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The Agricultural Potential of Sudan

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1. Introduction

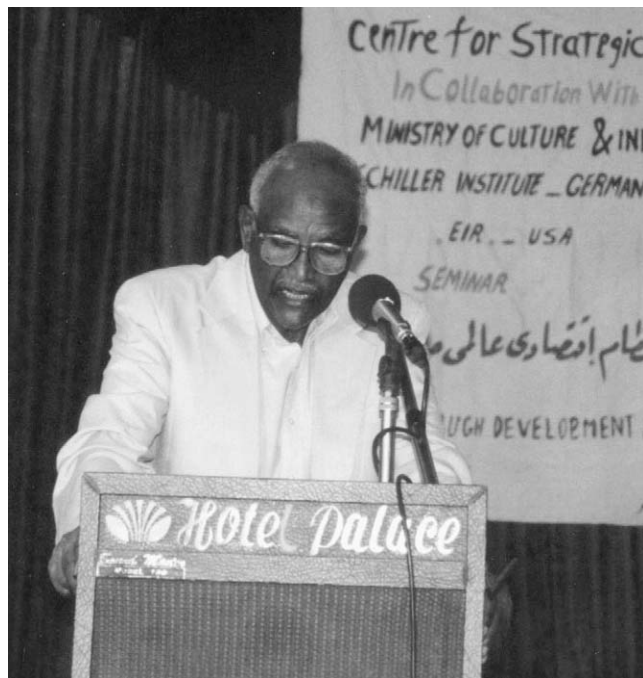
Sudan is the largest country in Africa with an area of about 2.5 million square kilometers. It is bounded on the east by the Red Sea, and on the other sides by nine African states: Eritrea, Ethiopia, Kenya, Uganda, Democratic Republic of the Congo, the Central African Republic, Chad, Libya, and Egypt. Its topography is generally a broad plain, with mountains in the northeast near the Red Sea coast, and low mountains near the southwestern borders. The Blue Nile and the White Nile originating, respectively, in the Ethiopian highlands and in the Equatorial lakes, join in Khartoum to form the Nile River which flows to Egypt. The Nile has several tributaries and extensive swamps in the south. Extending from the arid north (21° North) to the wet tropics (5° North), Sudan has several agro-ecological zones (**Figure 1** and **Table 1**), with varying climatic conditions. Rainfall ranges from none in the hot arid north, to more than 1,500 millimeters in the wet tropics of mixed deciduous forests.

a. Arid zone: Covers 29% of the total area of the country; rainfall is rare, and hence there is no vegetation cover; crop production is concentrated in the irrigated areas along the Nile, and, because of the cool nights of the relatively longer Winter season, faba beans, wheat, dates, vegetables, fruits, and spices are grown. This part of the country falls within the water-bearing Nubian sandstone aquifer, and further agricultural development will depend on the use of the groundwater and on the intensification of irrigated agriculture.

b. Semi-arid zone: Comprises 20% of the total country area; rainfall varies from 50 to 300 mm, adequate only for annual vegetation suitable for limited transhumant grazing; vulnerable to frequent droughts; investment potential lies in rational grazing and cropping in wadies (valley).

c. Savannah, low rainfall: 13% of the total area dominated by goz soils, and rainfall ranging from 200 to 400 mm, suitable for traditional farming of sorghum, groundnuts, and millet (dukhun); potential for farming gum arabic and live-stock.

d. Savannah, medium rainfall: 14% of total area, rainfall



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FIGURE 1D
Sudan: Agro-Ecological Zones

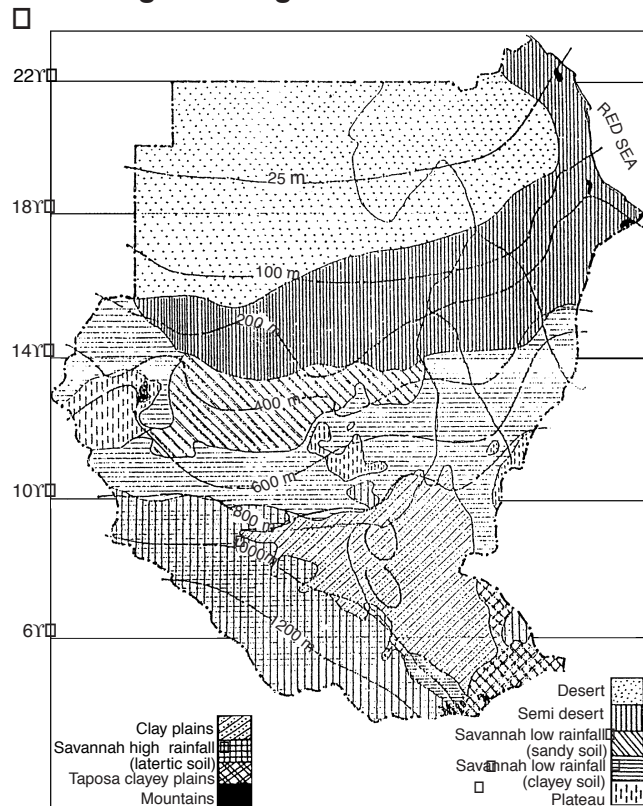


TABLE 1

Climatic Regions of Sudan

(Area in Thousands of Sq. Km.)

