OUTLOOK 2016

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Soil productivity and food security in Sudan: Current situation and challenges

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ABSTRACT

Purpose: As a country of the developing world, Sudan already contends with chronic poverty and a food crisis. Soil productivity presents yet another significant challenge to be met. The decrease in agricultural production during the growing seasons adversely affects human lives and causes scarcity of major crops in Sudanese markets. As a result, prices increase and imports from outside the country also increased to fill the gap even for major crops, for example, wheat and some vegetables.

Methodology: As a country of the developing world, Sudan already contends with chronic poverty and a food crisis. Soil productivity presents yet another significant challenge to be met. The decrease in agricultural production during the growing seasons adversely affects human lives and causes scarcity of major crops in Sudanese markets. As a result, prices increase and imports from outside the country also increased to fill the gap even for major crops, for example, wheat and some vegetables.

Findings: Results revealed that most agricultural schemes grow vegetables and fodder throughout the year. There is also a significant reduction in agricultural production in all schemes that reached up to 40% compared to the last 10 years. The increase in temperature, especially during the winter season, forced some farmers to change their crop bands. The irrigation of the water supply, spread of diseases, high cost of fertilisers, soil erosion and lack of agricultural extension also affected crop production in most schemes.

Value: Therefore it is recommended that urgent measures should be implemented in order to increase agricultural production. Land management programmes and fertilisation strategies must be considered.

Implementation of awareness programmes about the hazards of climate change and temperature increases is needed urgently, especially among farmers and decision makers for better planning and future outlook.

Keywords: agricultural potential; soil productivity; food security; fertilisation management; climatic hazard; soil quality.

INTRODUCTION

The agricultural sector has gone through evolution over the past decades when many new ideas were implemented and many new technologies were introduced. Producing more food for higher demand had become a continuous challenge around the globe, leading to food security problems in the medium and long terms. In the late 1960s and early 1970s, it was assumed that the growth of agricultural production would be unable to meet world demand. However, in the mid-1970s world food production grew rapidly by using various newly introduced farming methods. Since the late 1980s, however, high food production raised new threats due to the depletion of environmental and natural resources and land degradation. Considering these facts, the concept of sustainable agricultural development and international food security has received priority (Lancker and Nijkamp, 2000).

Despite the continued development of new and improved modern varieties and greater use of chemical fertilisers, yield growth began to slow in the latter part of the 20th century. The world's annual cereal yield growth rate has declined from an average of 2.2% in the 1970s to 1.1% in the 1990s. Wheat yields in Asia grew at an average annual rate of 4.3% during the 1970s, but during 1990–1997, wheat yields dropped to the far slower growth rate of 0.7% per year. After rapid growth of almost 2.4% per year during the 1980s, the Asian rice yield growth fell to 1.5% per year in the 1990s. This global slowdown has raised concerns that yield growth may have reached a plateau or begun to decline in many of the world's most fertile areas.

In Sub-Saharan Africa, the situation is even more dramatic, with cereal yield growth decreasing steadily from 1.9% during the 1970s to 0.7% in the 1990s. These declines in Sub-Saharan Africa are partly attributable to poor soil management, which in turn has been accentuated by a number of other factors, including inappropriate policies, insufficient commitment to investment in agricultural research, falling agricultural prices, demographic pressures, land availability constraints and ill-defined property rights. The cumulative effect of all these factors has led to increased soil mining.

A significant decline in soil quality has occurred worldwide through adverse changes in its physical, chemical and biological properties, and contamination by inorganic and organic chemicals. In the past half a century, about 2 billion of the 8.7 billion ha of agricultural land, permanent pastures, and forests and woodlands have been degraded. The rate of growth of global grain production dropped from 3% in the 1970s to 1.3% in the 1983–1993 period, and one of the key reasons for this decline is inadequate soil and water management (Steer, 1998).

Concerned by the decline in soil quality, and in an attempt to reverse this trend, Dennis Keeney, director of the Leopold Center for Sustainable Agriculture (USA), has called for an enactment of a national soil quality act, similar to the water and air quality legislation, with an emphasis on a strong, co-ordinated research-demonstration-incentives approach. When soils are degraded to the level that they can no longer perform their ecosystem functions, restoration is slow, expensive and uncertain. "How many waste sites have been truly reclaimed?" How many salt slicks made productive? Any nation or state that supports an ecosystem that degrades soil is not sustainable" (Keeney, 1999).

