Food and Agriculture Organization of the United Nations

AgWA
Partnership for agricultural water for Africa

National Investment Profile

Water for Agriculture and Energy

SUDAN

Khartoum/Rome

December 2015

EXECUTIVE SUMMARY

Sudan is endowed with many natural resources, among which cultivable land that is estimated at 74 million hectares, only 25 percent of which is currently under cultivation. Agriculture is the hub of economic activity and people's livelihood in the country.

Sudan's agriculture sector contributes around 30 percent to the GDP, provides livelihood to approximately two-thirds of the population, employs about 60 percent of the labor force and supplies raw material needed by the agro-based industries and generates demand for industrial consumer goods. It supplies about all people's requirements of sorghum and millet, which together form the bulk of the staple food, in addition to most of the domestic needs for oil seeds, vegetables, fruits and livestock products. Nevertheless, increasing amounts of wheat are being imported due to short domestic supply. The agriculture contribution to exports has drastically declined having been affected by oil production.

Both the agriculture's current status and potential perspective largely hinge on its considerably diversified ecosystem ranging from desert to high rainfall savannah. The agricultural sector is commonly typified into three sub-sectors: irrigated, traditional rainfed and semi-mechanized rainfed in addition to a livestock sector accommodated within these sectors and the natural rangelands and forests lying therein.

Despite the huge resources, the agriculture sector performance has not lived up to its paramount potential. This is reflected by sluggish agricultural GDP growth falling way below other economic sectors, a declining GDP share in the economy, slowly growing cereal grains production with high annual variability and declining per capita production. This has followed disappointing growth in production in all three crop-based agriculture subsectors.

Agricultural productivity is low; lying below regional and global averages and is further declining in trend. As revealed by research findings, a high potential exists for raising productivity by many folds. Due to the disappointing performance of the agricultural sector, food insecurity is high, with incidence averaging 33 percent but rising to 44 percent in some states.

The hunger gap varies from 249 to 389 Kcal per capita per day. It is evident that states with high intensities of irrigation have low food insecurity; this demonstrates the importance of irrigation and water management. Food access is partly impaired by food price surges and high poverty incidence, averaging 46 percent but climbing to 58 percent in rural Sudan. The nutrition situation is poor resulting in high rates of child stunting, wasting and underweight.

Although the agriculture sector has suffered from a legacy of anti-bias oil discovery has largely added to its neglect. The drastic impact of South Sudan's secession in 2011 that deprived Sudan of 75 percent of the oil resources induced needed attention to agriculture, when its share improved past 2011 from 25.8 to 29.1 percent. Feeling the high negative impact of inattention to agriculture, government policies have been strongly advocating agricultural development.

Irrigated farming is a pivotal part of Sudan's agriculture. Although it occupies only about 10% of the total cropped area it contributes around 14 percent of the agriculture value added and as much as 40 percent of the value added by the crop sector. Irrigation control is substantial in gravity-irrigation and big pump schemes, more so in small private pump schemes, but hazardous in flood basin irrigation.

Water resources comprise water from the River Nile and its tributaries, seasonal streams, underground water and rainfall, estimated around 30 billion cubic meters. Current water use exceeds availability by about 2 billion cubic meters, while future demand is expected to reach 59.2 billion by 2027. Given substantial potential for hydropower output, utilization is now only 10 percent and national electrification rate in 2009 stood at 35.9 percent. This means that the country should exert efforts to develop more water resources and hydropower.

Climate change poses high challenges on account of the fragile ecosystems inducing frequent droughts. Climate scenario analyses indicate expected rises in temperature and rainfall decrease. In light of this, agriculture and water resources are considered as priority sectors where urgent and immediate action is needed. In an attempt to address climate change and related issues, Sudan has already completed several activities that are expected to reduce vulnerability to the climate change impacts.

Sudan has developed various strategies and plans for its national and agricultural development that accommodate modernization of the agriculture sector with substantial attention to irrigation to reduce poverty and food insecurity. At the forefront of these plans is the Five-year Plan 2015-2019, which has macroeconomic and sectoral dimensions. Within the Plan, the agricultural sector is postulated to grow at 6.8% on average subject to institutional reform, improvement of infrastructure and modernization in the agricultural sector.

Sudan's water resources are governed by National Water Policy formulated in 2007, which assigns water management responsibilities to relevant institutions, of which Ministry of Water Resources and Electricity (now the Ministry of Water Resources, Electricity and Irrigation) and the Ministry of Agriculture and Forests have high involvement. On the other hand, the Ministry of Water Resources and Electricity has most responsibility and control of renewable energy development in the country.

Sudan's irrigation investment envelope comprises 38 on-going projects and 28 pipeline projects with costs averaging USD127 and USD128 million per project, respectively with highly unequal distribution of investment cost per project.

The total investment is estimated at US$9 286 million and the average annual agricultural budget is US$929 million, which is 1.25 percent of Sudan's GDP. As much as 40% of the envelope is allocated to large scale hydropower projects, indicating changing priority areas of investment from irrigation to hydropower. Only 7 percent is allocated to the development of new small scale irrigation schemes, which defeats objectives of poverty eradication. The analysis shows sharp negative relation between time and investment due to government planned budget of a maximum of 8 years. This imposes an adverse effect on the sustainability of agricultural growth. Investment in rehabilitation of existing hydropower plants is insignificant, likely signaling underinvestment in O&M of hydropower projects with the danger of irrigation schemes to be inoperative.

Besides the Government of Sudan, funding comes from a number of international donors and private funding partners. Funding partners are diverse for the pipeline projects, indicating a favorable situation for sustainability. On the other hand, high dependence on donor financing entails risks of likely withdrawal. The investment portfolio will develop or rehabilitate about 7.8 million ha with different disaggregation per crop type between ongoing and pipeline projects.

LIST OF ABBREVIATIONS AND ACRONYMS

ARC	Agricultural Research Corporation
ARP	Agricultural Revival Programme
ASARECA	Agricultural Research in Eastern and Central Africa
CAADP	Comprehensive African Agriculture Development Programme
CBS	Central Bureau of Statistics
COSOP	Country Strategic Opportunities Paper
DSSAT	Decision Support System for Agro-technology Transfer
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
GEF	Global Environmental Facility
Hafirs	Earth banks structures built according to the contour lines to catch and store rain water
HCENR	Higher Council for Environment and Natural Resources
ICARDA	International Center for Agricultural Research in the Dry Areas
IFAD	International Fund for Agricultural development
Kcal	Kilo calories
LDCF	Least Developed Countries Fund
MDG	Millennium Development Goals
MEPD	Ministry of Environment and Physical Development
MWRIE	Ministry of Water Resources, Irrigation and Electricity
MoAF	Ministry of Agriculture and Forests
NAP	National Adaptation Plan
NAPA	National Adaptation Programme of Action
NBHS	National Baseline Household Survey
NWP	National Water Policy
PRSP	Poverty Reduction Strategy Paper
SIFSIA	Sudan Integrated Food Security Information for Action
SSCCSE	Southern Sudan Commission for Census Statistics and Evaluation
SUDNAIP	Sudan National Agriculture Investment Plan
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
USD	United States dollar
Wadis	Natutal seasonal streams
WDI	World Development Indicators

TABLE OF CONTENTS

1. CONTEXT

This chapter will give an introduction into the contextual information of agriculture and food security (chapter 1.1), water resources and hydropower (chapter 1.2) and climate change in Sudan (chapter 1.3).

1.1 AGRICULTURE AND FOOD SECURITY

Agriculture

Although lost about one quarter of its area after South Sudan secession in 2011, Sudan still ranks third in area among the African countries after Algeria and the Democratic Republic of Congo. It extends over 1.86 million square kilometres and hosts a total population of 39.35 million according to the World Development Indicators (WDI 2015). Most of the population (66 percent) is rural (SUDNAIP 2015).

