	12727	16090	13530
- Rain-fed (000 fedd)	12482	13661	1697	14456
Total (000 fedd)				
d. Annual growth rate of sorghum harve. area	-4	-6.8	-2.8	-0.8
- Irrigated Sorghum	4.9	2.7	1.6	1.9
- Rain-fed Sorghum	4	2	1.3	1.7
Total Sorghum				
e. Average production	668	813	745	742
- Irrigated (000 ton)	2408	2776	3523	2922
- Rain-fed (000 ton)	**3076**	**3588**	**4268**	**3664**
Total (000 ton)				
f. Annual growth rate of sorghum production	-1.5	-7.6	-2.3	0.1
- Irrigated Sorghum	6.4	3.1	6.9	2.2
- Rain-fed Sorghum	**4.2**	**1**	**4.8**	**1.8**
Total Sorghum				
g. Average yield	694	870	842	801
- Irrigated (kg/fed)	209	218	219	216
- Rain-fed (kg/fed)	**246**	**263**	**251**	**253**
Total (kg/fed)				
h. Annual growth rate of sorghum yield	2.6	-0.9	0.5	0.9
- Irrigated Sorghum	1.5	-0.9	5.3	0.3
- Rain-fed Sorghum	**0.1**	**-0.9**	**3.4**	**0.1**
Total Sorghum				

Source: Central Ministry of Agriculture, 2021

Average production of sorghum: Table (2) presented the average production of sorghum by term and type of irrigation. The average total production of sorghum was 3,076 thousand metric tons during the first term which increased up to 3,588 thousand metric tons during the second term with significant increase up to 4,268 thousand metric tons during the third term, with overall average production during the whole period as 3,664 thousand metric tons. The total sorghum production and rain-fed production has shown a positive trend and a mixed trend in irrigated sector.

Annual growth rate of sorghum production: The paper aimed to illustrate the annual growth rate of sorghum production for the whole period as 1.8% with highest growth rate during the third term as 4.8%, followed by the first term of 4.2 % and 1% for the second term. The growth rate was observed to be negative during the three terms as shown in Table (2). The study also observed that the production of sorghum showed a higher annual growth rate of 1.8% than the cultivated and harvested areas respectively. This mostly means that the production of sorghum increased in the country due to utilization of improved technologies by sorghum growers rather than the increase in the cultivated areas of the crop. The paper revealed further results regarding sorghum yield as shown in Table (2).

Average yield of sorghum: The total average yield per feddan of sorghum was 246 kg in the first term which increased up to 263 kg in the second term but decreased to 251 kg in the third term with average of 253 kg for the whole period. The increase of yield in the rain-fed sector is positive during the three terms but with slight increase with exceptional to the increase between the first and second term.

Annual growth rate of sorghum yield: The study also found that the annual growth rate of sorghum yield was 0.1% for whole period of the study with the highest growth rate during the third period (3.4%) and a negative growth rate during the second term (-0.9%). The study shows a mix trend of growth rate in all sectors as shown in Table (2).

Sorghum consumption in Sudan: Home consumers, commercial poultry and dairy farms: sorghum is a staple crop in Sudan and especially in the eastern part of the country. However, consumption habits are changing with growing preference for wheat particularly around urban centers. This is clear through the increasing level of wheat and wheat flour imports in recent years (OEC, 2017). Commercial and large poultry and dairy farms purchase processed feed containing sorghum from feed mills either directly or through proxy distributors which supply these farms with other inputs.

Table (3) Sorghum production and consumption in Sudan in 000 tons (1990/91 – 2019/20)

Term*	Average Production (000 tons)	Average Consumption (000 tons)	Marketable Surplus (000 tons)	Import gap (000 tons)
First term 1990 - 1999	5560	4, 104		0.0
Second term 2000 - 2009	5936	3,355		0.0
Third term 2010 - 2019	6994	4,357		0.0

** Term= a 10-years period*

Source: Ministry of Agriculture and Forestry and ICRISAT

Small poultry and dairy farms access sorghum through local market aggregators that also seem to advise them on appropriate feed mixes. Sorghum is mainly grown for local consumption by small scale holders (60% of quantity produced) in main producing areas, particularly in traditional rain-fed farming, semi-mechanized and irrigated agriculture. There has been a notable increase during the period (1990 - 2020) as shown in Table (5). The domestic consumption of sorghum is also grown and it is clear there is no import gab. as depicted in the table.

Sorghum Trade

In Sudan Sorghum is produced in different types of farming systems namely, irrigated and rain-fed. The large amount of the crop is produced at rain-fed semi-mechanized areas in Gedarif, Blue Nile and South Kordofan States while the irrigated farming system of Gezira scheme is ranked as a second largest area of production. The rain-fed traditional system comes after irrigated sector.

The exported quantities of sorghum depend mainly on favorable climatic factors that contribute to the success of the season. Sorghum is considered as an important crop for food security for both human consumption and animal feed, and because it is strategic crop its export quantities vary depending on production quantities and consumption requirement, for example in 1997, 2009 and 2016 there was no export of sorghum due to food security policies which is prevent or restrict export of sorghum during seasons of low production.

