FOOD SECURITY IN SUDAN: A HISTORICAL ANALYSIS OF FOOD AVAILABILITY

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ABSTRACT

This study aimed to analyse historical food availability in Sudan during 1961-2013. This was achieved by assessing the food supply (kg/capita/yr.), dietary energy supply (DES) (kcal/capita/day), composition of diets and food self-sufficiency. The study depended on the available secondary data from FAO balance sheets. Percent share, annual cumulative growth rate and trends were used as analytical tools. The total food supply had a positive growth rate of 4.9%. The DES increased from 1743 to 2186 kcal/capita/day, implying that Sudan is food insecure. Cereals constitute approximately half of the total DES. The percentage share of vegetal sources was paramount in the DES (80%), protein supply (60%) and fat supply (45-68%) relative to that of animal sources. The per capita consumption of protein and fat (g/capita/day) were considered within the adequate supply, and below the average of the world and Arab countries. Carbohydrates ranked as the highest source contributing to the DES, followed by fats and proteins. These macro-nutrient contributions to the total DES fell within the recommendation ranges of the WHO for the balanced diets. The growth rate of imports outnumbered that of the domestic food supply and production, reflected in declining trend of the overall food self-sufficiency ratio by 1.5% per decade. The study recommended efficient use of Sudan abundant resources to increase food availability.

Key Words: Balance sheet; dietary energy supply; total food supply and self-sufficiency ratio

الأمن الغذائي بالسودان:التحليل التاريخي لإتاحة الغذاء

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المستخلص

تهدف هذه الدراسة للتحليل التاريخي لإتاحة الغذاء بالسودان خلال الفترة 1961–2013. وتم تحقيق هذا الهدف من خلال تقييم امدادات الغذاء(كجم/ فرد/ سنة)، الاحتياجات الاستهلاكية (سعر حراري/ فرد/ يوم)، المكونات الغذائية والاكتفاء الذاتي من الغذاء. واعتمدت الدراسة على البيانات الثانوية المتاحة من ميزانيات الأغذية بمنظمة الزراعة والأغذية العالمية. وتم استخدام نسبة المساهمة، معدل النمو التراكمي السنوي وتحليل الاتجاه العام كادوات تحليلية لتحقيق الأهداف. واتضح من الدراسة بان معدل النمو للامداد الغذائي كان إيجابياً وبلغ نحو 4.9% وشهدت الاحتياجات الاستهلاكية زيادة من 1743 الى 2186 سعر حراري/ فرد/ يوم ، مما يشير الى عدم تحقيق الأمن الغذائي بالسودان خلال فترة الدراسة. وساهمت مجموعة الحبوب بحوالي 50% من الاحتياجات الاستهلاكية للسعرات الحرارية . كما أتضح بان مجموعة المنتجات النباتية لها النصيب الأكبر في كل من امداد الطاقة الغذائي (80%) ، البروتين (60%) والدهون (45–68%) مقارنة بمجموعة المنتجات الحيوانية. وأتضح كذلك بان نصيب الفرد من البروتين والدهون (جم/ فرد/ يوم) يقع في المدي المطلوب ولكنها أقل من نصيب متوسط الفرد بالعالم والدول العربية. واحتلت الكاربوهيدرات المرتبة الأولى للمساهمة في الاحتياجات الاستهلاكية للسعرات الحرارية تليها الدهون والبروتين. ويقع معدل نصيب الفرد من العناصر الكبرى ضمن المدى الموصى به من منظمة الصحة العالمية للغذاء المتوازن. وفاق معدل نمو الواردات كل من نمو المتاح للاستهلاك والانتاج المحلي مما انعكس في انخفاض نسبة الاكتفاء الذاتي من الغذاء بنحو 1.5% لكل عقد من الزمان.