Climatic Region	Area	%	Potential Field Crop
Desert (Lat. 16-22°N)	726	29	Sorghum, maize, millet, wheat, barley and pulses. north of 14°N under irrigation
Semi-Desert (Lat. 14-16°N)	490	20	Sorghum, maize, millet, rice in all areas. wheat, barley and pulses north of 14°N under irrigation
Low Rainfall Savannah (Lat. 10-14°N)	684.4	27	Millet, sorghum, maize, rice and oil seeds in all areas. wheat and barley, north of 14°N under irrigation
High Rainfall Savannah (Lat. 4-10°N)	348.7	14	Sorghum, maize, millet
Swamps	246	9.7	Rice, sorghum, maize and millet, after reclamation
Uplands	7.748	0.3	Mediterranean fruits and vegetables in Jebel Marra
Total	2,502.848	100	

Source: Ministry of Agriculture, Natural Resources and Animal Wealth, Khartoum, Sudan.

400-800 mm; includes rainfed mechanized farming in clay soils, traditional farming, gum arabic, and large Summer grazing area. Vast agricultural potential for mechanized and improved traditional farming and livestock.

e. Savannah, high rainfall (800-1,500 mm): 13.8% of total country area; includes vast pasture areas and productive soils for several crops with immense potential for crop production and forests.

f. Mountainous areas: Includes J. Marrali, Amatong, Aloun plateaus, suitable for growing of tea, coffee, and other tropical crops.

Sudan's total population is estimated at 30.7 million in the year 2000, with a population growth rate of 2.9% per year. Twenty-five percent of the population are urban.

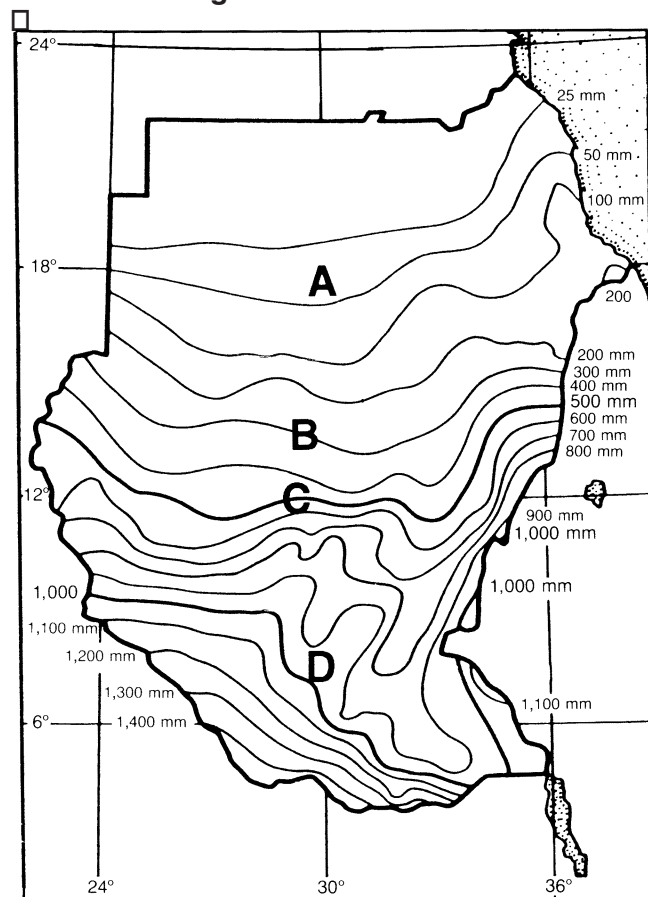
Agriculture, including crops, livestock, forests, fish, and wildlife, has been and will continue to be for some time the backbone and engine of the national economy. Its annual share of GDP has been around 36%, and until recently has been contributing about 90% of Sudan's exports. It employs about 60% of the active labor force, and provides livelihood for more than 75% of the population. The relative contribution of the different sub-sectors in the GDP indicates that livestock and irrigated crops are leading, contributing, respectively, 5.7% and 11% of average GDP for the period 1990-91 to 1994-95. The contribution of the traditional and mechanized rainfed farming and forestry was 3.2, 3.8, and 3%, respectively. All other sectors, including trade, manufacturing, transportation, and services, depended on it.

2. Renewable Agricultural Resource Base

Sudan has a wide and diversified national agricultural resource base. The renewable agricultural resource base includes the climate, soils, water, and biodiversity.

a. Climate (rainfall, temperature, radiation): Sudan's multivariate ecological zones, with plenty of sunshine, provide for diversity in crops and farming systems, vegetational

FIGURE 2

Sudan's Average Annual Rainfall

cover and, hence, livestock production and forestry. Average annual rainfall is shown in **Figure 2**.

b. Agricultural soils resources: The total arable land amounts to 84 million hectares. There are also large areas

TABLE 2

Sudan Land Use

(Thousands of Hectares)

Type of Land Use	Area	%
Land suitable for cultivation:	84,000	35.7
1) Land under crops:	14,690	(17.5%)
a. Irrigated	1,600	(1.9%)
b. Rainfed	12,054	(14.4%)
c. Fallow	1,044	(1.2%)
2) Land not exploited	69,310	(82.5%)
Forest and Woodland	64,360	27.4
Range	24,000	10.2
Desert and waste land	26,942	26.7
Total land area*	235,302	100

*Total estimated geographical area is 250,581 hectares.

Sources: Forest National Corporation (1992); FAO Year Book.

