Agricultural Production Systems in Sudan

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Abstract

Agriculture is one of the strategic elements of any developed or developing country. It's fundamentally related to political and social stability. Sudan is characterized as an agricultural country that has all the extended factors of that. Agriculture and cultivating-related activities are carried out in many different patterns which are adopted and practiced in Sudan. Agricultural production in Sudan is generally practiced through three systems: small-scale farming using a traditional rain-fed system, mechanized rain-fed systems, and irrigated farming systems. Each system produces specific crops and is located in appropriate regions with varying levels of mechanization in the production areas. Manually carried tools and animal power dominate in the traditional rain-fed system. Mechanical energy and sophisticated tools are commonly used in irrigated and mechanized rain-fed systems. Different crops are grown in Sudan regarding of farming system. Here we are presenting the common agricultural practices systems in Sudan, which help those who are unfamiliar and/or interested in this country to get closer by knowing the cropping systems in Sudan.

1. Introduction

Geographically, Sudan is a large country lying within the Sudano-Sahel region of northeast Africa between latitudes 10° and 23° N, and longitudes 21° 45′ and 38° 30′ E, and is located in the middle part of the Nile Basin. It covers an area of about 1.9 million km^2, and most of the country consists of vast arid plains broken by a few widely spaced ranges of hills and mountains. The country borders are South Sudan, Ethiopia, Eritrea, Egypt, Libya, Chad, the Central African Republic, and Saudi Arabia across the Red Sea. The country's population has been estimated at approximately 43 million, with an annual population's growth rate of 2.9 % (Central Bank of Sudan, 2017; Osman & Ali, 2021)

The economy of Sudan is based on agriculture, which contributes about one-third of Gross Domestic Product (GDP). Sudanese agriculture has different cropping and livestock production systems. Agriculture supplies the growing population with food, creates employment opportunities, and supplies the industry with raw materials. Sudan considered one of the three countries in the world that can contribute to international food security if it manages their resources wisely. Sudan is divided into five different ecological zones: desert, semi-desert, forest savannah, floodplain, and mountainous vegetation. About 72 % of the land in Sudan is semi-desert. It has been reported that agriculture supports the national economy; it estimated about 90.7 million ha are suitable for cultivation, but only 23.5 million ha are in use (FAO, 2022). Sudan's economy heavily depends on the agricultural sector, with almost 65 % of the population engaged in agriculture, which makes it the main supplier of raw materials for industry. The agricultural sector, including forestry, livestock, and fisheries, accounted for 20 percent of the GDP in 2020. In addition, Sudan raises livestock, with an estimated total livestock population in 2021 of about 111 million head of cattle, sheep, goats, and camels, mainly depending on natural grazing land for fodder and hafirs*****, rivers, seasonal streams, and wells for watering (FAO, 2022). The Sudan embed with the Great Nubian Sandstone, which is part of the largest source of freshwater on Earth, the Umm Ruwaba, and many aquifers, as well as the Nile River Basin, which is providing about

80–85 % of the water used in Sudan (Lee and Chula Vista, n. d.).

Agricultural production in Sudan is mainly practiced through three systems: traditional rain-fed system, mechanized rain-fed system, and irrigated farming system, each

producing specific crops and utilized different levels of mechanization (Abdalla & Abdel Nur, 2001). Hand tools and animal power dominate in the traditional rain-fed system (Siddig et al., 2011). An improved animal-drawn plow seeder is introduced into this system. Mechanical power and advanced technologies are commonly used in irrigated and mechanized rain-fed systems. Somehow, the country utilizes significant wind and solar energy to some extent, especially in rural areas, solving the problems of unavailability of electricity and petroleum supply for irrigation pumps and other agricultural activities. Agricultural mechanization in Sudan faces numerous technical problems that can be solved by providing training programs for machine operators and mechanics, and improved management system. Here the aim of this paper is introducing the common cultivation systems in Sudan, and its constraints.