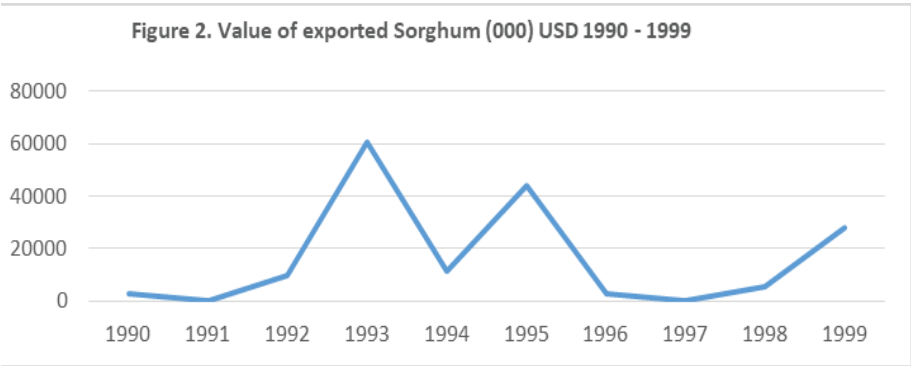


Figure 2. Value of exported Sorghum (000) USD during 1990 - 1999

The trend of annual exported quantities and the value from export of sorghum during the period of 1990 – 2020 was fluctuating as illustrated in figure (5). The average growth rate of the exported value of sorghum during the period 1990 – 1999 formed a positive rate of 28 %. Figure (2) depicts the trend of the export value of the crop during this period, while the average growth rate during the period 2000- 2009 showed a positive rate of 21 %.

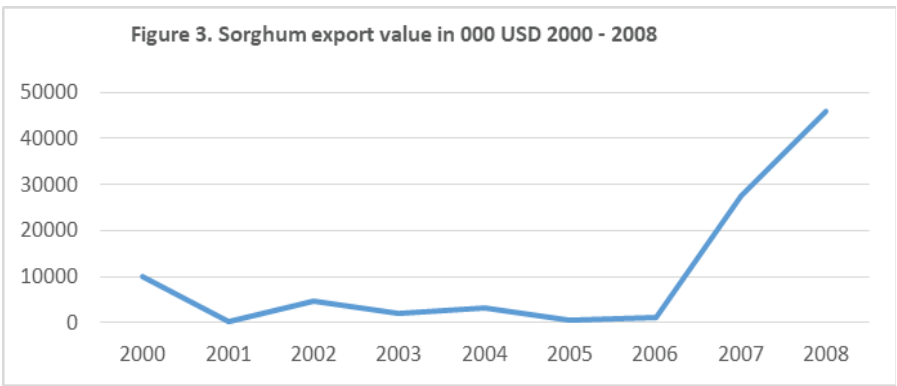


Figure 3. Value of exported Sorghum (000) USD during 2000-2008

Sorghum exports during the following 10 years, 2010 – 2020, showed a declining trend as in figure (4). The average growth rate of exported value declined from 28% during 1990 – 1999 to 21 % during the periods 2000 – 2008 and declined to 0.6 % only during the last 10 years 2010 – 2020. The overall average growth rate of the period 1990 – 2020 was positive (4.7 %). Figure (5) shows the change in values of exported quantities during the period 1990 – 2020 in thousand USD.