Sudan is blessed with enormous cultivable land, estimated at 74 million hectares, out of which only some 19 million hectares (25 percent) are currently under cultivation. Sudan's agriculture is the hub of economic activity and people's livelihood in the country. Both the agriculture's current status and potential perspective largely hinge on its considerably diversified ecosystem. The pattern of its ecosystem depicts five vegetation zones contingent on the rainfall gradient along the North-South axis (HCENR 2014). These are desert, semi-desert, low rainfall savannah and high rainfall savannah with respective rainfall ranges of 0-75, 75-300, 300-500, 500-900 and 500-900 mm in addition to Montane vegetation in the 500-900 mm range. In the northern drier zone and except for intermittently utilized scattered *wadis*, agriculture is mainly practiced along the Nile banks, exclusively under irrigation. As rainfall increases southwards, rain-fed cropping and livestock rearing spreads over the expanses of the country together with irrigated farming, which is nevertheless mainly located within the reaches of the Nile and its tributaries; largely within the 300-500 m rainfall zone. Major flood basin modes of irrigation are located in the eastern part of the country. The sector provided forms a safeguard in the case of critical drought conditions in the country.

Given this ecosystem distribution, the agricultural sector is commonly typified into three sub-sectors: irrigated, traditional rainfed and semi-mechanized rainfed in addition to a livestock sector accommodated within these sectors and the natural rangelands and forests lying therein. Covering around 10 million ha, the traditional rainfed subsector is by far the largest crop sector in area, largely found in the sand soils of western Sudan but also practiced in various areas across the country. Cropping practices comprise minimal land preparation and traditional practices with hardly any use of modern inputs. Various food and cash crops are

produced there, predominantly sorghum, millet, groundnuts and sesame. Semi-mechanized rain fed agriculture is found in the central clay plains of the Sudan, covering nearly 6.7 million ha and largely producing sorghum and sesame. Mechanized practices are mainly confined to tillage and harvesting operations. According to the statistical records of the Ministry of Agriculture and Forest (MoAF)[1] this system produces the major quantity of sorghum - the leading staple food in the country – amounting to 44 percent during 2009-2013. The traditional rainfed and irrigated sectors produced similar shares (29 and 27 percent, respectively). The irrigated sector occupies about 1.8 million ha and produces all Sudan's wheat, cotton, vegetables, faba bean, lentil and a sizeable part of its sorghum and groundnuts.

Sudan's agriculture sector provides livelihood to approximately two-thirds of the population (as of 2013), employs about 60 percent of the labor force and supplies raw material such as cotton lint, oil seeds and livestock products needed by the agro-based industries and generates demand for industrial consumer goods (SDNAIP 2015). In general, agricultural supplies about all people's requirements of sorghum and millet, which together form the bulk of the staple food. Nevertheless, increasing amounts of wheat are being imported because wheat domestic production runs short of satisfying its ever rising demand. Likewise, the sector produces most of the domestic needs for oil seeds, vegetables, fruits and livestock products.

With a share of about 32% in the GDP in 2014 (Central Bank of Sudan 2014), agriculture is a major contributor to the economy; coming second to services, which accounts for 52%. Before oil discovery at the turn of this century, Sudan used to get most of its foreign exchange earnings from agricultural exports. Statistics of the Central Bank of Sudan reveal a 57% agriculture share in the export proceeds in 1999; decreasing to 23% in the following year and eventually dwindling to a current contribution of around 4%. The basket of major agricultural export commodities has continued to comprise live animals, sesame, gum Arabic, cotton, melon seed and modest amounts of groundnuts.

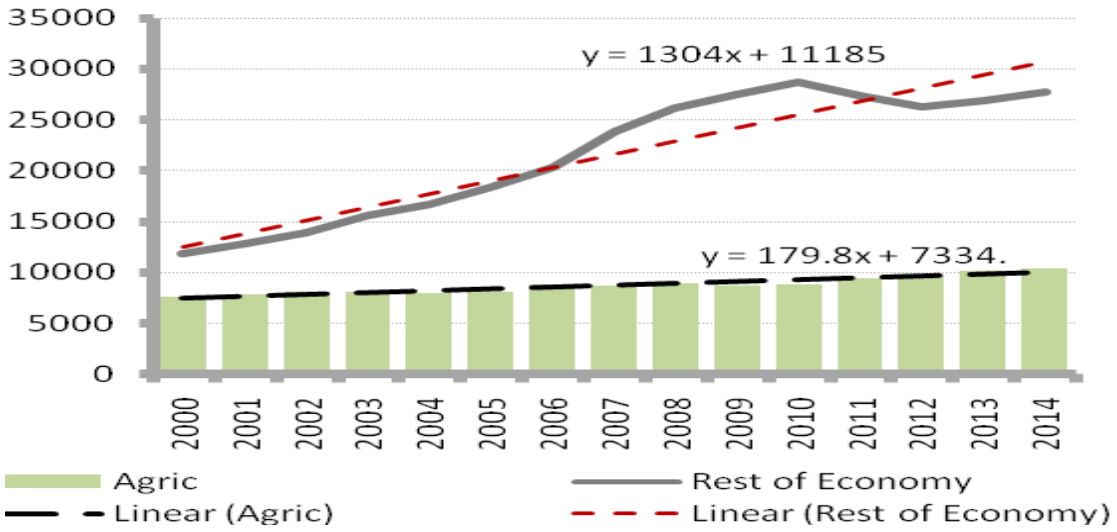
Despite the tangible role of agriculture, the enormous agricultural potential that gives promise for agriculture to take lead in the country's economic growth and livelihood improvement has not been adequately exploited. According to the FAO statistics, out of a total Sudan's area of close to 188 million ha, 109 million ha (or 58%) was agricultural area in 2011 (post South Sudan Secession); a proxy to a huge agricultural potential. Arable land (land under temporary agricultural crops, pasture, gardens and fallow) of 17.1 million ha made about only 16% of the agricultural area; which signals high potential for agricultural expansion. Although South Sudan's secession reduced the former Sudan's total land area by about a quarter and increased the area classified as arid from 65% to 90% of total area, three-quarters of the former

[1] It is currently the Ministry of Agriculture and Forests

agricultural land area still remains in the country and the cultivated area remains almost unchanged. On the other hand, it can be generalized that most of Sudan's soil types do not face unmanageable constraints that impair agricultural production such as high water tables or presence of salinity (Ali, 1996).

The agriculture sector's performance has not lived up to its paramount potential. Some of the important performance indicators are the trends in the sector's position in the economy and in agricultural production and productivity. For instance, Fig. 1 traces the development of agriculture GDP compared with that of the rest of the economy, measured in million USD at constant 2005 USD. The poor performance of agriculture is apparent with its GDP trend value falling way below that of the rest of the economy – measuring only 14%.