2. Crop Production Systems

In Sudan is practiced according to the following patterns**:**

1. Irrigated agriculture, which includes major national irrigation schemes (Gezira, Suki, New Halfa, and Rahad) using water from the Nile and its tributaries,
   - Large flood irrigation systems (Gash and Tokar) using seasonal flooding.
   - Small irrigation along the banks of the Nile and its tributaries.
2. Mechanized rain-fed agriculture.
3. Traditional rain-fed agriculture.

2.1. Irrigated agricultural system

Irrigated agriculture plays a significant role in expanding agricultural mechanization and production. It considers the most effective production system regard of using agricultural inputs and crop productivity. In this sector, the major mechanized operations are land preparation, planting, spraying, and fertilizer application. Weeding and harvesting are still somehow carried out manually (Awadalla et al., 2019). This system covers approximately 1.9 million ha, irrigated primarily by the Nile and its tributaries; this system includes the largest irrigation schemes in the country (Gezira, New Halfa, and Rahad), in addition to sugar cane schemes. Major crops grown under irrigation systems include cotton, sugarcane, sorghum, groundnut, wheat, legumes, fruits, vegetables, and irrigated forage crops. The sub-sector contributes 100 % of the wheat and sugar, about 99 % of the cotton, 52 % of the groundnut, and 25 % of the sorghum. On average, the irrigated sub-sector accounts for about 64 % of the total crop contribution to GDP (Abdalla & Abdel Nur, 2001). Although its contribution to crop production is less than that of the rain-fed sub-sector, it is more stable. In drought years, it plays an important role to meet consumption needs of the population (Mohamed, 2011). Including large-scale mechanized federal schemes, approximately 1.9 million ha are accounted for, including the Gezira scheme, which at approximately 1 million ha is one of the largest irrigation schemes in the world that is irrigating by surface system with the land slopes. The irrigation sector is the main user of imported agricultural inputs as yields and therefore production are more reliable (Figure. 1). Irrigation water is mainly obtained from the Nile and its tributaries by gravity or pumping. All agricultural activities in this sector are carried out with machines (FAO, 2022). The production

system of this sector consists of main channels leading from the Nile towards the northern part flooding the water by gravity. The irrigation system in this farming system is completely carried out by gravity (surface irrigation system). The system is supplied with irrigation water from the Sennar and Roseires dams on the Blue Nile. Annual water flow from the Blue Nile is estimated to average about 50 billion cubic meters, measured at Roseires. However, this stream is characterized by strong annual and seasonal fluctuations. From the end of June it rises steeply to a peak at the end of August. Water storage in the reservoirs of the Sennar and Roseires dams begins in early September, after the flood period. Irrigation water is channeled to the scheme areas through a network of channels covering the entire area. The network consists of thousands of kilometers of main channels passing through the scheme (Plusquellec, 1990).