Sudan's economy, like that of many developing countries, is heavily based on farming and livestock keeping, the major employment sectors of the country. More than 70% of the population relies on traditional and subsistence agriculture, the majority of which are dependent on rainfed agriculture and pastures. This all makes our economy extremely vulnerable to any slight changes in the weather. These changes are happening now and many people's livelihoods are under threat.

Sudan, together with other countries in the Sahel belt, has suffered several long and devastating droughts in the past few decades. The most severe drought occurred in 1980–1984, and was accompanied by widespread displacement and localised famine. It was estimated that six million people have been displaced, mostly by drought, desertification, and famine in the north, and by conflict, famine and flood-induced epidemics in the south.

Desertification now threatens agriculture and the livelihoods of millions of Sudanese people living at the edge of the dry Sahel belt; even small variations in temperature and rainfall here could tip the balance towards desert conditions. By 2030, Sudan's average annual temperature will increase between 0.5 and 1.5°C, and rainfall is expected to drop by approximately 5%. We predict a major decline in yields for Sudan's three most common crops – sorghum, millet and Gum Arabic (Bennett et al., 2013).

Reports from FEWSNET (2015) revealed that preliminary crop estimates from the 2015/16 agricultural season suggest national cereal production could be up to 25% below the five-year (2009–2013) average, driven by dryness-related reductions in yield and area planted in both surplus-producing and deficit-producing areas, including eastern areas affected by El Niño.

Cereal production in the key producing area of Gedaref State is likely to be below average, and similar to or slightly less than in 2013/14. In North Kordofan, Kassala and North Darfur States, the harvest is expected to be well below average.

In December, sorghum prices in Gadaref and Kassala remained stable or increased slightly, contrary to the seasonal tendency for prices to continue decreasing in December following the harvest. Millet and sorghum prices in El Fasher, although showing declines in December, remain 40% above the two-year average, and are expected to continue increasing more than usual through the rest of the consumption year.

Pasture deficits are estimated to be very severe in most areas, particularly in North Darfur, North Kordofan, Kassala and While Nile States, as well as the Butanah plain. These conditions have led to poor condition of livestock, large-scale migrations of livestock two months earlier than usual, and below-average livestock prices. In Kassala market, sheep prices are 15% and 25% below last year and the recent two-year average, respectively, while terms-of-trade are 24% below the recent two-year average. Together, increasing staple food prices and decreasing livestock prices will reduce terms of trade for pastoral and agropastoral households, who will face difficulty meeting staple food needs.

The 2013/14 harvest was, as expected, 15–20% below average; this was due to a late start to the rains, and rainfall deficits during critical points in the season. In the central and eastern surplus-producing areas of Sudan, the harvest is likely to be well below average, roughly 60–70% of average (FEWS NET, Oct 2013).

In the surplus-producing areas of eastern and central Sudan, rainfall totals over the course of the season were 20–50% below average. Due to a late start of the rains and heavy rains in August, most farmers planted at least one month late, in August/September instead of July: late planted crops are extremely vulnerable to wilting. A rapid mid-season assessment by FEWS NET, FAO, USAID/FFP and the Federal Ministry of

Agriculture and Irrigation (MoA&I, 2011) in September found that total area planted was 20–30% below the five-year average (2005/6–2009/10).

However, the traditional rain-fed sector of White Nile, North Kordofan and Darfur states, and the irrigated sector of central and east Sudan, performed relatively better compared to the semi-mechanised rain-fed sector of central and east Sudan. Since the semi-mechanised sector produces about 50% of Sudan's total cereal production, national cereal production this year is projected to be 15–20% below average.

A below-average harvest of cereal and cash crops is likely this year. In the areas most affected by conflict, the harvest is likely to be 20–30% of normal. In relatively secure areas, the millet and groundnut harvests are likely to be 50% and 60% of average, respectively (FAO report, 2010).

In many parts of East Darfur State, late rains and high levels of conflict and insecurity due to tribal conflict are driving increased food insecurity. Harvests are expected to be below average in seven out of nine localities in East Darfur, particularly for millet, the main staple food.