الكلمات المفتاحية: ميزانيات الأغذية ،إمدادات الغذاء، إمدادات الطاقة الغذائية والاكتفاء الذاتي من الغذاء

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INTRODUCTION

FAO stated that 'Food security' exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious foods to meet their dietary needs and food preferences for an active and healthy life (5).This definition reveals the four dimensions of food security, including the physical availability of food, economic and physical access, utilization, and stability of the previous three dimensions over time. Food security remains a major humanitarian concern in multiple contexts. The second Sustainable Development Goal is to end hunger, achieve food security, improve nutrition and promote sustainable agriculture. This requires improving the productivity of small-scale farmers and increasing investments through international collaboration to increase the productive capacity of agriculture in developing countries (23). The agricultural sector acts as an engine of growth for the Sudanese economy. It supplies food for the people, employment opportunities and provides the industrial sector with raw materials. Sudan is considered as one of the three countries in the world that can contribute in the international food security (19). The sector contributed about 30% GDP and 53% of employment in 2018(7). Consumption is considered an important welfare indicator. It is a crucial factor in the development of production and price policies. Moreover, the studies of changes in consumption patterns and factors affecting consumption play a great role in improving the economic welfare of society. Food balance sheets (FBSs) are referred to as national food accounts, apply/utilization accounts, food disappearance data, or food consumption level estimates. They are prepared by the Food and Agriculture Organization (FAO) of the United Nations in collaboration with national statistics offices. Foods tracked through FBSs include primary commodities and a number of processed ones (15). Attaining food security is one of the major challenges facing the forthcoming decades; therefore, analysing the past is one of the key elements for tackling future food security challenges. This study focuses on assessing historical food availability as one of the pillars of food security in Sudan during the period of 1961-2013. This is achieved by assessing the food supply (kg/capita/yr.), dietary energy supply (kcal/capita/day) and diet composition. The analysis of diet composition is performed by assessing vegetal and animal food supply sources and the macro-nutrient components of the dietary energy supply. Since part of the food supply is internationally traded (imports and exports), food self-sufficiency is investigated during the study period.

MATERIALS AND METHODS

This study depends mainly on secondary data that were collected from the FAO balance sheet during the period from 1961-2013.The study limited the time horizon up to 2013 as the available data from FAO website is only up to 2013 for all countries. Moreover the National institutions of Sudan do not provide the required detailed data and the most recent released household survey was dated 2009. The period includes data for formal Sudan (1961-2011) and for the Republic of Sudan (2012-2013), since the secession of South Sudan from the formal Sudan in 2011. Nevertheless, as most of the data are on a per unit basis, no differentiation is considered in the analysis. The data were rearranged and calculated into 10-year averages (decades) to reduce inter-annual variation and to permit comparisons between the decades. The information supplied in FBSs considered for this study included the production (1000 tons), domestic supply quantity (1000 tons), food supply quantity (kg/capita/yr.), food supply (kcal/capita/yr.), protein supply quantity (g/capita/day), and fat supply quantity (g/capita/day). The contributions of different food groups to the macronutrients (proteins, fats and carbohydrates) were calculated and analysed. This study treats food groups as originally classified in the FBS. Descriptive statistics such as percentages, cumulative annual growth rates and trends were used to achieve the study objectives. Three measures classifying the minimum Dietary Energy Supply (DES) levels for food availability were used as benchmarks to assess the status of the DES in Sudan. The First measurement was the global minimum DES for years 1990–2005of 1820 kcal/capita/day (10). The second measurement was the analysis of the national

baseline household survey conducted in Sudan in 2009, which was 2180 kcal/ capita/ day(11). The third measurement was the adjusted adequate DES, of 2500-3000 kcal/capita/d (17, 20). The diet composition (vegetal and animal sources) was analysed by using the thresholds set by (6) stating that the level of animal food considered inadequate was 0–5% of the total DES; adequate,5–15%; high,15–25%;and very high,>25%.Moreover, the global and Arab standards for the different measures were used for comparison with the Sudanese diet composition. The self-sufficiency ratio (SSR) for different food items was calculated in accordance with the methods of (21) as follows:

$$\textbf{Self} - \textbf{sufficiency Ratio } (\textbf{SSR}) = \frac{\textbf{Domestic production}}{\textbf{domestic consumption}} \textbf{ X100} \qquad (1)$$

$$\textbf{domestic consumption} = \textbf{Production} + \textbf{imports} - \textbf{exports} + \textbf{changes in stocks} \qquad (2)$$