Figure 1: Agriculture and rest of economy sectors GDPs at constant 2005 USD, 2000-2014 (million USD)



Source: Derived from WDI, World Bank

Likewise, the agriculture share in the overall GDP has been on the downfall (Table 1). It has declined from an average of 41.3 percent during 2000-2003 to 29.1 percent over the past three years. The pattern of the share is closely related to the development of the oil sector, which produced rising proceeds peaking in 2007 and 2008. During the oil boom, agriculture had been left behind. The drastic effect of South Sudan's

Table 1: Periodic average shares of agriculture in GDP 2000-2014

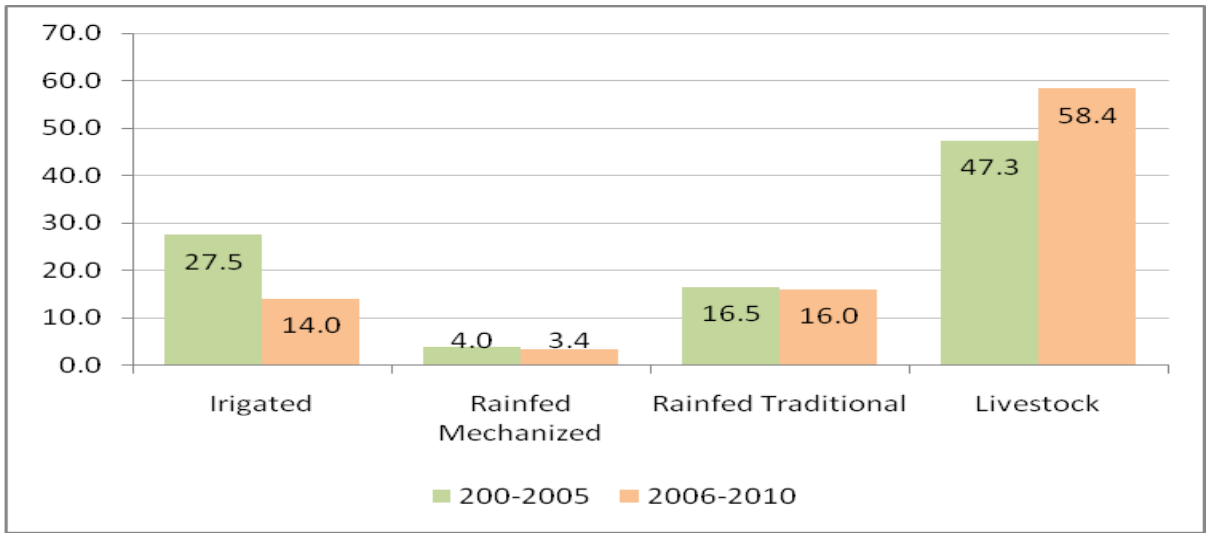
	2000/03	2004/06	2007/11	2012/14
Share in GDP (%)	41.3	32.0	25.8	29.1

Source: Derived from World Bank, WDI

secession that deprived Sudan of 75% of the oil resources induced needed attention to agriculture, when its share improved past 2011 from 25.8 to 29.1 percent.

The overall disappointing agriculture sector performance is obviously the product of the performance of the individual subsectors. Except for the livestock subsector, all subsectors revealed approximately constant shares from 2000 until 2005, after which the shares were almost steadily declining (SDNAIP 2015). Grouping of the shares in the form of averages in two periods, shown by Figure 2, depicts a sharp drop in the irrigated sector's share by almost half. This is attributable to the deterioration of the largest irrigated scheme in the country – the Gezira Scheme – following the issuance of a 'Gezira Scheme Law 2005' that gave greater decision-making powers to farmers in the administration and production process and made shifts in the institutional setting of irrigation water delivery to the scheme. It is likely that the shift disrupted a time-long running system without adequate preparedness. A notable rise is evident for the livestock sector, which seems to receive more attention.

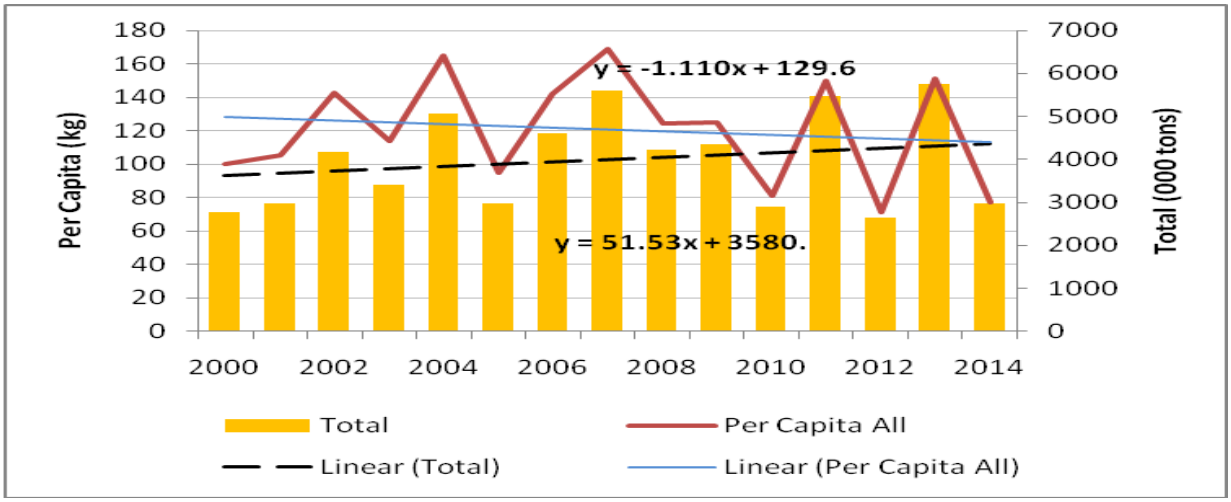
Figure 2: Average shares of the major agriculture sub-sectors in Agric. GDP (%), 2000-2005/2006-2014



Source: Adapted from SDNAIP 2015

The production performance can be demonstrated by the situation of cereals. As portrayed in Figure 3, both total and per capita production of the three principal cereal crops; sorghum, millet and wheat have been highly variable. The former has shown an overall increasing but a sluggish trend that has induced a declining per capita production. It can further be discerned that both total and per capita trends have been on the downfall as from 2007.

Figure 3: Total and per capita cereals production



Source: Derived from production data of Ministry of Agriculture & Irrigation

Production patterns in the three subsectors follow a similar pattern. Table 2 reveals almost consistently decreasing production in the irrigated system, variable and also decreasing trend in the traditional rain-fed system, and an increasing yet highly variable mechanized rain-fed production. Average annual trend values for the three systems could be respectively derived as -128, -14 and 85 thousand tons (Abdelrazing and Faki 2014).

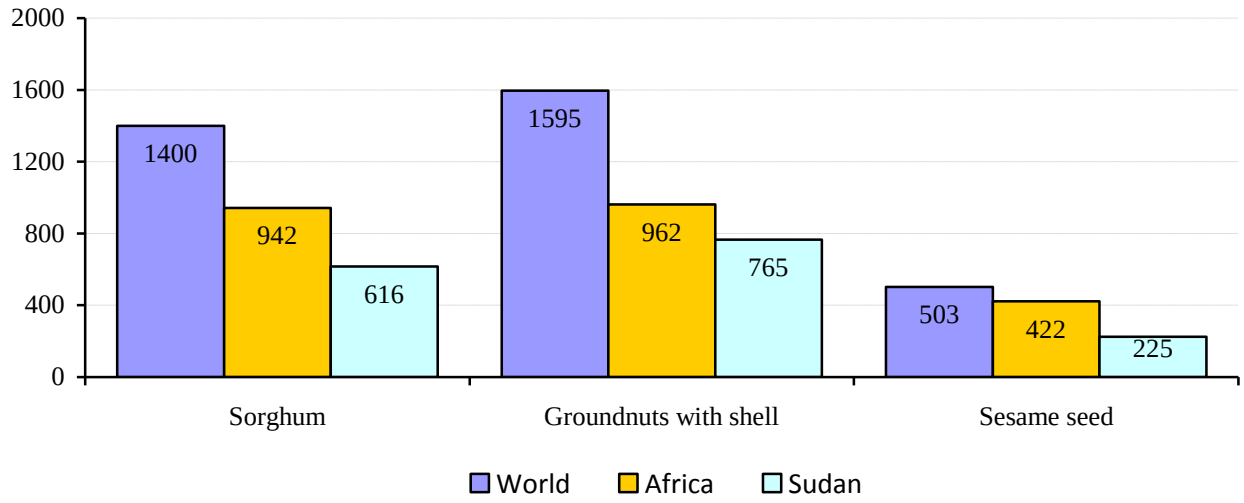
Table 2: Grain production according to farming system, 2007-2013 (000 t)

System	2007	2008	2009	2010	2011	2012	2013
Irrigated	1807	1386	1604	1061	1258	1036	963
Mechanized Rainfed	2132	1148	1341	784	2426	764	2818
Traditional Rainfed	1665	1683	1407	1056	1796	836	1966

Source: Data of the Ministry of Agriculture & Irrigation

Agricultural productivity is the agriculture performance indicator that has been attracting the highest concern; logically due its high direct consequence on the performance of the sector as a whole and indirect ones on the livelihoods and economy. Regional and global comparison of Sudan's agricultural productivity is shown in Figure 4 with respect to three important products. Sudan's yields of sorghum, groundnuts and sesame are respectively 65, 80 and 53 percent of the Africa average and only 44 to 48 percent of the world's average.