TABLE 3

Average Annual River Flows in the Nile River System

(Billions of Cubic Meters)

Bahr el Jabal at Mongolla (before entering the swamps in the suds region)	26,000
Bahr el Gazal	15,000
Sobat at junction with the White Nile	13,000
Total	54,000
Losses in the swamps of the suds region	27,300
Available in the White Nile at Malakal	26,700
Blue Nile at junction with Nile	53,400
Atbara at junction with Nile	11,600
Total	91,700
Losses along the river downstream of Malakal	7,700
Net available*	84,000

*Sudan's share according to the Nile Water Agreement of 1959 is 18.5 milliards of cubic meters measured at Aswan (20.55 at Sennar).

Source: Ministry of Irrigation, Khartoum, Sudan.

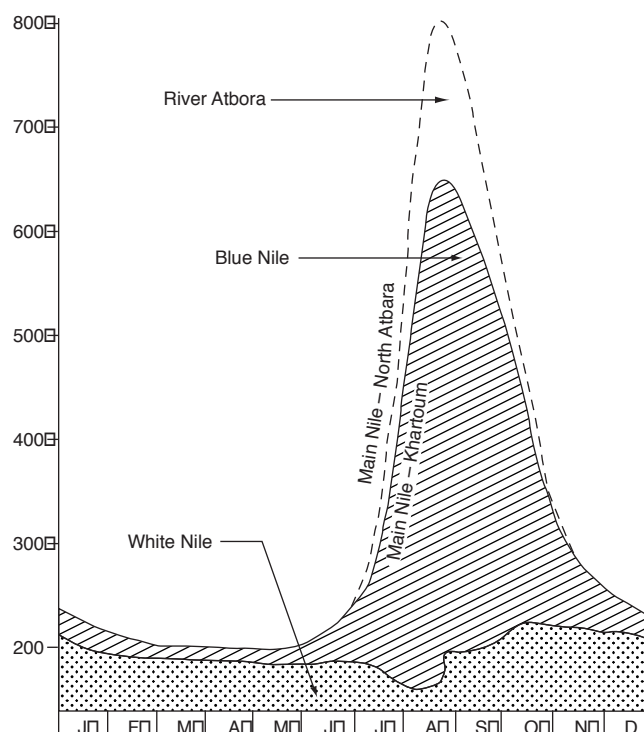
classified as N1 (not suitable for cultivation now). This means that arable soils are plentiful and would not constitute a limiting factor for agricultural development, and particularly so in soils in areas with underground water. Out of the 84 million hectares of arable land, only about 18 million are now utilized. The breakdown of the total land area of Sudan is shown in **Table 2**.

c. Water resources: Water resources in Sudan comprise

FIGURE 3□

The Nile and Its Tributaries' Flow, 1912-89□

(Flow in Millions of Cubic Meters Per Day)



Source: A. A. Ahmed, 1991.

rainfall, groundwater, and river flows, all interrelated as part of the national hydrological cycle. Annual river flows are shown in **Table 3**.

The current water resources available to Sudan amount to about 30 billion cubic meters (bcm) (share from Nile is 18.5 bcm at Aswan, non-Nile streams, groundwater) (see **Figure 3**). Expected share from reclamation of swamps in the south is about 6 bcm.

Rainfall is a major water resource for agriculture. Annual rainfall varies from nil in the hot arid north to more than 1,500 mm in the wet tropics. The duration and amount of rainfall increases from north to south.

Rainfall varies from year to year. This variation is crucial for rainfed farming.

3. Major Farming Systems

Farming systems have evolved mainly as a function of agro-ecological conditions, acquired technology market, and socio-economic conditions. Crop production is practiced in three main farming systems, namely: irrigated, traditional rainfed, and mechanized rainfed.

a. Irrigated farming system: Covers about 1.9 million hectares, irrigated mainly from the Nile and its tributaries and

includes flush irrigated areas (Tokar, Gash Delter), and, to a less extent, from groundwater. The irrigated sector is dominated by the large irrigation schemes (Gezira, New Halfa, and Rahad) which are owned and managed by the public sector.

The main crops grown under irrigation include cotton, sugarcane, sorghum, groundnuts, wheat, legumes, fruits, vegetables, and irrigated fodder. 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 crops contribution to the GDP.

b. Traditional rainfed farming: Largely confined to the 350-800 mm isohyets for sorghum, cotton, and sesame. Millets and groundnuts are grown in the sandy soils, receiving around 300 mm.

The sector is also a major producer of gum arabic and livestock. The cropped area varies from 5-8 million hectares and varies annually with variation in rainfall. Crop production is labor-intensive with hand tools and the productivity is low; 75% of the population live in this sector.

The sector contributes 90% of the millet, 48% of groundnuts, 28% of the sesame, 11% of the sorghum, and 100% of the gum arabic. Despite its importance, the sector has been largely neglected.

c. Mechanized rainfed farming: Traditionally practiced in the heavy clay soils in areas with rainfall between 400-800 mm per annum. The area cropped varies with variation in rainfall. The annual area covered is on the average about 8 million hectares. The main crops in this sector are sorghum and sesame. Mechanized farming accounts for about 65% of the sorghum, 53% of the sesame, 5% of the millet, and almost 100% of the sunflower. On average, mechanized rainfed farming accounts for about 18% of the crops contribution to the GDP.