In South Kordofan State, the area planted during the past two years has been 45–50% below average, and 60–70% below the five-year average, for the traditional rain-fed and semi-mechanised rain-fed sectors, respectively. By mid-September this year, only 60–70% of the area was planted compared to the last two years, due to late rains (FAO report, 2010).

This year's harvest is likely to be 30% of the pre-conflict average in the traditional rain-fed sector (compared to average production of 281,000 tons), and 70% of the pre-conflict average in the semi-mechanised rain-fed sector (compared to average production of 165,000 tons).

In Blue Nile state, the bulk (over 80%) of cereal production is produced in the semi-mechanised rain-fed sector, while conflict has mainly affected the traditional rain-fed sector. Thus, the area planted and crop production has been close to average over the last two years. However, by the first week of September this year, about 60% of the typical area was planted in the semi-mechanised sector of Blue Nile state. This figure is likely to increase, but the harvest is still expected to be below average given late planting (FAO report, 2010).

The semi-mechanised sector of Blue Nile state is an important destination for seasonal agricultural labour from within the state, Upper Nile state of South Sudan, and for labourers from North Kordofan and other neighbouring areas.

A study by Zakieldeen (2009) revealed that climate variability and climate change are likely to intensify the desertification of arable areas. It also predicts that the humid agro-climatic zones are likely to shift southward, rendering areas of the north increasingly unsuitable for agriculture.

In addition, crop production is predicted to decline substantially for both millet and sorghum; this is because of decreasing rainfall and increasing variability in its distribution. The same results were also shown where the climate effects from both models resulted in a yield loss of 5–25% between 2000 and 2050 over most of the country's sorghum harvest area.

The areas suitable for arable land, as well as the important gum Arabic belt, are also expected to decrease in size, with negative impacts for both local incomes and food security (Zakieldeen, 2009).

Study findings show that humid agro-climate zones will shift southwards, rendering areas of the north increasingly unsuitable for agriculture. For example in Kordofan Region millet production is predicted to decline between 15% and 62%, sorghum between 29% and 71% and gum Arabic between 25% and 30% during the period 2030 to 2060 (Nimir and Elgizouli, 2011).

Those same climate models show some limited gain in the baseline area that could potentially offset part of the yield loss in the rest of the cropped land. For irrigated wheat, both climate models predict very negative impacts, ranging from a complete loss of the baseline area to a yield loss of 5–25% of baseline or more. The most heavily affected areas will be central Sudan (the Gezira scheme and along the White and Blue Niles) and part of the River Nile state. While these areas produce 75% of Sudan's wheat, they are marginal areas for wheat production, with current temperatures already warmer than optimal for wheat.

METHODOLOGY

Data collection and field survey

The study site: The study was carried out in different agricultural schemes in Khartoum state covering Khartoum North and Khartoum. The locations of the schemes were shown in Table 1.

Table 1 Locations of the investigated agricultural schemes

Scheme	*Alshaab*	*Alsilait*	*Alwaha*	*Wad Ramli*	*Om Arda*	*Algumoyia*
Location	36 P 454830 1782476	36 P 463322 1720140	36 P 489937 1695253	36P 486992 1695903	36 P 453647 1750725	36 P 440707 1693405

Source: Devised by the authors.

Data collection

1. Data were collected from farmers in the selected schemes using a questionnaire, focusing on history of the schemes, area cultivated, agricultural potential, productivity, problems and constraints that affected agricultural production.
2. Arc View version 3.1 was used to present the change in agricultural potential from the year 2000 to 2014. Data about the yield in 2000 of the schemes studied was collected from the Ministry of Agriculture, Khartoum State. Data for the year 2014 was obtained from the questionnaire.

The change in area cultivated in the studied schemes was calculated as follows:

Area cultivated in the year 2000 $= (X - C1) \times 100/X$

Area cultivated in the year 2014 $= (X - C2) \times 100/X$

Where:

X = Total area of the scheme

$C1$ = Area cultivated in the year 2000

$C2$ = Area cultivated in the year 2014

Soil sampling and analysis

Soil sampling: Soil samples were collected from the schemes in different locations and at 0–30 cm and 30–60 cm depths. Soil samples were analysed in the laboratory for productivity and quality control assessment using the methods described by Page et al. (1986).