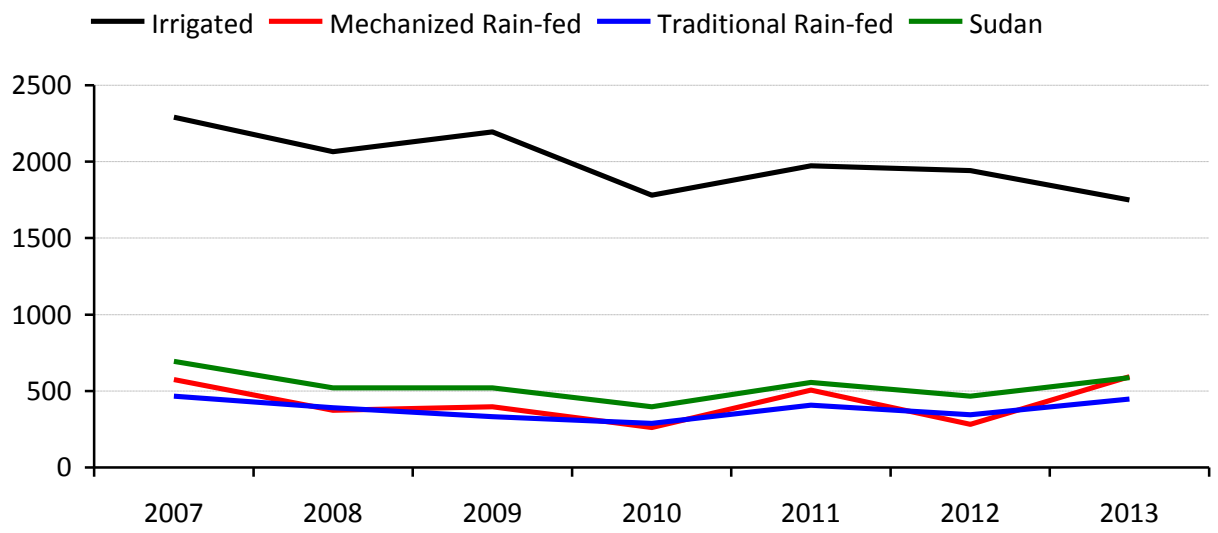
Figure 4: Comparison of yields of sorghum, sesame and groundnuts (kg/ha), averages 2003-2012



Source: Derived from FAOSTAT

Not only crop yields are low, but there are strong indications that they are rather deteriorating over time. This is best illustrated by cereal yields under different crop subsectors in recent years. Figure 5 portrays down-trending yields per unit area in all three main crop subsectors and Sudan's average. The figure reveals the superiority of irrigated agriculture compared to the humble rainfed yields, both traditional and mechanized. The low productivity under these systems pulled Sudan's average closer to the dry land productivity. Yield trends can be derived to display negatives of 74.6, 0.6 and 2.6 kg/ha annually for the irrigated, mechanized rain-fed and traditional rain-fed systems, respectively and an overall negative of 14.0 kg/ha. Despite higher yields of irrigated crops and a generally lower poverty incidence in dominantly irrigated areas (PRSP 2012), the declining yield trend there signals a deteriorating situation where both poverty and food security will be on the increase.

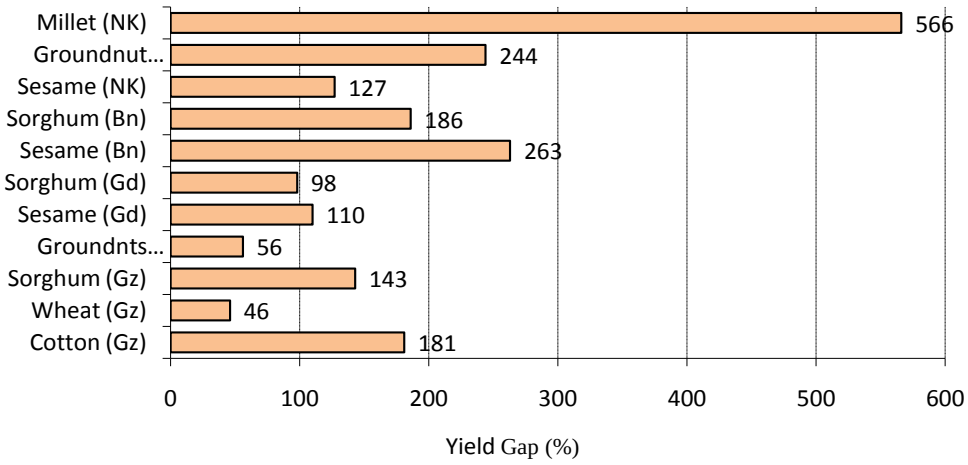
Figure 5: Average yields of cereals under main subsectors and in Sudan, 2007-2012 (kg/ha)



Source: Derived from data of the Ministry of Agriculture & Irrigation

Low commercial productivity poses a challenging situation in Sudan's agriculture. It is nevertheless evident that high potential exists for substantial yield improvements. This is revealed by analysis of research results from on-farm trials over a long period as depicted in Figure 6. yield gaps defined here as the percentage yield increments with on-farm technology over those actually realized in farmers' fields signal an enormous yield enhancing potential for a number of crops in some states that encounter low per capita agricultural incomes. Irrigated crops can be improved by margins ranging from about 50% to over 140%. Even higher yield potentials have been identified for rain-fed crops with potential margins ranging from two-fold to over five-fold. Among others, right policies, investment in research infrastructure and capability, reinforcement of extension and technology transfer capacities, capacity building of producers, build-up of agricultural knowledge and information, and private sector involvement will be conducive to agricultural productivity enhancement see (SDNAIP 2015, Faki and Abdelrazig 2014). While efficient water management is an important productivity-enhancing factor in irrigated agriculture, water harvesting along with other technologies have a highly promising potential in rainfed farming. Evidence is there that improved crop variety, fertility and water management through water harvesting and conservation and micro-dose fertilizers application on sorghum could raise sorghum grain yield by as much as 189% (Mekki A. Omer 2012).

Figure 6: Yield gaps of major crops in some states, averages in the period 1985/86 -2004/2005



Source: Shams Eldin 2008.

Irrigation and Water Control

Irrigated farming is a pivotal part of Sudan's agriculture. Although it occupies only about 10% of the total cropped area it contributes around 14% of the agriculture value added and as much as 40 percent of the value added by the crop sector. Highly controlled irrigation systems exist in a wide range of schemes under two main systems, namely gravity irrigation and water pumping from rivers or ground water. Gravity irrigation from dams comprised the Gezira and New Halfa Schemes with a total area of about one million ha. Rahad Scheme uses both water pumped from the Blue Nile and water flowing in the Rahad seasonal stream. The major remainder of irrigated agriculture exists in pump schemes in the Northern, River Nile, Blue Nile, White Nile and Suki Scheme in Sennar State; together making some 360,000 ha. A large number of small private pump schemes in various states. Water distribution used to be under relatively strict control by the Irrigation ministry in most of the irrigation schemes. A hierarchical system of canalization is in place that governs water distribution from the water source to farms. In later years, many of these schemes underwent a restructuring regime that transferred the water management, among other functions, to farmers' organizations; apparently with doubtful success. Water control seems to be more efficient in small private pump schemes. A considerable part of irrigated agriculture is under basin irrigation, mainly in Gash and Baraka deltas in eastern Sudan where seasonal rivers' waters are directed to flood fields through earth banks where water stored in the soil is used to grow annual crops. Water control under this

system is rather arduous and often cases of inequitable distribution of water, excess flooding, and drought occur.