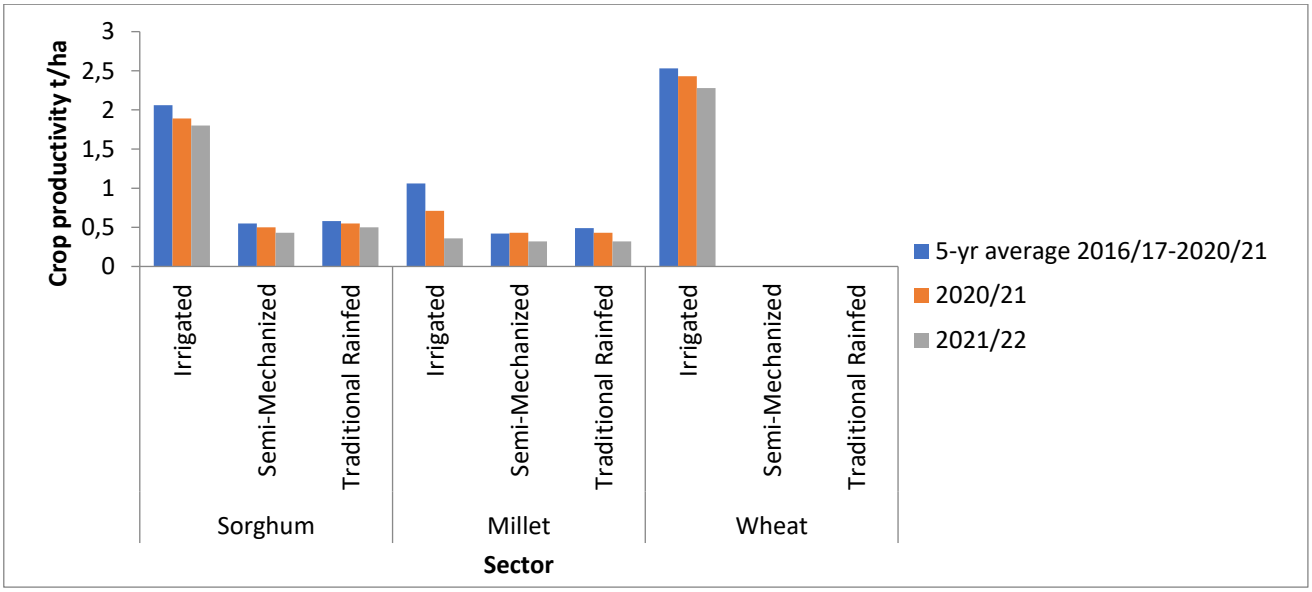

Figure 1: Some cereal productivity under different sectors (t/ha) (FAO, 2022).

For example, the irrigation system of Gezira consists of about 2300 km of main channels and 8000 km of sub-channels. Water is channeled to the irrigated areas of the scheme through two main channels (the Gezira and Managil main channels), which converge from the reservoir at Sennar. The two channels run 57 km north of the dam to a group of regulators. The main Gezira channel runs another 137 kilometers further north, branching into many larger channels to irrigate the different areas of the main Gezira. The large channels in turn branch into smaller channels, which direct the irrigation water through closed field outlet pipes to field ditches called Abu Ishreens. Each Abu Ishreen irrigates 90 fed (the regulated area that divided the scheme for irrigation), which ends in the field getting through farrow (Eldaw, 2004).

2.2. Mechanized rain-fed agricultural system

The mechanization of cultural practices and its impact on agricultural productivity were studied by many researchers in different areas of the world. In Sudan, traditionally, farming is practiced in the heavy clay soil with annual rainfall between 400 and 800 mm. The cropped area varies and depending on the amount of rainfall. The average annual area under

mechanized rain-fed farming is practiced in a broad belt of about 8 million ha, running mainly through the states of Gedaref, Blue Nile, Sennar, White Nile, and South Kordofan, and receiving an average of more than 500 mm of rainfall annually. This system completely depends on rainfall. Mechanized farming accounts for about 65 % of sorghum, 53 % of sesame, 5 % of millet, and almost 100 % of sunflower (Figure 2). On average, mechanized rain-fed agriculture accounts for about 18 % of crops' contribution to GDP. In this farming system, mechanization is used in all of the practices, e.g., soil preparation, seeding, and harvesting, but sometimes some of the field work is carried out manually. Sorghum is a commonly grown crop, accounting for about 80 percent of the total area under cultivation and typically meeting about 45 percent of the country's needs. Besides, considerable area of cotton is grown in this sector. Farms in the mechanized system are often very large, with an average area of 420 ha to more than 50,000 ha owned by farmer. Crop yield in this sector depends on the amount and distribution of rainfall during the growing season (Abdalla & Abdel Nur, 2001; FAO, 2022).