RESULTS AND DISCUSSION

The food availability has increased worldwide over the last four decades due to improvements in productivity, greater diversity of foods, less seasonal dependence, increasing income levels and decreasing food prices. This phenomenon has resulted in considerable changes in food consumption over the past five decades (16). Food availability as a dimension of food security captures not only the quantity but also the quality and diversity of foods. Indicators for analysing food availability include the adequacy of the DES, the share of calories derived from different food groups and the average protein and fats supply (8).

Food supply (kg/capita/yr.):

The food supply (kg/capita/yr.) represents the estimates of per capita food supplies available for human consumption during the reference period in terms of quantity. FBSs illustrate the food consumption per capita of a country, but they don't represent the amount of food actually consumed, which results in an overestimation of food consumption compared with dietary surveys at the individual level (13, 16). In Sudan, the total average food supply (kg/capita/yr.) had a positive growth rate of 4.9% from an average of 358 kg during the period of 1961-1970 to 479 kg in2011-2013, with an increase of 32.4 kg/capita/yr. for each decade. Over the same time period, milk, vegetables**,** sugar and sweeteners and cereals expressed high growth rates compared to the other food groups, amounting to 10.6%, 6.6%, 5.1% and 4.1%, respectively. Starchy roots and oil crops showed negative food supply growth rates of -11.5% and -1.4%, respectively, between 1961 and 2013as shown in Table 1. The fruit and vegetable consumption of Sudan is below the recommended level of the WHO of 146 kg/yr. (17) and below the level of the vegetable consumption in Arab countries of147.59 kg/yr. in 2008 (18).

Table 1. Share of the selected food groups in food supply (kg/capita/yr.), 1961-2013

	1961-1970		1971-1980		1981-1990		1991-2000		2001-2010		2011-2013		CAGR	Trend equation
	v	%	v	%	v	%	v	%	v	%	v	%		
Cereal	102	28	119	31	121	30	137	30	124	23	130	27	4.1	Y= 105+4.8X
Fruits	36	10	35	9	28	7	27	6	50	9	38	8	0.6	Y= 30.5+1.5X
Oil Crops	5	1	5	1	5	1	5	1	5	1	5	1	-1.4	Y= 5.5-0.1X
Pulses	6	2	4	1	4	1	6	1	8	2	7	1	2.8	Y= 3.9+0.5X
Starchy Roots	20	6	13	3	8	2	9	2	12	2	10	2	-11.5	Y=17.4-1.6X
Sugar and Sweeteners	14	4	18	5	20	5	14	3	22	4	18	4	5.1	Y= 1.5+1.4X
Vegetables	37	10	36	9	35	9	47	10	67	12	54	11	6.6	Y= 26.7+5.5X
Meat	20	6	21	6	18	4	20	4	25	5	21	4	0.8	Y= 19+0.5X
Milk	85	24	85	22	119	30	139	31	183	34	155	32	10.6	Y= 61.1+18.9X
Others	34	9	43	11	43	11	46	10	44	8	42	9	3.7	Y= 37.4+1.3X
Total	358	100	379	100	401	100	450	100	541	100	479	100	4.9	Y= 321+32.4X

V: value (kg/capita/yr),
CAGR: Cumulative annual growth rate

Dietary Energy Supply (DES):