RESULTS AND DISCUSSION

Agricultural potentiality in the studied schemes: results of the data collected from the field survey revealed that vegetables were found to dominate in all schemes, followed by fodder, cereals, legumes and fruits.

Change and reasons in Agricultural yields reduction in the studied schemes: results of the change of the agricultural yields in the schemes from 2000 to 2014 ARFE shown in Figure 2, where more than 50% of the farmers investigated suffered from a reduction in their production throughout the growing seasons.

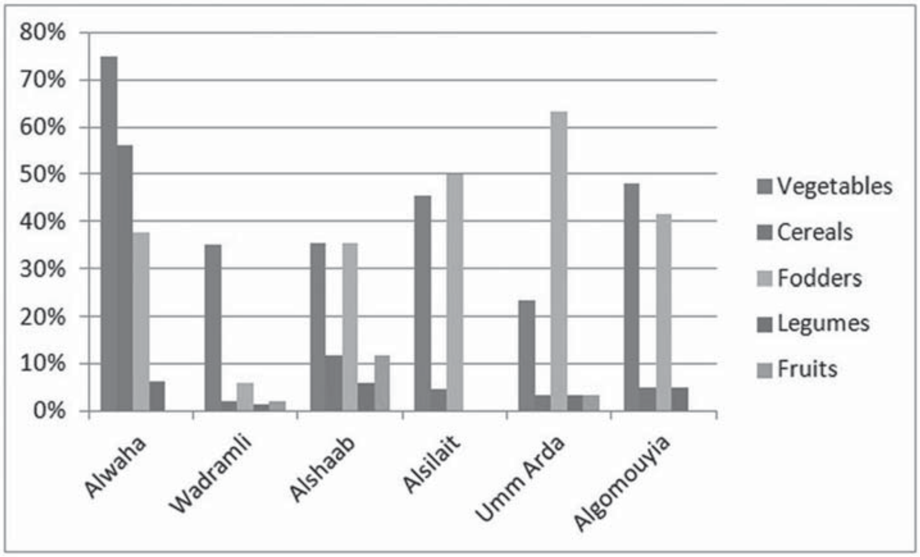

Figure 1 Agricultural potentiality in the studied schemes, % of total area

Source: Devised by the authors.

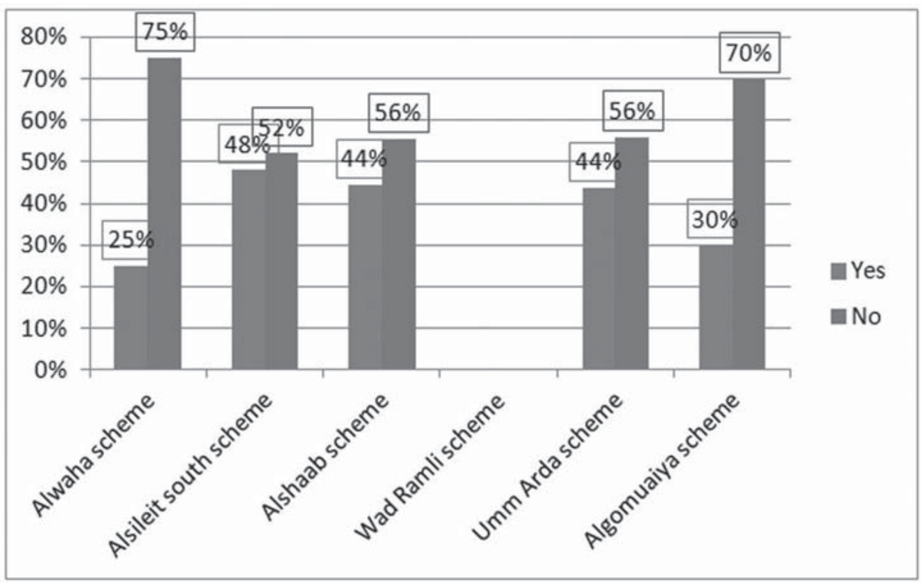

Figure 2 Reduction in agricultural yield from the growing season 2000–2014, % of total farmers questioned

Source: Devised by the authors.