The major constraints in the sector include poor infrastructure, poor services, and lack of drinking water which limit permanent settlement of farmers.

d. Livestock production system: Sudan has about 110 million head of cattle, sheep, and goats. Livestock production, generally confined to the traditional rainfed sector, contributes significantly to the GDP, reaching 20%, and food security of the country. It accounts for about 45% of the agriculture GDP, with a valuable contribution to export earnings. However, the quantities and qualities of the animal products are not commensurate with its size and falls short of the domestic and export-market demand for these products. The livestock is raised under a national pastoral system, which makes them vulnerable to ecological and environmental changes.

Major constraints include food shortages, overgrazing, and desertification, low genetic potential of local breeds for high production, in addition to some institutional, technological, and disease constraints. The development potential is, however, great in the traditional pastoral system. Sudan is self-sufficient in meat and has surplus for export.

e. Forests system: Trees provide timber and about 80%

TABLE 4

Cereal Production in Sudan (1984-85 to 1995-96)

(Thousands of Metric Tons)

Year	Sorghum	Millet	Wheat	Total
1984-85	1,097	158	79	1,334
1985-86	3,542	428	360	4,330
1986-87	3,277	285	157	3,719
1987-88	1,363	153	181	1,697
1988-89	4,425	495	247	5,167
1989-90	1,536	161	409	2,106
1990-91	980	85	686	1,751
1991-92	3,581	308	838	4,727
1992-93	4,042	449	445	4,936
1993-94	2,386	221	475	3,082
1994-95	3,648	973	448	5,069
1995-96	2,433	385	527	3,345

Source: Ministry of Agriculture, Khartoum, Sudan.

of the total energy requirements of the country. Gum arabic produced from hashab is a valuable export product and provides for shelter belts.

4. Land Utilization

Total arable land in the Sudan is estimated at 85 million hectares, of which 17 million hectares are currently under crop production. The arable land within the zone of isohyets 400-800 mm is estimated at 25 million hectares, of which 15 million are currently utilized either traditionally (9 million) or mechanized (6 million). The grazing area is estimated at 39 million hectares, while the forests occupy some 64 million hectares.

Field crops: Field crops in the Sudan may be divided into six groups: cereals, oil crops, legumes, fiber crops, fodder crops, in addition to sugarcane.

a. Cereals: These include sorghum, dukhn (millet), wheat, corn, cassava, and rice (**Table 4**).

Sorghum: Sorghum comes first by area and volume of crop. At least one-third of the total cropped area in Sudan is annually placed under sorghum, producing about 75% of food grains in the country. Most of the crop is consumed locally, with a significant part used as fodder, and yet another part is utilized by the industry for the production of glucose and starch. All excess sorghum is exported, especially to the markets of the Kingdom of Saudi Arabia.

Sorghum is grown all over Sudan in the irrigated as well as in the rainfed areas. However, as 90% of total sorghum area is in the rainfed areas, total production varies from year to year relative to the volume and distribution of rains. However, the rainfed sector provides, on average, about 66% of total sorghum production. This necessitates the establishment of a strategic reserve to secure food requirements and trade

commitments.

Sorghum in Sudan is characterized by wide genetic variations, opening the way for selecting varieties with differentiated qualities with respect to ripening period, stalk length, grain color and size, drought resistance, resistance to pests and diseases, etc., to suit the various environmental regions and consumer tastes.

Breeders in the Research Corporation have produced high-quality varieties that suit both the irrigated and the rainfed regions, in addition to some hybrids. Farmers are increasingly using suitable technological packages to enhance productivity and promote the comparative advantage of sorghum production in Sudan.

Dukhn (millet): Dukhn is the most important cereal in western Sudan, where 95% of total dukhn area is found. Estimated at 2.1 million hectares, dukhn is grown in the Goz soils with sparse rains, and soils with poor fertility. The productive area is usually not more than half the cultivated area. The total annual production is estimated between 320,000 and 400,000 tons, all consumed locally.

Wheat: Wheat cultivation has been known in northern Sudan between latitudes 17 and 22 North for thousands of years. The area cultivated with wheat never exceeded 15,000 hectares up to the end of the '50s and the production was enough to cover the consumption needs in northern Sudan and the main towns. The rest of the population has been dependent either on sorghum in central and eastern Sudan, and on dukhn in the west or cassava in the south. All these grains, with the exception of wheat, are produced under rains. However, with the expansion of the urban communities in the last 50 years, food consumption habits have changed, and wheat consumption has soared to about a million tons annually. The wheat area expanded from about 75,000 hectares in 1989, to 415,000 hectares in 1992, increasing production from 234,000 tons to 839,000 tons consecutively, which was enough to realize self-sufficiency in wheat at that time. However, in the following years of policy liberalization and the ensuing inflation, the cost of production became prohibitive and the area was reduced to the level of 1989, prompting the country to import most of its wheat requirements.

At present the Gezira Scheme produces more than 50% of total wheat production, which is also produced in the northern and Nile States, in addition to specified areas in Rahad and New Halfa schemes. However, plans are under way to construct Hamdab and Kajbar Dams to facilitate the expansion of wheat production area in the Northern State, not only for attaining self-sufficiency, but also for export. Moreover, the heightening of Roseires Dam will avail adequate irrigation water to intensify wheat production in the irrigated schemes of central Sudan.

Corn: Corn is one of the most important cereals in world trade, drawing its importance from its use as human food, animal feed, and raw material for the production of vegetable oil, glucose, starch, etc. Locally, corn is a secondary crop, and is used as a food crop in some parts of the Southern States.