Insufficient food energy intake is almost always accompanied by incomplete intake of most nutrients. Understanding the consequences of how insufficient energy intake in children and adults affects their health, as well as food and agricultural policies worldwide. More recently, the consequences of increasing rates of obesity and nutrition-related chronic diseases have also been known as major determinants for the health, food and agriculture sectors (12). Diets in Sudan are extremely different and are largely associated with the highly diversified climate and resource base of the region. The climate varies from hyper-arid in the north to sub-humid in the south. Given the climate, diets in the north tend to be less diverse than diets in the more fertile south (22). Table 2 shows that during the last five decades, the DES in Sudan increased from 1743 to 2186 kcal/capita/day with an annual growth rate of 3.8%.This implies that Sudan is food secure based on FAO(2010 and 2013), while it is insecure when using the adjusted levels of the minimum dietary energy supply (17, 20).This result is in line with the (9) stating that "statistics show that average available calories from all foods in Sudan varied from 2187 to 2282 Kcal / capita / day during 2003-2007 which put the country at the margin of standard energy requirements of 2100-2200 Kcal / person /day. These levels are way below the world average of 2749-2798 Kcal as well as averages reported in various regions of the world, e.g., North Africa (2948-3016), Southern Africa (2884-2918) and West Asia (3037-3104). Moreover, they obscure great disparities among states illustrated by high levels of under nutrition as described above". Cereals constituted approximately half of the total DES during the study period, with an annual growth rate of 4.0%. This result is in line with (16,22) stated that cereals provided a high share of 56.5% of the total DES in Sudan in 2009 and as much as 54% in developing countries. The annual growth rate of the milk contribution to the DES outnumbers the other food groups (12.1%) between 1961 and 2013, indicating improvement of the food security status in Sudan. This result is also confirmed by the positive growth rates of pulses and fruits and the decreasing contribution of starchy roots and oil crops.

Table 2. Percent share of major food items in food supply (kcal/capita/day) during the period 1961-2013

Food Group	1961-1970	1971-1980	1981-1990	1991-2000	2001-2010	2011-2013	CAGR
Cereal	50.4	50.6	51.5	54.5	45.9	50.6	4.0
Fruits	3.3	2.9	2.4	2.2	3.7	2.9	1.8
Oil Crops	4.5	3.8	3.9	3.5	3.2	3.2	-1.5
Pulses	3.0	2.0	2.0	2.4	3.3	2.8	2.7
Starchy Roots	3.3	1.7	1.1	1.0	1.2	1.0	-14.3
Sugar and Sweeteners	7.6	8.6	9.5	6.4	9.2	8.2	5.2
Vegetable Oils	7.9	12.4	8.4	7.1	5.7	6.5	0.6
Meat	6.3	5.7	4.9	5.1	6.1	5.4	1.5
Milk	8.9	7.8	11.5	12.7	15.9	14.0	12.1
Others	4.7	3.9	3.6	4.1	5.1	4.6	3.3
Total DES	1743	2020	1983	2134	2307	2186	3.8

Source: Authors calculation based on FAO balance sheet Sudan data

Composition of Diets

In addition to the assessment of the food supply (kg/capita/yr.), the energy content of foods and the composition of diets during the study period were analysed. This was done by first analysing the share of animal and vegetal sources in the DES. Second, the share of the food supply represented by the protein and fat supplies (g/capita/day) was measured. Third, the contribution of macronutrients to the total

DES was analysed. The percentage share of vegetal sources is paramount to the DES (approximately 80%), the protein supply (approximately 60%) and the fat supply (ranging approximately 45-68%), relative to that of animal sources during the last five decades as shown in Figure 1. Nevertheless, the contribution of animal sources to the DES is considered adequate to high following (6). This result is in line with (17), in which the kilocalories from animal-source foods remain very low across most of the African countries. In addition, the result is aligned with (2), explaining that the vegetal sources in the Arab world constitute approximately85%of the DES, 68% of the protein supply and approximately 70% of the fat supply. These rates are below the global share of animal sources estimated by the FAO of 17%, 38% and 45% of the DES, protein supply and fat supply, respectively (1). The annual growth rate of animal sources dominated that of vegetal sources. This is shown by the growth rate of the animal sources amounting to 7.8%, 6.5% and 7.7% of the DES, protein supply and fat supply, respectively, relative to that of vegetal sources with 2.9%, 3.7% and 0.03%, in the same respective order, between the period 1961/70 to 2011/2013 as shown in Table 3.