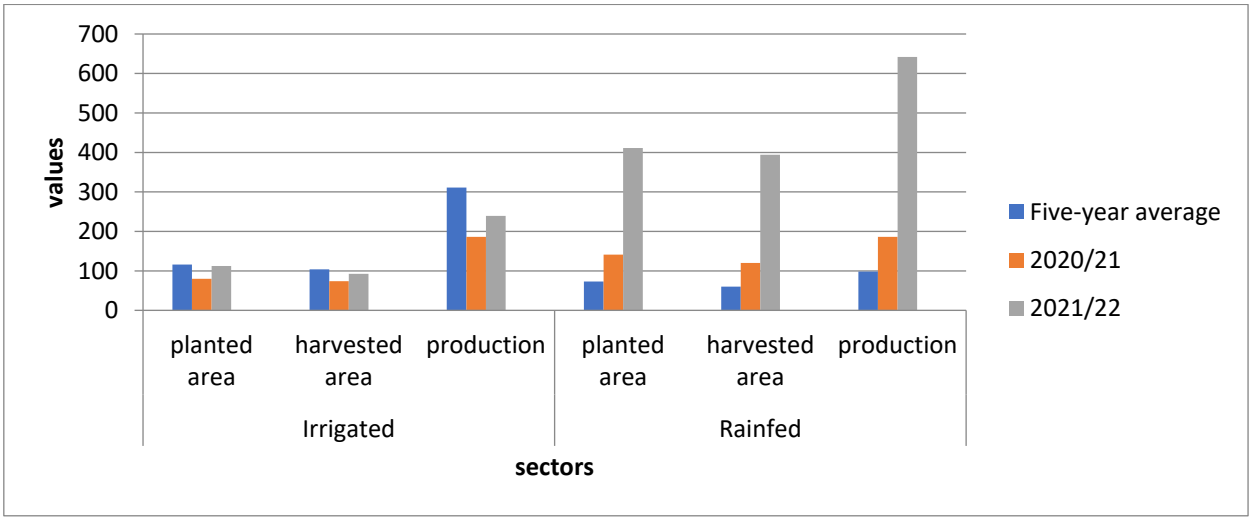

Figure 2: Cotton production 2021/22 compared to 2020/21 and five-year average (FAO, 2022).
Area in ‘000 ha, production in ‘000 ton

2.3. Traditional rain-fed farming system

Traditional rain-fed farming covers about 9 million ha and employs most farmers. The sector is characterized by small family units farming 2 to 50 ha for both income and self-consumption. The agricultural practices are conducted manually or by animals’ power. Only larger units are mechanized for land preparation, but the other farm work is conducted manually. Traditional rain-fed farming is prevalent mainly in the western parts of the country, the Greater Darfur region, and most of the Greater Kordofan region, where the main crops are millet, groundnut, and sorghum (Figure. 3). Input levels are low, and yield particularly vulnerable to unfavorable rainfall. Other important crops in this sector are sesame, hibiscus, watermelon, and gum Arabic (Abdel Rahman et al., 2022). The productivity of this sector is very low. Because of low soil fertility and the hazard of applying fertilizers. Harvesting in this system is partially

done with small machines. Crops production in rain-fed sector represents about 95 percent of the planted area shown variations in annual rainfall regard to frequency and distributions. That led to late sowing or even a wave of severe drought. It's often made the needed for reseeding or completely crop failures (Ibrahim et al., 2015).

3. Agricultural Production Constraints in Sudan

Despite the fundamental roles of agriculture in Sudan, it is still faces and surrounds with so many challenges. Agricultural growth and expansion are constrained by various factors, such as natural and structural, technology, socio-institutional, policy, infrastructural, and exogenous constraints (Abdalla &Abdel Nur, 2001).

Table 1. The Sudan - Sesame production 2021/22 compared to 2020/21

	Mechanized Rainfed		Traditional Rainfed	
	2020/21	**2021/22**	**2020/21**	**2021/22**
Planted area	2768	1473	4281	5950
Harvested area	1997	1075	3274	3997
Yield	299	275	260	107

(FAO, 2022)