TABLE 5

Oilseeds Production in Sudan (1984-85 to 1994-95)

(Thousands of Metric Tons)

Season	Sesame	Groundnut	Sunflower	Total
1984-85	130	121	—	251
1985-86	134	192	—	326
1986-87	216	193	—	409
1987-88	233	234	39	506
1988-89	194	298	40	532
1989-90	140	99	22	261
1990-91	80	22	23	125
1991-92	97	66	11	174
1992-93	266	380	38	684
1993-94	175	428	32	635
1994-95	170	714	48	932
1995-96	313	738	25	1,076

Source: Ministry of Agriculture, Natural Resources and Animal Wealth, Khartoum, Sudan.

Now there is a growing attention to expand corn production for export, making use of the favorable conditions with respect to climate and abundance of land and rainfall that give the country a comparative advantage in growing corn. Moreover, the existence of the Greater Arab Duty-Free Zone will enhance the competitiveness of Sudan in the Arab markets, which import 5 million tons of the 8 million tons which are traded in the international market. To support these efforts, a number of research programs are being implemented to produce high-quality hybrids and improved seeds that suit the main production regions. In the circumstance, a number of investors from Qatar, Algeria, Morocco, and Libya have expressed interest in investing in corn production.

Pearl millet: This is an important cereal in Southern Sudan and is cultivated traditionally in areas with excessive rains that do not allow sorghum production. It is also inter-cropped with dura and sesame.

Rice: Trials to introduce rice cultivation in Sudan started in 1905. Rice was introduced in the crop rotation in the Gezira Scheme during the '60s. However, due to its high water demand and the risk of spreading water weeds, it was excluded from the rotation. As rice grows wild in the Heavy Rains Savannah Zone of Northern Bahr El Ghazal and Southern Darfur States, a project was launched in the early 1960s to introduce commercial rice production in the area, starting with Aweil Region, but the efforts were frustrated by the civil war. Some private investors from Egypt and Pakistan, in collaboration with farmers, are active in rice production in the White Nile State.

b. Oil Crops: Sesame, groundnuts, cotton seed, and sunflower are the main vegetable oil crops in Sudan. Other prospective oil crops which have been successfully tried in Sudan

TABLE 6

Exports of Sudan by Commodity Share in Percentage (1990-91 to 1994-95)

Commodity	1990-91	1991-92	1992-93	1993-94	1994-95
Cotton	51.8	33.0	18.2	18.2	15.2
Gum Arabic	14.5	11.7	5.7	16.4	13.9
Oilseeds and Products	11.4	14.0	20.2	18.7	20.0
Meat and Livestock	6.5	9.2	20.9	17.4	19.1
Skins and Hides	5.5	—	3.7	1.1	2.7
Others	10.3	32.1	31.3	28.2	29.1
Total	100.0	100.0	100.0	100.0	100.0

Source: Ministry of Economic and Finance (October 1995): *Economic Review Report*, Khartoum, Sudan.

include safflower and niger (see **Table 5**).

Sesame: Sesame is the most important vegetable oil crop in Sudan, coming third in area after sorghum and dukhn. It draws its importance as a food crop, a raw material for industry, as a feed for livestock, as well as a leading export crop (see **Table 6**). Sudan is second to none in the volume of sesame exports, cultivating 80% of all sesame area in the Arab world, and 40% of all sesame area in the African continent. Sesame cultivation is concentrated in the Goz area of Northern Kordofan State, as well as in Gedarif and Damazine clay plains, in addition to scattered areas in the states of Southern Kordofan, Southern Darfur, and Northern Upper Nile. Recently sesame has been introduced in the crop rotation of the irrigated schemes in the Nile State as a Winter crop. Expansion of irrigated sesame will open the way for the country to enter the international market earlier and to stay longer.

Groundnuts: Groundnuts is a leguminous crop that fits beautifully in the crop rotation of irrigated schemes, as well as in the rainfed areas. Annually more than a million hectares are cultivated, which constitutes about 90% of all the area grown with the crop in the Arab region. At present, only a limited quantity of selected seeds is being exported, as all seeds are processed locally in favor of exporting the oil, which fetches high prices in the European markets.

Sunflower: Sunflower ranks fourth in the world oil crops after palm oil, rapeseed, and soybeans. Locally, commercial production was only started during the late 1980s in an area of 150,000 hectares in Damazine and Gadaref regions. The need to import the seeds has impeded expansion of the area. Now programs are under way to produce the seeds locally with private capital, and this will lay the foundation for extensive crop production in various parts of the country, specifically under rains in the Nuba Mountains region, by flush irrigation in the deltas of El Gash and Tokar, as well as in the irrigated schemes.

e. Leguminous crops: The leguminous crops grown in Sudan include faba beans (*Vicia faba*), cow-pea, chick-pea, haricot beans, peas, lentils, and lupin, all of which are grown as Winter crops in the irrigated schemes, as well as in the flooded area after the flood water recedes.

Vicia faba is also grown as a Summer crop in the rainfed areas. *Vicia faba* is the most important leguminous crop, due to its role as a staple food item all over Sudan, specially for urban populations.

d. Fiber crops: Cotton is the main fiber crop in Sudan, while Kenaf is grown in limited areas in Sennar State.