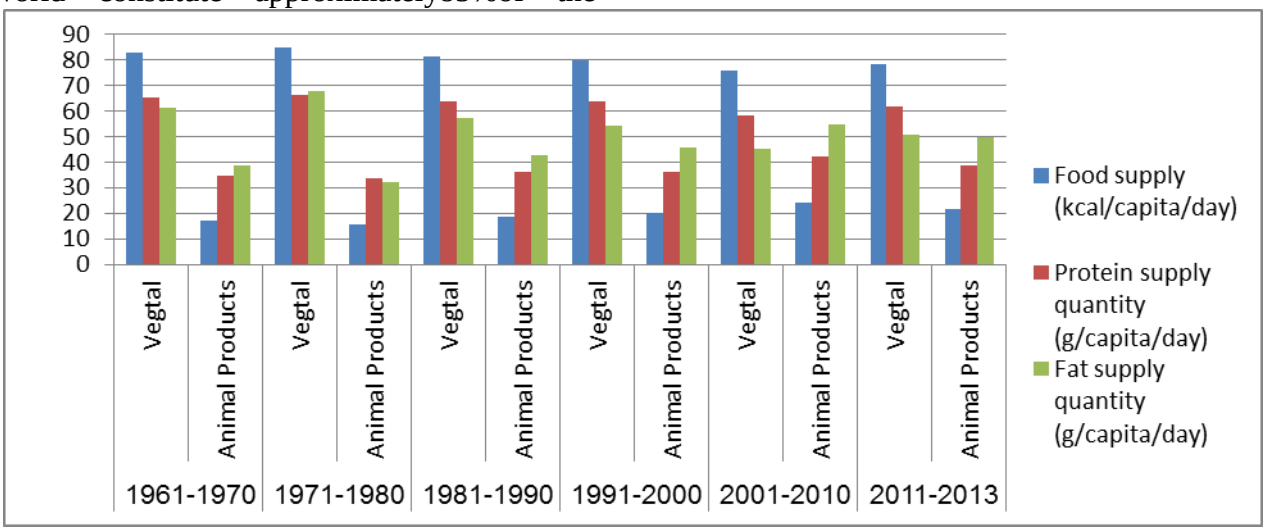

Figure 1. Percentage share of vegetable/animal origin of energy, protein and fat supplies (1961-2013)

Table 3. Cumulative average growth rate (CAGR) of vegetal and animal products in dietary energy, protein and fat supplies in Sudan (1961/70–2011/13)

Item	1961-1970	2011-2013	CAGR
Share of Dietary Energy Supply (Kcal/capita/day)			
Vegetal	**1442**	**1714**	**2.9**
Animal Products	**302**	**472**	**7.8**
Share of Protein Supply(g/capita/day)			
Vegetal	**34**	**43**	**3.7**
Animal Products	**18**	**27**	**6.5**
Share of Fat Supply(g/capita/day)			
Vegetal	**33.07**	**33.13**	**-0.03**
Animal Products	**21**	**33**	**7.7**

Source: Authors calculation based on FAO balance sheet Sudan data

Contribution of selected food groups to protein and fat content (g/capita/day):