Area in '000 ha, yield kg/fed

It is clear that the most common challenges in any sector or production system are the irrational prices of production inputs (certified seeds, fertilizers, fuel, and labor) or sometimes even the unavailability of these inputs, especially at the beginning of sowing times. In addition, there is a lack of technical support and extension services, as well as marketing and storage capacities. Furthermore, the sub-sector also has some limitations; these include low yields, high production costs, a lack of formal credit, and poor infrastructure (Table 1). Shortage of extension services for the small farmers, poor access to marketing services, and insecure land tenure with a dominance of the traditional rain-fed agriculture sector (Mohamed, 2011). Rainfed farming is located in vulnerable zones where instability of rainfall and overall climate change and variability, one way or another, a major impact on land and crop productivity, which is directly related to the contribution rural communities make the livelihoods of areas where rain-fed agriculture occupies more than 90 % of the cultivated land of Sudan (Siddig et al., 2020). This considers the biggest problems that face mechanized and traditional farming systems in Sudan. Weak in political stabilities and fluctuate of economic and financial support. As well as, fragile of administrates and implementation capacity of the governmental institution (Osman & Ali, 2021).

Lack of crop rotation, which is one of the agricultural practices that manage land use and limit frequent land overutilization, optimizes nutrient and water use efficiencies, Often, rain-fed agriculture damaged land through shifting cultivation practices and overgrazing of livestock, limiting land value and crop production. The mechanized systems cause deforestation and erosion. However, implementing irrigation techniques such as drip and pivot irrigation greatly desalinates the water supply while producing higher yields (Lee & Chula Vista, n. d.).

Deficiency of transportation and related infrastructure, lack of proper communications

infrastructure, and rough terrain has kept production areas isolated. It was difficult, and sometimes impossible, to take agricultural products out of large production areas to take advantage of manufactured goods and government services. This situation has traditionally suppressed farmers get prices and led to high prices for industrial consumer goods and services in remote and relatively isolated areas (Getahun, 1978). Moreover, with the products during harvesting times being very cheap or even unmarketable, this means more losses and a negative aspect to the farmers' welfare.

Restriction of investment and development of agriculture sector especially the rain-fed sector. With the current situation in techniques development, agricultural systems have the ability to adapt to these factors such as climate change, increased food demand, and prices of inputs; however, many new technologies are imported and adapted to local conditions (Hardy et al., 2011).

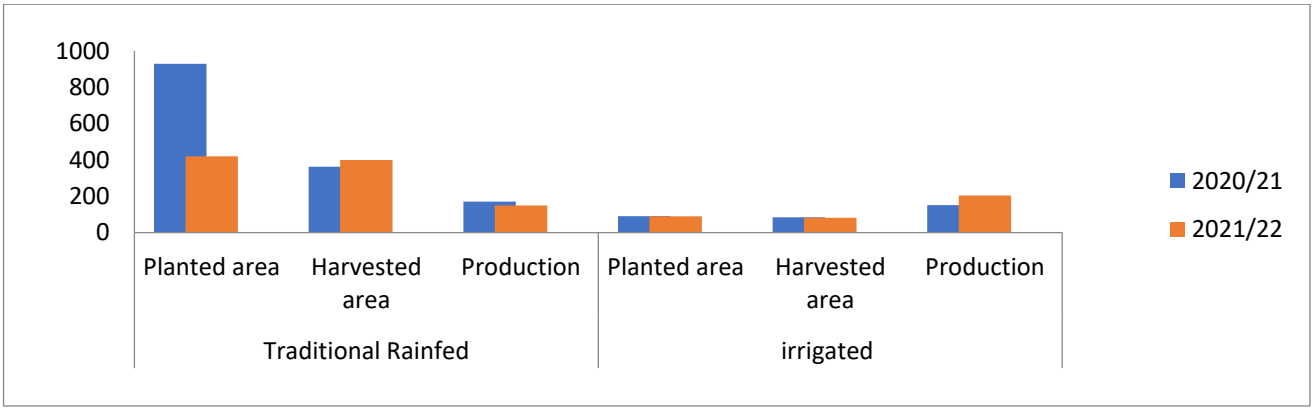

Figure 3. Groundnut production 2021/22 compared to 2020/21 (FAO, 2022)

*Area in '000 ha, production in '000 ton

4. Suggested and recommended solutions to overcome some constraints of agriculture production

In spite of all constraints that are surround agriculture in Sudan, often there are several way to clear it out. The lack of access to agricultural inputs (seeds, fertilizers, fuel and credit) is solved through serious legislation intervention. Besides, exploit the related institutions (Agricultural Bank of Sudan) to act their roles of provide these inputs before the beginning of the growing season. In addition, to change in credit policy with very simple guarantees that comes in useful for any farmer.