Cotton: Cotton used to be the leading export crop, but has now given way to sesame, and livestock and meat. This has come about for various reasons. First: The demand for extra long and long staple cottons has decreased in world trade. Second: The cost of imported inputs has been inflated, as a result of floating the price of the local currency, thus decreasing the economic feasibility of cotton. Third: Sesame and livestock are not dependent on imported inputs, a comparative advantage that has increased their economic feasibility and opened the way for expanding exports. However, cotton is still an important crop, as it provides the local textile factories with lint, and the oil factories with cotton seed. The resultant seedcake is an important feed element, especially in fattening export animals. Sometimes cottonseed oil is used for soap production in place of imported fats.

Long staple cotton was first grown in Tokar delta in 1862. It is believed that the success of cotton production was among the factors that attracted Great Britain to intervene in Sudan affairs. The British Administration later facilitated the construction of Sennar Dam on the Blue Nile in central Sudan to provide irrigation water for cotton plantations. When cotton prices soared during the early 1950s as a result of the wars in Southeast Asia, cotton cultivation expanded greatly, not only in irrigated schemes, but also in rainfed areas, especially in the Nuba Mountains area. With time, the area expanded to reach its climax in season 1974-75, when 500,000 hectares were cultivated. In the following years, the area has gradually decreased to reach its bottom line of 120,000 hectares in 1993-94. When the prices in world trade doubled in 1994 to 110¢ per pound, the area increased to about 200,000 hectares.

Further expansion was hampered by the high cost of imported inputs and the scarcity of credit financing. However, with the upturn of the economy due to the earnings of petroleum exports and the functioning of fertilizer factory, cotton may regain the lost ground and sustain itself as an important export and industrial crop.

e. Forage crops: Total fodder available to livestock is estimated at 85.6 million tons of dry matter, including natural range, crop residues, processed feed, and green fodder.

The grazing area with natural range is estimated at 110 million hectares, extending throughout all environmental zones from the equatorial region in the south, to the poor Savannah in the northern part of central Sudan. The natural

range provides 90% of the animal feed estimated at 62.4 million tons of dry matter. Production of green fodder is estimated at 3.6 million tons grown in the northern states (0.36 million tons), the eastern states (0.93 million tons), the central states (1.25 million tons), and Khartoum State (1.09 million tons). The production of green fodder is concentrated mainly around towns and urban centers to feed dairy cows and small ruminants. Alfalfa is the most important green fodder, contributing 94% of total green fodder, followed by Abu 70 with 5% total weight. Alfalfa grows well in Sudan, giving about 17 cuts per annum, compared to Abu 70 which gives 8-12 tons per hectare per annum.

Other green forage include hyacinth bean, phillipesara, clitoria, and lemon grass, which together give no more than 1% of total fodder crop. In view of the expansive areas grown with field crops, the crop residues constitute an important fodder element, contributing about 18.6 million tons annually. These are mainly the residues of sorghum, sugarcane, wheat, oil crops, etc. There are a number of animal feed factories in Sudan making use of sorghum, as well as about 410,000 tons of cotton seedcake, 106,000 tons of groundnuts seedcake, 61,000 tons of sesame seedcake, 168,000 tons of wheat bran in addition to 1.5 million tons of molasses.

f. Horticultural crops:

Vegetables: Various vegetables are grown in both irrigated and high rainfed areas, in a total area of about 525,000 feddans (220,000 hectares) i.e., about 3% of total cultivated area, giving an average of about 489 tons of vegetables. The most important vegetables are onions, tomatoes followed by potatoes, okra, eggplant, water melons, cucumbers, pumpkins, and a number of leafy vegetables. Onions and tomatoes occupy about 50% of the vegetable area. Vegetables are grown in small plots with pumped water, as well as in the national corporations, such as Gezira Scheme, where about 30,000 hectares are devoted to vegetables. Vegetables are also grown in the traditional sector for household consumption. Most of the vegetables are consumed in the urban areas at a rate of 70 kilograms per capita per annum, in comparison with the rates in the rural areas which average about 8 kg per capita per annum.

This is far below the average in developed countries, estimated at 100 kg per capita per annum. This reflects the potential local demand, which may be realized in the near future when petroleum production increases and exports are sustained. Apart from the local market, there is a big demand for vegetables in the Arab markets, as well as in the markets of the European Union. Already, thousands of tons of galia (melon, onions, potatoes, green beans, and green peppers) are exported annually. Research stations have incorporated programs to improve the varieties and to produce improved seeds. The new Arab-Sudanese Seed Co. is investing in the propagation of selected seeds for the local market, as well as for export. Facilities to promote the post-harvest operations are being installed in some central markets and airports. A small export complex is being established in the vicinity of

TABLE 7
Fruit Production, 1992-99
(Thousands of Tons)

Year	Production Estimates
1992	921
1993	943
1994	1,056
1995	1,231
1996	1,458
1997	1,646
1998	1,914
1999	2,150

Source: Ministry of Agriculture & Forestry, Horticultural Dept., 1999.

Khartoum Airport to provide integrated services for exported vegetables. A company for the development of vegetable exports has been established to promote export and to encourage foreign investments in this sector, preferably in the Northern and Nile States, the Rahad basin, and the deltas of El Gash and Tokar.

The food canning industry in Sudan was initiated in the early 1960s in the Northern and Kassala States, but has since then spread to Khartoum, Gezira, and other states. With increased vegetable production, the processing industry may develop to meet the local demand and for export.