Food Security

With an average food-insecure population of about 33 percent but reaching up to 44 percent in some states, the food security situation in the country is challenging (SSCCSE, CBS, SIFSIA/FAO 2010; SDNAIP 2015). Food deprived rural population was 34% compared to 31% for urban people (NBHS, 2009). Statistics show that overall average available calories from all foods in Sudan varied from 2187 to 2000 Kcal per capita per day during 2003-2010, indicating a marginal situation relative to the standard energy requirement range of 2100-2200 Kcal per person per day and putting Sudan behind the world's average of 2749-2798 Kcal as well behind averages reported in various regions of the world, e.g. North Africa (2948-3016), Southern Africa (2884-2918) and West Asia (3037-3104) (Ministry of Agriculture 2014). In four of the 18 states of the country deprived population exceeds 40 percent. The hunger gap varies from 249 to 389 Kcal per capita per day. It is evident that states with high intensities of irrigation such as Northern, River Nile and Gezira are less likely to face high food insecurity indicating the critical role that irrigation and the related water management play in food security. But it is also the case that states with adequate rainfall such as Blue Nile, Gadarif and West Darfur face modest food insecurity incidence ranging between 20 to 24 percent.

Food availability is jeopardized by high variability and, as discussed earlier, domestic availability of cereal grains per capita is downward trending mostly due to low productivity. Sudan has been experiencing incidents of food shortages due to droughts and civil conflicts. Food insecurity is largely influenced by rainfall, which supports the production of more than 70% of staple commodities (i.e. sorghum and millet). For example, the poor harvest of 2013/2014 season was about 48% lower than the previous year’s crop and 68% lower than the five-year average.

Food access is partly impaired by the recurring food price surges at the global level and ever-rising domestic food prices that are partly a consequence of local inflation. Food access is aggravated by low incomes and high poverty, averaging 47 percent in the country, but especially enormous in rural areas (reaching 58 percent compared with 27 percent in urban areas). Poor food utilization is induced by high poverty, poor access to water and sanitation, inadequate health care, low education and nutritional awareness. The country indicators show a nutritionally poor situation where, along with diseases, inadequate dietary intake is key to food and nutrition insecurity. In addition, low food quality, as determined by deficient nutritional content, inadequate safety measures and poor processing attributes poses various challenges. With nutrition deficiency, high rates of child stunting, wasting and underweight

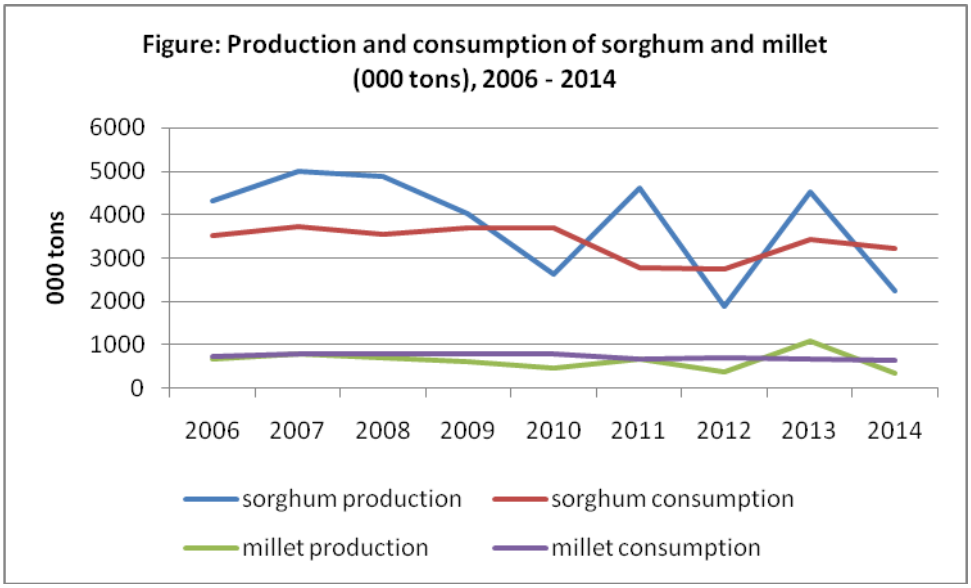
have been recorded (Ministry of Agriculture 2014). Underweight among children less than 5 years old measured 29.6 percent, infant mortality rate reached 71 and maternal mortality rate was 534. Only 65% of the population has access to clean drinking while 42 percent have access to improved sanitation facilities. The economic crisis after the secession of South Sudan together with seasonal shortages and ongoing conflicts resulted in worsening of the food security and nutrition situation in 2014. The Integrated Food Security Phase Classification (IPC) estimated people affected by food insecurity to increase from 4.2 million to 4.8 million during August-October 2014 (FAO, 2014).

Food security challenges require concerted efforts to avail food in a sustainable manner, diversify domestic production for expansion of high value products such as vegetables and livestock products, increase employment and improve on the various social services of education health care, clean water supply and sanitation.

Food Self-Sufficiency

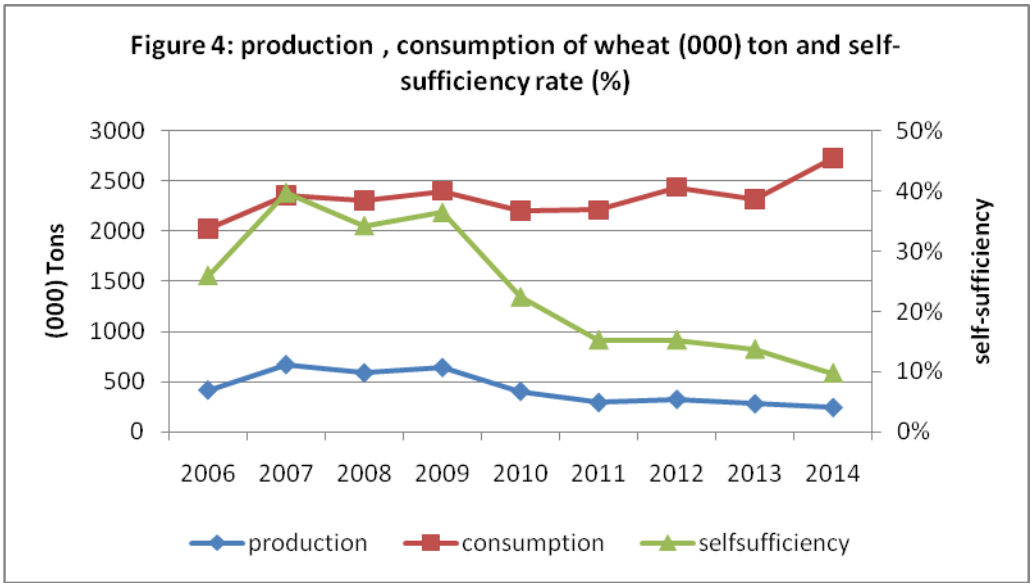
The country's vulnerability is evident in the fact that food self-sufficiency and food security in Sudan is mainly determined by rainfall, particularly in rural areas. Sudan is generally self-sufficient in basic foods, albeit with important inter-annual and geographical variations, and with wide regional and household disparities in food security prevailing across the country. Generally, the sector has succeeded to keep up with the increasing demand for the traditionally staple grains sorghum and millet (Figure 7), but has failed to keep up with the rapid demand for wheat (Figure 8). Sorghum production usually satisfies consumption with small exports in good years and small imports in years of low production. However, for wheat, the production and consumption situations reflect a variable and increasing gap between domestic production and actual consumption demand (Figure 8). Such increasing gap has been catered for through imports. Wheat imports increased from around 100,000 tons in 1971 to 2,314,200 tons in 2013. Consequently, and according to information provided by the National Wheat Program, the value of wheat imports increased from less than US$ 360 thousand in 1970s to over one billion dollars in 2013 Between 2006 and 2014, the wheat self-sufficiency ranged between 10% to about 40%, with an average of 24%.