Sudan is characterized by large genetic variations of the most common crops, which opens the way for the selection of cultivars with different qualities in terms of maturity, unpredictable growing conditions, drought resistance, resistance to pests and diseases, etc., to adapt them to different environmental regions and consumer tastes. Breeders at the research institutions have produced high-quality varieties suitable for both irrigated and rain-fed systems. Moreover, farmers in remote areas are increasingly using appropriate technology packages to increase productivity and promote the comparative advantage of production in Sudan.

There is a great opportunity to optimize current farming and production systems through an enabling policy framework, the use of modern technology to increase sustainable productivity, and improve rural area, public and physical infrastructure. Current levels of productivity per farmer or land unit are low in both crops and livestock. The potential for irrigated and mechanized rain-fed agriculture lays primarily in the

increase use of appropriate technology packages, including high-yielding varieties, the use of machinery and improved crop production methods. In addition, the utilizing of advanced storage tools significantly will decrease the losses of crops due to the traditional storage methods (Ahmed, 2004). Further attention should be paid to the mechanized rain-fed sub-sector as it is a large and effective sub-sector that has considerable potential for building a national food supply and earning foreign exchange through exports and trade exchanges.

Efforts should be aimed at removing barriers and promoting foreign and domestic private investment, which can make a momentous contribution to agriculture development. Furthermore, institutionally provides relevant agricultural extension packages to meet farmers' needs for culture practices (Siddig et al., 2011). Early price declaration or ensuring a minimum price level and improving market information regarding crop supply and demand to increase crop productivity and production in the regions strongly important and encourage farmers. Implement institutional and legal reforms, including laws on taxes, prices and labor relations, with the aim of facilitating resource allocation and increasing efficiency of utilizing resources (Bello et al., 2016; Ibrahim et al., 2014). In the private sector of mechanized rain-fed farming system in Sudan, the government's role in providing incentives for the provision of modern inputs, better infrastructure and other basic services should be enhanced. Counseling services should be strengthened by expanding extension services, upgrading extension staff's qualifications and providing them with the better necessary facilities. The credit system should be improved. Loaning to farmers should be expanded in order to maintain access to credit from banks, especially medium- and long-term credit for investments in agricultural production. The credit system should also be more flexible, with simpler loan application forms and procedures, longer repayment periods, and more accurate monitoring and tracking (Mustafa, 2006).

The development process does not mean that the traditional methods are harmful, but rather that the new is more globally competitive and better able to bring hard currency. Therefore, more attention, planning and tireless work in this sector will move the rural communities for sufficient and mobile to emerging whole country, all of this steps would be firmly by the statements of the minister of agriculture and to set up a food security strategies (Ibrahim et al., 2020).

5. Conclusion

The agricultural sector and its products in Sudan supply and secure about 80 % or more of food demand. Agriculture production in Sudan is mainly practiced through different systems; traditional rain-fed system, mechanized rain-fed system, and irrigated farming system. Mechanical energy and some production technology are commonly used to enhance crops production. Furthermore, modern and advanced production technique is well practiced around the Nile banks. That depends entirely on pumping water from the Nile and Nubian basin using a modern agricultural system. The variations of Sudan's climate make it possible to cultivate different types of crops. Regardless of, these opportunities agriculture practices face significant and severe limitations. Complementing and providing inputs and formal credit is critical and important to prove and solve these limitations in order to achieve sustainable and more stable cultivation. Investments in machinery, fertilizers, and packaging are well needed to make serious revolution change in agriculture production. The

harsh environment in which most farmers have had to work since the beginning of farming in the country has ensured that those who continue to farm make efficient use of their limited resources.

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