Reasons for reduction in agricultural potential: The farmers in all investigated schemes confirmed that the major reason for lower land productivity in their farms was that they depend on producing crops suitable for the growing season, for example, Summer crops or Winter crops. Also the spread of diseases during the growing season, irrigation water shortage, soil problems, negatively affected the productivity.

Up to 70% of the reduction in productivity was caused by seasonal ability of production, and 50% was due to diseases and irrigation water availability. Soil problems counted for 40% of the reduction in yield, especially in the Alwaha scheme that was subjected to soil erosion especially during the Summer season.

The lack of crop rotation also adversely affected production as soils became exhausted with continuous cropping and the application of chemicals (see Figure 3).

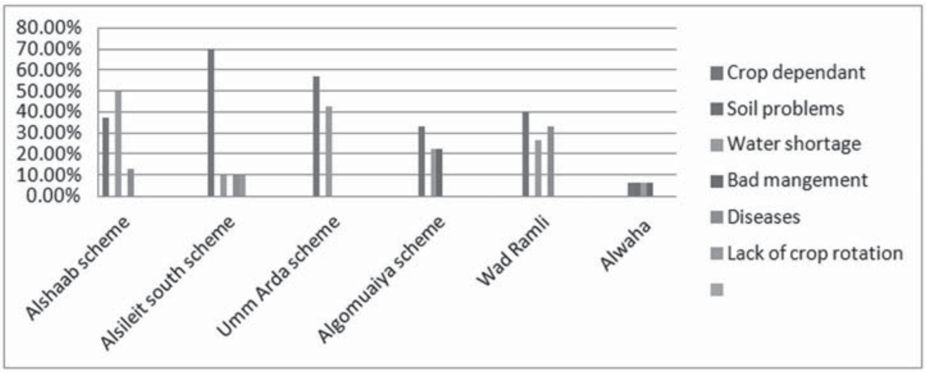

Figure 3 Reasons of reduction in land productivity, % of total farmers questioned

Source: Devised by the authors.

Types of chemicals applied to the soils: the types of fertilisers applied to the soil were also investigated. Results (see Figure 4) revealed the huge amounts of nitrogenous fertilisers applied each season; up to 100% of the farmers questioned confirmed their use of different types of nitrogen fertilisers, for example, Urea, Ammonium Sulphate. They also combine different types of phosphorus fertilisers, organic improvers and raw manure.

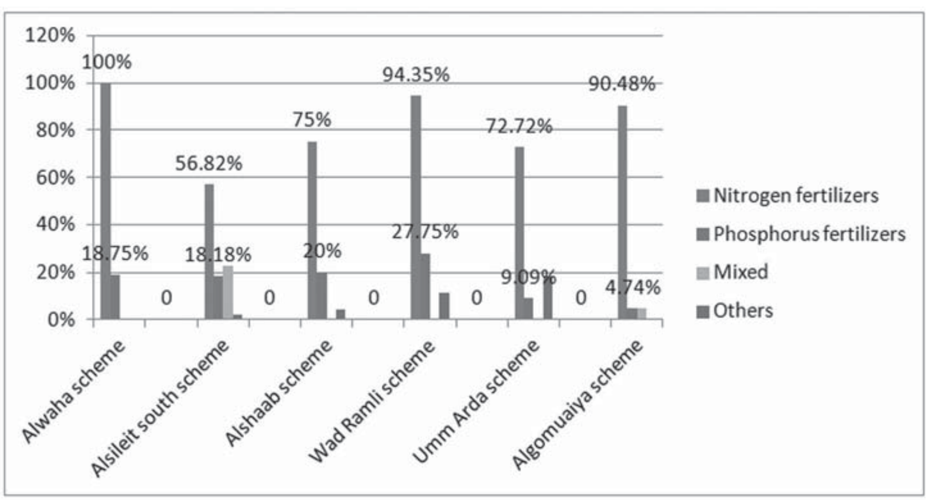

Figure 4 Types of fertilisers applied during the growing season, % of total farmers questioned

Source: Devised by the authors.

Contribution of agricultural extension in agricultural production: farmers were asked about the role of Agricultural Extension, the Ministry of Agriculture and their contribution to the recommendations about all agricultural practices and fertilisation programme in the Agricultural Schemes studied. Results are shown in Figure 5, where the absence of agricultural officers' recommendations and follow up was observed in most of the schemes. It was reported that more than 80% of the schemes have no agricultural officers. Therefore, farmers rely on their own experience and local knowledge to improve their production and solve their problems. This adversely affected the fertiliser management, mainly the rate and time of application.