Figure 7: Production and consumption of sorghum and millet (000 tons), 2006-2014



Source: Compiled from reports of Ministry of Agriculture and Forests

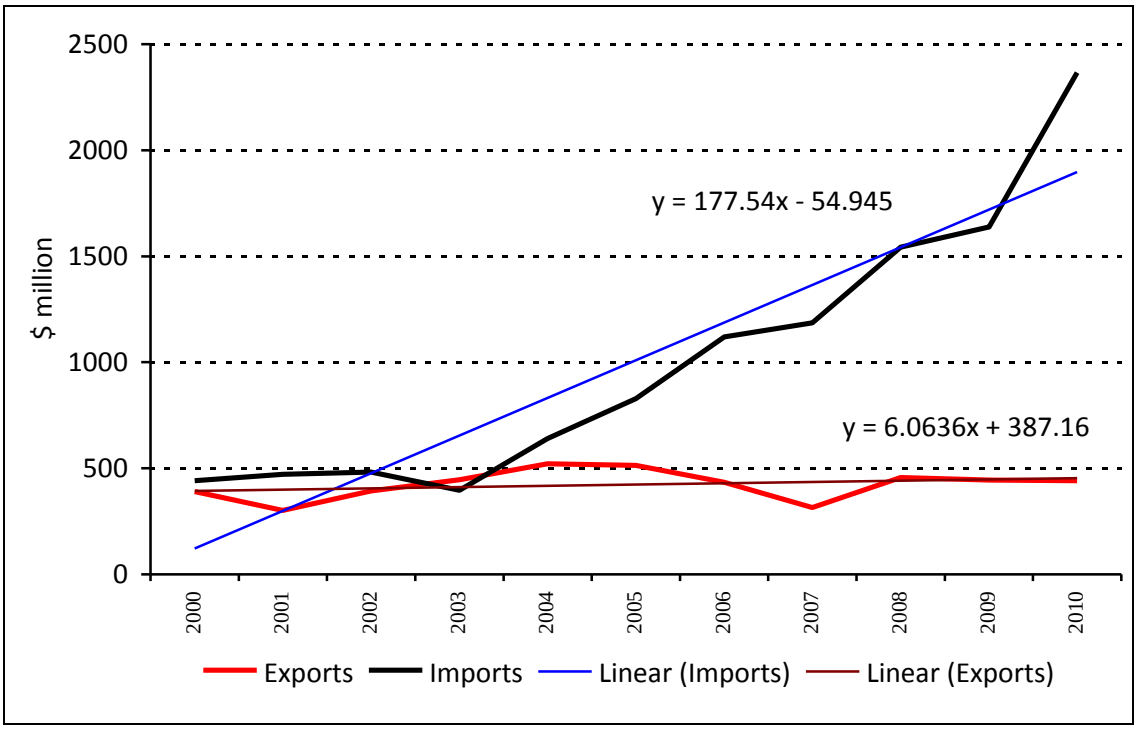
Figure 8: Wheat production, consumption (000 tons) and self sufficiency (%)



Source: Compiled from reports of Ministry of Agriculture and Forests

At the sector level, agriculture trade situation is showing a higher gap between imports and exports reflected in the deficit of the agriculture trade balance (Figure 9).

Figure 9: Development in agricultural export & import value 2000-2010



Source: FAO statistics

1.2 WATER RESOURCES AND HYDROPOWER

Surface Water

Water resources in Sudan comprise three main categories, the Nile system; surface water from rainfall and *wadis* (seasonal non-Nilotic streams), and groundwater. The average annual flow of the Nile recorded at Aswan, Egypt, is estimated at 84 bcm (billion cubic meters). Evaporation is estimated at 10 bcm and the balance of 74 bcm is divided between Egypt (55.5 bcm) and Sudan (18.5 bcm at Aswan) according to the 1959 Nile Water's Agreement between the two countries. Flood basin waters comprise Gash and Baraka seasonal rivers as the largest basins, which originate from Eritrea and flow between July and September. Their average annual runoffs are estimated at 0.6 and 0.5 bcm, respectively. *Wadis* of Azum, Hawar, Kaja, Ebra, Toal, Elkou and Salih are the largest *wadis* in western Sudan supplied from rainfall, with an estimated annual runoffs ranging from 120 to 500 mcm (million cubic meters) (Adam 1993). Including these, the combined total annual runoff of some 40 *wadis* in Sudan is estimated to vary from 5 to 7 bcm (Eltyeb, 2002) with an average about 6.7 bcm, which is largely unutilized except for about 0.16 bcm used for domestic purposes (Republic of Sudan 2006). This was then made possible by the

construction of 63 barrages across the *wadis* to store 130 mcm and 840 (*hafirs*) to store about 26 mcm. However, within the last ten years or so, many expansions in water harvesting have been made that have certainly raised the utilization of otherwise lost runoff water. Sudan's Agricultural Revival Program (ARP) 2008-2011 allocated 11% of its five-year budget of a little more than SDG4.819 and was reported to have constructed 12 dams and 219 *hafirs* in the rainfed sector (High Council for Agricultural Revival 2008; undated). In ARP's second phase 2012-2014, it was envisaged to construct 45 Dams and 165 *hafirs,* but no information could be sourced for actual implementation. On the other hand, the Dams Unit of the Ministry of Water Resources, Irrigation and Electricity (MWRIE) implemented a total of 345 water harvesting projects during 2010-2014 comprising 291 dams and hafirs in which 89.5 mcm have been harvested, in addition to 54 projects on water services (WRIE website). Further, water harvesting activities have been implemented by IFAD where, for example, rain-water harvesting for crops have benefited some 6775 beneficiaries in various regions during IFAD's COSOP 2009-2012 and is planned to continue within the ongoing IFAD's COSOP 2003-2018 (IFAD 2013).

Rainfall in Sudan is generally erratic, varying according to the zones identified earlier. Renewable groundwater is estimated at 4 bcm and is found in Nubian Sandstones, Umm Ruwaba Formation and alluvial deposits.

Irrigated agriculture is by far the major user of water in Sudan. It consumes more than 90% of the water; human and animal consumption shares are estimated at 5% and 1% is estimated for the industrial and other uses (Figure 10). In 2010, the total water used was estimated at 32.1 bcm and, as shown in Figure 6, is shared by irrigation (27.1 bcm), animal consumption (3.9 bcm), and other uses (1.1 bcm). The main crops grown under irrigation are cotton, sorghum, groundnuts and wheat.

Owing to storage capacity expansion created by heightening of Roseires dam and other irrigation development projects, and the planned expansion in irrigated areas, the irrigation needs are projected to reach about 42.5 bcm by 2027, while human and animal usage and other domestic and industrial needs are projected at 10.1 bcm. If evaporation from the reservoirs of the proposed hydropower development projects is added (6.6 bcm) the total demand would be 59.2 bcm (Abdalla and Mohamed 2002).

Hydropower

Sudan's potential for hydropower output is estimated at 4,920 MW. However, only 10% of the hydroelectric power is currently utilized. There are more than 200 suitable sites for the use of in-stream turbines along the Blue Nile and the main Nile. The country's main hydroelectricity generating facility is the 280-MW Roseires dam located on the Blue Nile river basin,

approximately 315 miles southeast of Khartoum. Recent capacity additions have included the 1,250 MW Merowe dam, commissioned in 2009 and now in full operation. In addition to Setit and Upper Atbara dam, which is almost completed, several power generating dams along the Nile system have being planned for and are in the pipeline (Figure 11). Significant capacity additions have been made in recent years (1,980 MW from 2003-2011), however, the government's current target of 3,383 MW of total capacity by 2016 is still appearing overly ambitious.