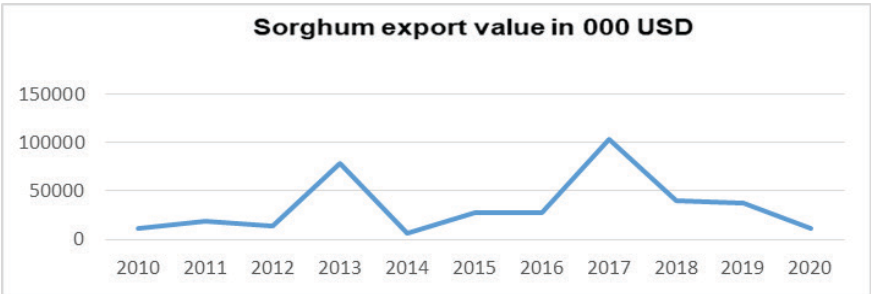


Figure 4. Value of Sorghum exported during 2010 – 2020

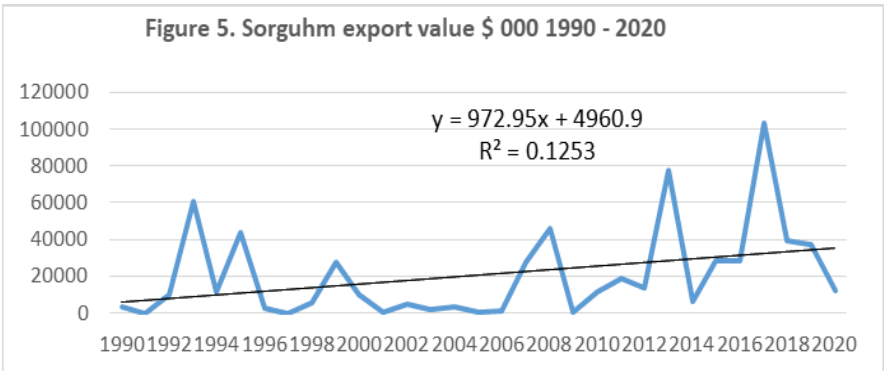


Figure 5. Value of Exported Sorghum during 1990 – 2020

The annual change in export value of the crop fluctuated between positive and negative rates. Figure (5) shows the linear trend of export values during the period 1990 – 2020, while figure (6) shows the change in the annual growth rate of the value.

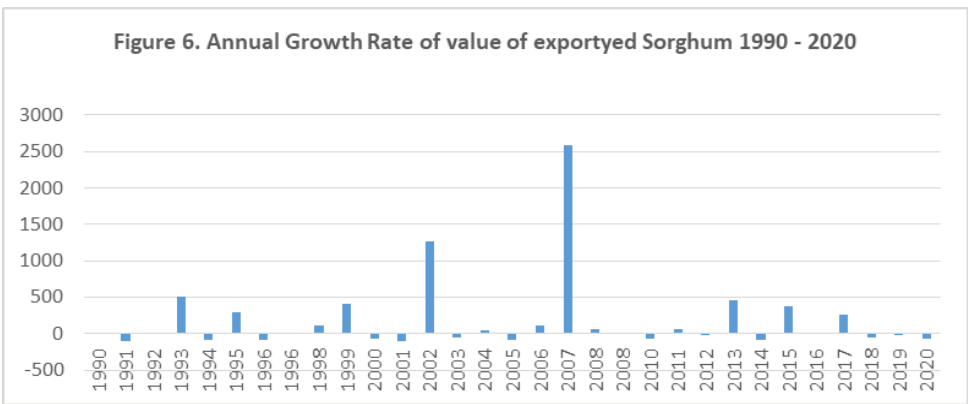


Figure 6. Annual Growth Rate of Value of exported Sorghum 1990 – 2020

Conclusion and Policy Implications

Agriculture is the backbone of Sudan's economy and is crucial for food security and poverty alleviation. Although between 1960 and 2020 agriculture ranked second to services in terms of contribution to the gross domestic product (GDP) each adding, respectively 35.2% and 48.7%. Recently, it generates 47.4% of employment with 69% of the own-account businesses operating in the sector (HBS, 2015). Agriculture in Sudan is enjoying three broad crop production systems namely, irrigated, mechanized rain-fed and traditional rain-fed farming systems, this beside the natural pastoral system. The rain-fed sector comprises both traditional rain-fed and mechanized rain-fed subsectors, and is considered as the most promising sector for the agricultural development in Sudan. The sorghum subsector is predominated by small and subsistence farmers (78%). Historically, the sorghum subsector faces numerous of challenges including: scarcity of improved seeds and dissemination of pest and diseases, leading to low crop yield. Furthermore, the sector is constrained by climate change volatility, population pressure; inadequate land tenure system and land fragmentation; lack of public investment, poor market infrastructure; and high poverty incidence. Therefore, the principal policy implications that needed to improve the sorghum subsector in Sudan are:

I. Adoption of advanced technologies including seed technologies to improve sorghum productivity and the existing seed systems in Sudan. This may contribute directly to poverty reduction, malnutrition and food safety, and farm sustainability.

II. Design of comprehensive sorghum research programs to manage climate change volatility.

III. Capacity building for labor in sorghum subsector. This will increase the availability and access to skilled manpower across the sorghum value chains.

IV. The pattern of sorghum consumption over the last three decades (1990 - 2020) has shown a clear trend: the increases demand of sorghum.

V. Management of sorghum farm transformation is needed to shift towards innovative and commercial farming systems to make the crop more attractive and to attain farm sustainability.

VI. Design a suitable strategy for sorghum bio-fortified development in Sudan

VII. Establish stakeholders network for sorghum bio-fortified products including social, nutrition, and public institutions.

VIII. Introduction of successful stories and experiences on of sorghum bio-fortified products and their nutrient bioavailability commercialization and trade.

References

CBoS, 2017. Central Bank of Sudan's Annual Report (No. 57). Central Bank of Sudan, Khartoum, Sudan.

Facts, Trends and Outlook. FAO and ICRISAT. Rome.

Food and Agriculture Organization (FAO) and International Crop Research Institute for the Semi-Arid Tropics (ICRISAT) (1996). The World Sorghum and Millet Economies

HBS. Households Budget Survey (2015). Sudan Poverty and Households Budget Survey 2014/2015.

Henry R. J. and Kettlewell, P. S. (1996). Cereal Grain Quality. London: Chapman & Hall.

World Bank (2015). Sudan Agriculture Value Chain Analysis. A Report Prepared by WBG in June 2020.