The per capita consumption of protein during the period of 1961-2011 ranged between 53-75 g/capita/day with a growth rate of 4.7%. According to the Centres for Disease Control (3), this amount is considered an adequate supply, given that an average and moderately active adult requiredapproximately50 g/capita/day in 2009. The protein supply (g/capita/day) is below the average of both Arab countries of 82g/capita/day(1) and the world average of 79 g/capita/day(3). Cereals constitute the main source of protein with a growth rate of 4.2%. Meat and Milk had an equal contribution to protein in the 1960s and 1970s; however, milk expressed the highest growth rate, amounting to 11.3% compared to only 0.5% for meat during the period of 1961-2013 as shown in Table 4. The per capita fat

consumption ranged between 54-70 g/capita/day, with a growth rate of 3.3% during the period of 1961-2011. This is in line with the recommendation of (24) of 53-93 g/capita/day. However, this amount is considered below the global average of 82 g/capita/day in 2009 (17) and of Arab country of 72 g/capita/day in 2010 (1). Most of the increase in fat consumption (g/capita/day) had come from vegetable oils followed by cereals, milk and meat. However, their growth rate is ranked as milk, cereals, meat and vegetable oils of 13%, 2.7%, 1.9% and 0.6%, respectively, during the period 1961–2013.

Table 4. Share of the food groups to protein and fat supply quantities (g/capita/day), 1961-2013

	1961-1970	1971-1980	1981-1990	1991-2000	2001-2010	2011-2013	CAGR
Contribution to Protein (g/capita/day)							
Cereal	24.8	29.0	29.5	33.6	30.3	31.8	4.2
Pulses	3.4	2.7	2.7	3.4	5.1	4.1	3.1
Meat	8.2	8.5	7.2	7.9	9.8	8.5	0.5
Milk	8.3	8.6	12.4	14.2	18.6	15.8	11.3
others	4.0	3.9	3.4	4.4	5.8	5.0	3.7
total	52.6	56.6	59.1	67.9	74.5	69.5	4.7
Contribution to Fat (g/capita/day)							
Cereal	9.7	11.1	10.1	12.1	10.8	11.3	2.7
Oil crops	6.7	6.6	6.5	6.5	6.3	6.0	-1.7
Vegetable oils	15.6	28.5	19.0	17.3	15.0	16.2	0.6
Meat	8.2	8.8	7.5	8.1	11.0	9.2	1.9
Milk	9.4	9.7	14.0	17.1	23.7	19.7	13.0
Animal Fat	2.6	2.7	3.0	2.9	2.9	2.8	1.4
others	1.7	0.6	0.4	0.4	0.7	0.4	-21.3
Total	53.9	68.0	60.5	64.3	70.3	65.7	3.3

Source: Authors calculation based on FAO balance sheet Sudan data

The Contribution of Macronutrients (carbohydrate, fat and protein) to DES

Energy for the metabolic and physiological functions of humans is derived from the chemical bonds in foods and their macro-nutrient components (carbohydrates, fats, proteins and ethanol). After food is ingested, its chemical energy is released and changed into thermal, mechanical and other types of energy (12). It is noted that carbohydrates ranked as the highest source of dietary energy supply in Sudan during the last five decades. It constitutes approximately 60% of the DES, with an annual growth rate of 3.9% during the period 1961-2011. Fats contributed 27-30%, with a growth rate of 3.3% in the DES during the same period. Proteins provide approximately11-13% of the total DES, with paramount growth of 4.7% during the same period as shown in Table 5. The macro-nutrient contributions to the total DES fall within the recommendations range of the WHO/FAO for macro-nutrient balanced diets consisting of 10-15% from protein, 15-30% from fat and 55-75% from carbohydrate (25).