Figure 10: Major dams projects in Sudan

The national electrification rate in 2009 stood at 35.9%. Approximately 27.1 million people lack access to electricity in the country. Urban electrification in 2009 was roughly 52% compared to 28% for rural electrification. Domestic power consumption dominates the market, with approximately 65% of electricity consumption being attributable to the sector. The government has announced plans to raise the country's electrification level from an estimated 35% to about 90% in the mid-term. Large investments into the medium and low voltage distribution grids are on-going, but not sufficient to reach this ambitious goal within the government's allocated time limit.

1.3 CLIMATE CHANGE

Sudan is a country of fragile ecosystems, frequent droughts and, as a result, pressing challenges to address the national priorities of food security, water supply, and public health. An examination of Sudan's ecological zones indicates that the majority of its area is quite vulnerable to changes in temperature and precipitation. More than two thirds of the country's area can be classified as desert or semi-desert and less than a quarter as arid Savannah. Inherent vulnerability is evident from the fact that food security is mainly determined by rainfall where 70 percent of the population lives in rural areas (MEPD 2003) with high agriculture dependence.

Factors that will exacerbate the effect of climate change include the dismantling of traditional institutions and traditional regulations led by tribal leaders and underpinned by indigenous knowledge, which have largely been ignored in policy formulation for climate change. Traditional resource managers used to play important roles in the management of natural resources through providing participation-enabling structures in response to the felt needs of communities (Yagoub 2013). Traditional forms of collective work are deeply rooted in Sudanese culture e. g. *Nafir* (collective work) under the guidance of local leaders. The local communities willingly participate in opening fire lines, control bushfire and fight bird and locust attack. This is based on labor contribution by members of the society to manage common property (natural resources) for the benefit of all. Land use is organized by tribally-based management system within which the right of use is recognized and communally managed. This applies to sedentary and mobile pastoral communities. The system is supported by equity of use right and social customs governing the use of common property resources. Although the traditional system has been largely dismantled due to shifts in government policy as well as due to long-standing conflicts, the traditional resource managers have continued to function; a situation calling for the inclusion of this system in decision making on natural resources.

Climate scenario analyses conducted as part of the preparation of Sudan's First National Communications indicate that average temperatures are expected to rise significantly relative

to baseline expectations. By 2060 projected warming ranges from 1.5^{o}C to 3.1^{o} C during August and from 1.1^{o}C to 2.1^{o}C during January. Results from some of the models show an average rainfall decrease of about 6 mm per month during the rainy season (MEPD 2003).

Sudan's First National Communications identified agriculture and water resources as priority sectors where urgent and immediate action is needed. For agriculture, climate variability and climate change are likely to intensify the ongoing process of desertification of arable areas. Areas in the north would become increasingly unsuitable for agriculture and crop production is predicted to decline substantially for both millet and sorghum (main staple cereals). Regarding water resources, reduced groundwater recharge would result from decreased precipitation or increased temperature and evaporation. When confounded with increased water consumption through population growth, a looming water crisis is likely to emerge.

Decision Support System for Agro-technology Transfer (DSSAT) crop simulation model was used to compute the potential impact on the yields of main crops (Taha and Waithaka 2013). The results of the model show a yield loss of 5 to 25 percent of baseline (2000 climate) over most of the country's sorghum harvest area. In the marginal cultivated areas of the semi-dry zone, three of the four models show some loss of baseline area. These results would have serious implications for food security as sorghum is the main staple cereal grain supporting the rural population.

For wheat, all four models show negative impact, ranging from a complete loss of baseline area (area not suitable for production) to a yield loss of between 5 percent and over 25 percent of baseline. The most affected areas will be central Sudan (Gezira scheme and along the White and Blue Niles) and part of the River Nile state. While these areas, particularly central Sudan, produce 75 percent of Sudan's wheat, they are considered marginal areas for wheat production because current temperatures are unsuitably warm for wheat growing. The challenge to research will be to develop appropriate wheat production technology which would mitigate the effect of climate change. Such technologies could include drought and heat stress resistant varieties and improved water management regimes. This result judges the situation of wheat production in Sudan as a winter crop grown in marginal areas and thus highly sensitive to climate change, particularly temperature.

In an attempt to address climate change and related issues, Sudan has already completed several activities. It has ratified the United Nations Framework Convention on Climate Change (UNFCCC) in 2003 and submitted its initial national communication the same year. It also completed in 2007 the development and implementation of Sudan's National Adaptation Programme of Action (NAPA), which focuses on major impacts and vulnerabilities. Further, the National Adaptation Plan (NAP) was developed in 2014. The Plan intends to reduce vulnerability

to the impacts of climate change through building local adaptive capacity and resilience and facilitating the integration of climate change adaptation into relevant new and existing policies, programmes and activities. Accordingly, major adaptation activities and needs have been identified for agriculture and water resources management. These include adaptation technology options for water resources and others for agriculture. Those for water resources comprise promotion of greater use of effective traditional water conservation practices, introduction of new water harvesting/spreading techniques, rehabilitation of existing dams and improvement of water basin infrastructure, introduction of water conservation and agricultural land management practices, construction of dams and water storage facilities in water valleys, improvement in access to ground water supplies (pumps), enhancement of capabilities of regional meteorological stations, and extension services in water capture and storage techniques for small-scale farmers. Adaptation technology options for agriculture, on the other hand, address drought/heat tolerant and early maturing crop varieties, better water-use efficiency, improved farming practices, alternative crops/varieties/cropping patterns, alley cropping/intercropping, soil moisture conserving techniques, alternative crop rotations, enhanced water requirements under different climatic change scenarios, and adopting soil and water conservation practices (conservation agriculture).

2 NATIONAL STRATEGIES FOR WATER, AGRICULTURE AND ENERGY

Overall Development Strategies

Sudan's overarching development agenda is realization of the MDGs which has been ratified by the 2005 Constitution as a prerequisite for achieving socio-economic stability in Sudan. On the road towards achieving the MDGs, Sudan has developed and implemented a number of strategies and plan. *The quarter centurial development strategy (2007 – 2031)* launched in 2006 as the master development strategy included strong references and commitments to the MDGs serves as the reference for medium and short term development plans and strategies. These are:

- *Sudan's Poverty Reduction strategy Paper (2011-2016)* having four pillars: (i) strengthening governance and institutional capacity of the public sector; (ii) reintegrating internally displaced persons and other displaced populations; (iii) developing human resources; and (iv) promoting economic growth and employment creation.
- *First Five-Year Development plans 2007 – 2011 and 2012 – 2016*. The two Five-Year Development Plans serve as growth oriented strategies with primary focus on sustainable development and poverty reduction in the medium-term.

- *Three-Year Economic Salvation Programme (2012-2014):* launched following the secession of south Sudan in 2011 and loss of 75% of oil production Sudan and intended to absorb the resulting shocks and impacts on the economy. The programme included a package of financial and monitory policies, production improvement policies, import substitution policies and social protection policies to mitigate the effect on vulnerable communities. Results were positive leading to sustainable increase in growth, reduction in public budget deficit and improvement in the balance of payment.
- *Five – Year Development Strategy (2015 – 2019):* The strategic objective is to support realization of a sustainable and stable economy and accordingly high comprehensive and sustainable growth, which would lead to opening more employment opportunities and transforming the economy into an extensive and diversified production base. The quantitative targets include 7% increase in GDP through availing the necessary finance and reversing institutional and structural failures of the production sectors, increasing the public revenue to 12% of the GDP, reducing the budget deficit to 1% of the GDP, maintaining the exchange rate and money supply within safe limits, reducing the level of inflation to a single digit by the end of the programme, reducing the level of unemployment to 18%, and increasing the rate of savings.