Results from the Algomuiaya and Alshaab schemes showed the high contribution of agricultural officers who follow all practices; 90% and 72%, respectively.

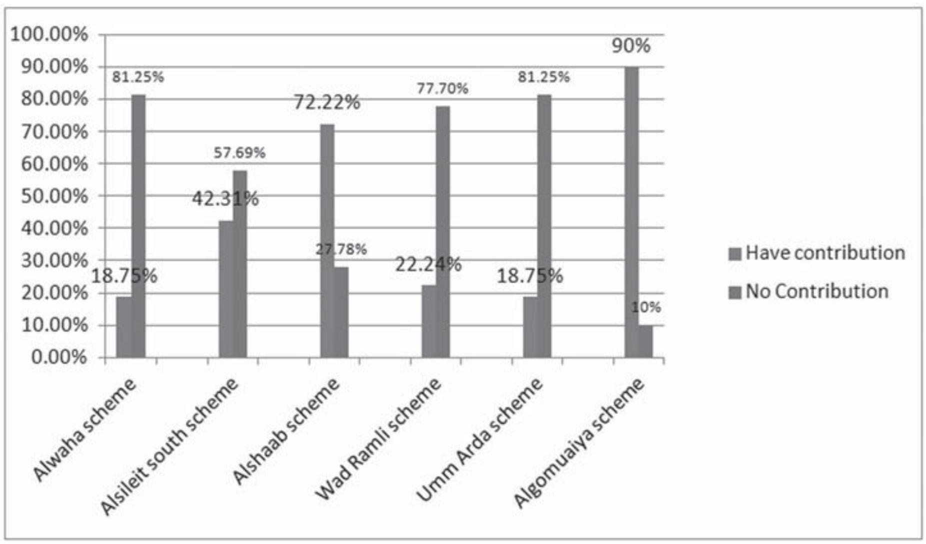

Figure 5 TContribution of agricultural extension in agricultural production, % of total farmers questioned

Source: Devised by the authors.

CONCLUSIONS AND RECOMMENDATIONS

It is concluded that the problem of soil productivity and reduction in agricultural potential is a serious problem that affected the availability of crops in Sudan.

Many factors affected soil productivity: lack of soil management units, and coordination between researchers and farmers especially for the transfer of scientific knowledge mainly about the fertilisers management and control of disease. Soil erosion also affected schemes in Eastern Khartoum North.

It is therefore recommended that further research work should be implemented to study other schemes outside Khartoum State.

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BIOGRAPHICAL NOTES

Dr. Sarra Ahmed Mohamed Saad awarded a PhD in Soil Science in 2002 from the University of Goettingen, Germany. She graduated from the Faculty of Agriculture, University of Khartoum majoring in Soil Science. She was appointed to the National Center for Research, Department of Environment in 1992, and is currently working as senior researcher of Soil Science. She is leading many research projects dealing with the problem of food security, soil productivity and climate change, in addition to organic farming and its applications in Sudan. She is a member of many scientific societies inside and outside Sudan, has been awarded prizes for scientific achievements in Sudan, and has some patents for producing compost from organic wastes. She has supervised many postgraduate students at both the MSc and PhD levels, and offered consultancy to governmental and private sectors about organic food production and fertilisation strategies, especially in poor fertile soils. In addition to Arabic, she speaks German, English, French and Spanish.

Dr. Moawia Yahia Babiker graduated from Faculty of Agriculture University of Zagzig, Egypt majoring in soil science. He awarded the MSc in soil science from University of Khartoum Sudan and PhD in soil science from University of Goettingen, Germany. He published many scientific papers related to soil pollution and remote sensing and also a member of many scientific societies. He founded Ekhtibarat Soil and Water Tests Services where he supervised postgraduate students and offer consultancy and feasibility studies to governmental and private sectors.

Suliman GasmElseed currently working as lecturer in Omdurman Islamic University. He was awarded the BSc In science from Asyiut University, Egypt and MSc in Environmental Studies. His research interest is environmental problems and the impact of climate change on food security and human lives.