Fruits: The variations in climate and topography have created conditions for the production of various types of fruits, including date palms, citruses, mangoes, guava, pineapple, and banana, in addition to tea and coffee, etc. In the high areas of Jabal Marra, temperate fruits, such as apple, grapes, strawberry, and sweet oranges, grow very well. However commercial production is hampered by the absence of good transport facilities (see **Table 7**).

Although the volume of fruit export is not great, the country has established a name for its high-quality grapefruit, mangoes, lemon, and dry dates. The expansion of exports is hindered by the lack of suitable transport facilities and proper package services. Efforts are being made to develop these services. Tissue culture laboratories are now producing improved varieties of banana, date palm seedlings, and other fruits, to pave the way for the production of high-quality fruits for export markets. Exportable crops include melons, snapbeans, onion, okra, pepper, eggplant, mangoes, grapefruits, lime, and banana.

Medicinal and aromatic plants: These are the main source of raw material for the production of medicines, for food flavoring, and for the production of aromatic products. The medicinal and aromatic plants may be divided into three categories:

- i. Wild plants that grow naturally.
- ii. Plants that have been introduced and have got acclima-

tized to Sudan conditions.

iii. Exotic plants that may be introduced.

The potential to expand the production of all these types is great.

Northern Sudan is suitable for the production of such plants as henna, shamar (fennel), yansoon (aniseed), karawya (caraway), black seed (black cumin), babong (camomile), lemon-grass, nanaa (mint), psilium, mahareab (camel's hay), sekran, handal (bitter melon), local khilla, shaitani, senna, etc.

Western Sudan is suitable for the production of karkade (roselle) and sanamakka (senna). White gorongal (galangal), zangabeel (ginger), sheeh (*Artemisia*), and pepper nanaah (peppermint) grow well in Jabal Marra area. In the east and center are found arak (tooth brush tree), winka, psilium, sabbar (aloe), garlic, lemon grass, and a host of other plants. Black pepper, rawlfia, zangabeel (ginger), and gorongal prosper in the upper lands of southern Sudan.

Numerous plants grow naturally or with traditional methods, requiring no chemical inputs, which is most suited for these products. Moreover, small capital investments are required, which suits the traditional farmer.

g. Forests and Forest Products: While trees in the north are only found along the banks of rivers and in wadis, the number of varieties and density of trees increase with rainfall. Indeed the life of the Sudanese is highly dependent on the forest, as it improves and protects soil, ameliorates climate, protects water sources, supports livestock and wildlife, and contributes to food security with such forest fruits as nabag, goddeim, jogan, dom, gongoles, daleib, and honey. Forest trees provide poles to construct rural houses and timber for furniture. Indeed Sudan is dependent on trees for about 78% of energy requirements in the form of firewood and charcoal. On the other hand gum arabic collected from *Acacia senegal* and *Acacia seyal* trees is an important export crop, fetching annually more than \$50 million on average.

Sudan is rich in valuable timber trees. Examples include Sunut (*Acacia nilotica*), which grows on the banks of rivers, Vuba (*Isoberlinia doka*), which grows well in the ironstone region in the south, which is suitable for railway sleepers and building material. Teak, mahogany (*Khaya senegalensis*), bai, and bu provide high-quality wood for furniture.

The extensiveness of forests calls for investment in forest products such as paper, plywood, and the furniture industry.

5. Crop protection services: Crop protection services were started in 1903, with the establishment of Welcome Laboratory. Later, research on plant pests and diseases was transferred to the Agricultural Research Corp., which boasts of having the largest pest collection in Africa. It is the main source of basic studies on the identification of insects and insect environments.

Research on pest and insect control is carried out by the departments of pest control of the Ministries of Agriculture and by the faculties of agriculture in the various states. Research is now concentrating on integrated pest management (IPM) and the continuous development of chemicals in accor-

dance with the articles of the chemicals action of 1994. Greater emphasis is placed on protection methods through the use of treated seeds and crop resistant varieties.

The actual protection services are performed by the managements in the irrigated schemes and by the farmers and producers in the private schemes. Various methods of protection are used, including air spraying by airplanes, implements drawn by tractors to combat weeds, while manual implements are used in horticulture fields. On the other hand, the Control Department of Plant Protection takes care of combatting migrating pests, such as grasshoppers, birds and mice, together with water hyacinths, etc.

To incorporate farmers effectively in controlling pest and diseases, a number of farmer schools have been established to educate and enlighten the farmers about pests, insects, and diseases, and the rationale of integrated pest management. Sudan is the first African country that uses farmer schooling as an effective extension leverage.

6. Plant quarantine: Plant quarantines play an important role in protecting the country from the spread of exotic pests and diseases. On the other hand, all exports are subjected to quarantine checks to ensure that they are disease-free and of high quality according to the standards accepted internationally and contracted for. No plant material may be introduced into the country without having acquired a phyto-sanitary certificate from the quarantine authorities. It should be noted that the first quarantine act was issued in 1900. The last modification of the law was made in 1998, to keep in line with the phyto-sanitary regulations of the GATT Agreement 1994 and the World Trade Organization. The main quarantine station is found in Port Sudan, in addition to stations within the main airports of Khartoum, Port Sudan, Halfa, Dongola, Gineina, Nyala, Kela, Nimole, and Juba. Smaller stations are also established in all towns connected with the outside world such as Abidiya, Gallabat, Hamart El Sheikh, Mellit, etc. Recently a number of quarantine farms have been established to keep introduced plant material and to train the technical personnel and upgrade their abilities. The farms are furnished with documents from the UN Food and Agriculture Organization and scientific journals and books to enhance the theoretical background of the technical staff.