Table 5. Share of macronutrients in the DES (Kcal/capita/day), 1961-2013

Items	1961–1970		1971–1980		1981–1990		1991–2000		2001–2010		2011–2013		CAGR
	V	%	V	%	V	%	V	%	V	%	V	%	
protein	210	12	227	11	237	12	271	13	298	13	278	13	4.7
fat	485	28	612	30	545	27	579	27	632	27	591	27	3.3
Carbohydrates	1048	60	1181	58	1202	61	1284	60	1376	60	1318	60	3.9
total DES	1743	100	2020	100	1983	100	2134	100	2307	100	2186	100	3.8

Source: Authors calculation based on FAO balance sheet Sudan data

Self-sufficiency Ratio (SSR)

=Food self-sufficiency measures the ability of a country to meet consumption needs (particularly for staple food crops) from domestic production as much as possible with minimal dependence on trade. It indicates the magnitude of production in relation to domestic utilization (4, 14).There is a long-standing debate on whether food self-sufficiency is a useful policy to attain food security. Supporters of this proposition argue that depending on the market to meet food needs is a risky strategy because of food price instability and possible supply interruptions. Therefore, self-sufficiency ensures a reliable food supply and avoids dependence on international markets. The opposing view is that it is costly for a household (or country) to concentrate on food self-sufficiency rather than production based on comparative advantages while acquiring some of its required food from the market (14). Table 6 shows that Sudan food production, imports and domestic supply increased by 4312, 367 and 4640 thousand tons per decade, respectively, during the period of 1961 to 2013. Nevertheless, the growth rate of imports (30%) outnumbered the growth rates of domestic food supply (25%) and production (24%). The net result is reflected in the declining trend of the overall food self-sufficiency ratio by 1.5% per decade.

Table 6. Trend of production, imports, domestic supply and food self-sufficiency in Sudan, 19961-2013

Item	Trend equation	Growth rate
Production	**Y= 1980+4313X**	**24.1**
Domestic supply	**Y=1395+4641X**	**25.4**
imports	**Y= -150+367X**	**30.0**
food self-sufficiency ratio	**Y=103-1.5X**	**-1.1**

Source: Authors calculation based on FAO balance sheet Sudan data

Most SSR analyses focus on the main staple food of a country to provide an approximation of food self-sufficiency. The main Sudanese staple foods are sorghum and millet. A significant quantity of meat and milk are consumed in more pastoral areas as well (22). Sudan was approximately self-sufficient for most food items during the study period, The SSR for cereals, vegetables, eggs, fish and milk showed decreasing trends during the study period. While that of fruits and meat exhibited increasing trends as shown in Table 7. The decreasing trend of the cereals SSR could be attributed to the changing consumption patterns towards wheat against sorghum. This situation is aggravated by the decreasing area allocated to wheat production, coupled with insufficient hard currency to meet the demand for wheat imports.

Table 7. Self-sufficiency ratio for Sudan main food items during the period of 1961-2013

Item	1961-1970	1971-1980	1981-1990	1991-2000	2001-2010	2011-2013	Trend Equation
Cereal	**100.5**	**101.8**	**85.6**	**89.3**	**79.8**	**81.8**	**y = 105-4.5x**
Fruits	**98.2**	**99.4**	**100.1**	**100.6**	**99.4**	**99.7**	**y=99+0.23x**
Vegetable	**99.8**	**99.6**	**99.9**	**99.6**	**98.6**	**99.0**	**y=100-0.22x**
Eggs	**100.0**	**100.0**	**99.7**	**99.7**	**97.4**	**98.7**	**y=101-0.41x**
Fish	**101.6**	**99.6**	**99.1**	**96.6**	**97.6**	**96.9**	**y=102-0.92x**
Meat	**99.9**	**100.8**	**100.0**	**101.2**	**100.4**	**100.6**	**y=100+0.1x**
Milk	**98.3**	**98.4**	**95.8**	**99.0**	**97.7**	**97.9**	**y=98-0.03x**

Source: Authors calculation from FAO Balance Sheet

Conclusion

The study concluded that Sudan is food insecure. The per capita consumption of protein and fat (g/capita/day) were within the adequate supply, and below the averages of the world and Arab countries. There was declining trend of the overall food self-sufficiency. The study recommended efficient use of Sudan abundant resources to increase food availability.

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