7. Agricultural potential: The agricultural development potential is manifest in the large mass of productive land not yet utilized and in the favorable land/man ratio. The magnitude of the arable land, water, vast pastures, and forests qualifies Sudan for large-scale crops and livestock production. Sudan is currently utilizing about 24% of its potentially arable land.

Only about 18% of that is under intensive irrigated agriculture. The remainder, including mechanized and traditional rainfed agriculture, is under extensive patterns of land use. About 75% of the total natural pasture is utilized by nomadic and transhumant animal production systems. There is a great opportunity for optimization of the present farming and production systems through an enabling policy framework, use

of modern technology for increased productivity and improved rural and public and physical infrastructure. The present levels of productivity per man or unit land are low in both crops and livestock.

The potential for irrigated and mechanized rainfed farming lies mainly in increased use of suitable packages of technology, including high-yielding varieties and improved crop management methods. There is also room for horizontal expansion.

Sustainable agricultural growth is constrained by natural and structural constraints, technology constraints, socio-institutional constraints, policy constraints, infrastructural constraints, and exogenous constraints.

In spite of these constraints, Sudan was able to produce about 6 million tons of sorghum in years of good rainfall. Sudan's annual need of sorghum for consumption is about 3 million tons. According to the Comprehensive National Strategy 1994/95-2001/2002, the area for grains will increase by 15 million feddans, i.e., 78% more than the area grown in 1992-93. This expansion will require investment in irrigation and water resources to improve on the information and implementation capacities, generation and rational use of technology, and effective coordination with the neighboring countries sharing water resources with us.

Sudan is not only viable for itself, it is also important for a viable future for the countries around it. The physical and human resources base in Sudan can provide for sustainable agricultural growth and food security for Sudan and others in the region. Several causes may be cited for its failure to do so in the past, including misguided policies, poor infrastructure, low-level technology, political instability, recurring droughts—all these elements and others have led to questioning the viability of Sudan in spite of its vast resources.

Conclusion

Sudan has plenty of sunshine, vast productive land yet to be utilized, and plenty of water resources from the Nile system, and rainfall and groundwater not yet fully tapped.

Sudan is geopolitically well located, bridging the Arab world to Africa. Its large size and extension from north to south provide for several agro-ecological zones with a variety of climatic ecological conditions that support a variety of food and industrial crops and vast natural pastures and forests that support a large herd of livestock, including cattle, sheep, goats, and camels (Tables 8 and 9). Sudan has clear comparative advantages for the sustainable production of cereals, oil crops, sugarcane, pulses and vegetables, and fruits. Sudan can produce surplus quantities of tobacco and cotton, in addition to tropical fruits, tea, and coffee in the south.

Water resources available to Sudan from the Nile system and the groundwater resources provide a potential threefold increase in the irrigated sub-sector. There are also opportunities for increased hydropower generation.

A great potential for increasing production of food crops

TABLE 8

Animal Population (1985-86 to 1994-95)

(Thousands)

Year	Cattle	Sheep	Goats	Camels	TLU*	Poultry
1985-86	19,630	18,690	13,799	2,713	28,503	29,373
1986-87	19,738	18,807	13,942	2,705	28,480	30,027
1987-88	19,858	19,207	14,196	2,722	28,723	30,536
1988-89	20,167	19,668	14,482	2,732	29,158	31,387
1989-90	20,583	20,168	14,875	2,742	29,720	32,262
1990-91	21,028	20,701	15,264	2,757	30,325	33,463
1991-92	21,630	23,043	18,650	2,787	31,783	35,429
1992-93	25,092	26,518	22,673	2,886	36,406	37,511
1993-94	27,571	30,977	27,267	2,886	40,265	39,715
1994-95	30,077	37,145	33,319	2,903	44,580	42,423

* Tropical Livestock Unit (TLU) = 250 Kg = 1 cow, 6 sheep, 8 goats, 0.7 camel.

Source: Ministry of Animal Resources (MAR), Khartoum, Sudan.

TABLE 9

Animal Production (1985-86 to 1994-95)

(Thousands of Metric Tons)

Year	Red Meat	Milk	Fish	Poultry	Eggs
1985-86	265	2,698	25.3	—	22.8
1986-87	302	2,717	29.2	20.1	23.1
1987-88	311	2,744	27.5	20.1	23.1
1988-89	328	3,179	27.8	20.5	23.5
1989-90	338	1,987	28.9	21	24.1
1990-91	422	2,402	31.7	17.3	25.1
1991-92	610	4,060	35	19	28
1992-93	860	4,353	36	25	30
1993-94	1,137	5,198	40	27	33
1994-95	1,295	5,955	45	29	35

Source: Ministry of Animal Resources (MAR), Khartoum, Sudan.

and livestock lies in the rainfed sector. Its realization will require attractive policies, generation and use of proper technology, and improved physical infrastructure.

The physical and human resources base in Sudan can provide for sustainable agricultural growth and food security for itself and for others in the region. Its failure to do so in the past derives from several causes and conditions that are manageable. These include misguided policies, poor infrastructure, low-level of technology use, recurring droughts, and political instability.

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