Agriculture and Irrigation

- Under the framework of overall development policies (mentioned above) and the Comprehensive Africa Agriculture Development Programme (CAADP), Sudan has prepared different policy documents and investment plans regarding agriculture and food security. Following the signing of CAADP Compact in July 2013, Sudan embarked on the preparation of its National Investment Plan (SDNAIP), which is now in the process of ratification. Sudan's CAADP Compact was mainly based on Sudan's Agricultural Revival Program 2008-2011 (ARP 2008). In addition to the ARP, the SDNAIP made reference to all plans and strategies of the country, which all put agriculture in the forefront of development in the country to reduce dependence on oil and realize food security and poverty reduction. Within the SDNAIP, irrigated agriculture formed a major component due to its vital role in achieving the priority national objectives. Among other, establishment of a modernized well-managed rain-fed, irrigated and livestock production systems furnished with adequate infrastructural facilities formed an important objective.

Agricultural Policy Framework and Strategy

Based on Sudan's long-term strategy 2007-2032, the government has formulated its Five-year Plan 2015-2019. Beside addressing improvements in many macroeconomic indicators the Plan encourages private sector investment and industrial progress including agricultural agro-processing for many products including sugar, vegetable oil, flour, hides and textiles. Raising agricultural productivity in both crop and livestock sectors to international levels and reducing agricultural production costs formed an important objective. The government aims within the agricultural sector to reduce the trade balance gap and achieve a tangible increase in the supply of food commodities to reduce their prices and reduce people's livelihood burdens. It is envisaged that the agricultural sector grows at 6.8% on average. Policies set in the plan include the continuation of institutional reform by restructuring the Ministry of Agriculture and Forests as well as the administration of the irrigated agricultural schemes along with establishing bodies to the run agricultural activities in the Nile states (Northern, River Nile, Sennar and White Nile). Modern production systems are planned to be introduced in all of the existing irrigation schemes in addition to the development of agriculture in the traditional and mechanized rainfed sectors and provision of needed infrastructure such as roads, water and improved seeds. Further, policies include expansion in field water harvesting and supplementary irrigation in the traditional rainfed sector. The livestock sector is foreseen for increasing livestock numbers and enhancing the output of various livestock products.

Water Resources

The National Water Policy (NWP) was formulated in 2007 coming as a single policy document covering many aspects of water resources management, utilization and protection. It has objectives bring together and clarify existing policy; to review and adapt water policy to meet changing circumstances within the country; to ensure that the water resources of Sudan are properly managed, protected, and efficiently utilized for the benefits of all; to provide the basis for the ongoing development of water related regulations and legislations; and to strengthen and rationalize water related institutions in both the public and private sectors in Sudan. However, having been preceded by an earlier version in 1999, neither of the two policy documents has been officially approved and the MWRIE as revealed in the validation workshop of this document whereby the MWRIE is working on formulating a water policy document.

Several institutions are concerned with AWM in Sudan. The key ones are the Ministry of Water Resources and Electricity (MWRE), and the Ministry of Agriculture and Forests (MAF) and a range of directorates falling therein, which are directly involved in AWM. Outside these

ministries, the Agricultural Research Corporation and the University of Gezira are conducting research and capacity building in the water sector. The Ministry of Water Resources and Electricity (MWRE) is mandated with the formulation of policies and plans to develop and modernize water resources and rationalize their use. It also has the mandate of drafting regulations and of service delivery. Such functions are performed at the national level. MWRE also assumes the political leadership and engineers in the relevant directorate implement key decisions for the agricultural water sector. Responsibilities of the Ministry extend to include the management of agricultural water services, tariff collection, water quality control, water supply network maintenance, auditing of relevant institutions, licensing and collection of users' complaints. It is further forms the authority in risk mitigation and risk sharing mechanisms. The Ministry of Agriculture and irrigation is mandated with creating an enabling policy and institutional environment for agricultural development and sustainable use of land and irrigation water resources and to promote and facilitate sustainable production in agriculture for food security and poverty alleviation. The State's governments usually provide water services but at local levels.

Legislations regulating uses of water resources in Sudan, which are currently in force, are the Irrigation and Drainage Act (1990) and the Water Resources Act (1995). The Water Resources Act of 1995 established the National Council of Water Resources with wide functions and authorities to regulate and monitor utilization of water resources from different sources (Nile, non-Nile and ground water courses) for various function (irrigation, drinking water, industry, hydro power and sanitation). In addition, there are several other pieces of legislation which illustrate a variety of different policies and govern the use of water resources for irrigation in Gezira scheme and the Gash Delta Agricultural Corporation.

Energy and Hydropower

The MWRE takes responsibility of reviewing the current status of renewable energy development in Sudan, assessing future prospects and proposing a master plan for policy development and systematic implementation of programs for promoting and commercialization of renewable energy applications including appropriate institutional structure and linkages. Moreover, the Ministry facilitates, through the master plan, a progressively increasing contribution from renewable sources of energy as part of the national energy balance and thereby helps to improve energy services especially in rural areas, reduce dependence on conventional energy, and lead to environmentally sound and sustainable development.

3 INVESTMENT ENVELOPE

The **investment envelope** is a matrix that presents current and planned investment in the development of water resources for agriculture and hydropower production in a given country.

The investment envelope is produced through the application of AgWA's **Financial Diagnostic Tool**. This tool processes project-based information to derive the investment estimates at country level. The fundamental project information to plug in the tool is: project description, project characteristics, funding partners, time-scale, total costs and type of project.

The Financial Diagnostic Tool also incorporates a number of variables such as the project cost distribution over time and the relevance of the water component as a percentage of the total cost in order to develop a detailed analysis of investment. A currency conversion application (annual average of historical foreign exchange rates) is built in this model to present the output in a single currency.

Nonetheless, the adoption of the second pound (SDG) in 2007 and the secession of South Sudan in 2011 limited data availability of historical foreign exchange rate to such a degree that this analysis assumes constant SDG/US$ rates for the years 2015-2018.

Project types included in the tool are the following:

1. Small scale irrigation development[2]
2. Rehabilitation/modernization of irrigation
3. Large scale irrigation development
4. Small/medium scale hydropower development
5. Rehabilitation of hydropower plants
6. Large scale hydropower development
7. Others (drinking water supply, etc.)

This tool also supports conducting **complementary financial analyses** such as investment by type of project, investment by source of funding, investment by timespan of the project, hectares to develop or rehabilitate by crop, etc. These complementary financial analyses are presented in Figures 6 to 16.

[2]Small scale: < 500 hectares, large scale: > 500 hectares

The investment envelope (Table 2) presents investment estimates according to the project characteristics mentioned above and distributed over three time scales: short-term (less than 4 years), medium-term (between 4 and 8 years), and long-term (more than 8 years)[3].

Description of project portfolio

In the case of Sudan, the investment envelope has been calculated based on 38 on-going projects and 28 pipeline projects.These projects are presented in Annex 1 (table 1.1 for on-going projects and 1.2 for pipeline projects). The on-going projects range from a cost of about US$250 000 to a maximum of US$1500 million (Table 1). The investment costs of pipeline projects range between a minimum of US$220 000 and a maximum of US$1525 million. The average investment costs of on-going projects and pipeline projects are respectively US$127 million and US$258 million.

Table 1. Summary statistics of the Projects Portfolio

	On-going	Pipeline
Number of Projects	38	28
Min (million US$)	0.25	0.22
Max (million US$)	1500	1525
Average (million US$)	127	128

A closer look at the distribution of costs among on-going projects (Figure 6) shows that 16 projects (42 percent of on-going projects) involvean investment of more than US$100 million. A portfolio of 11 projects (29 percent of on-going projects) cost between US$100 million and US$10 million; the remaining 29 percent requires an investment cost between US$8,3 million and US$250 000. It can be observed from Figure 6 that the distribution of investment cost per project is unequal, few projects such as the ‘upper Atbara and Setit Dams Projects: Construction of irrigation structures to irrigate 420 000 hectares’ project (US$1500 million) and the ‘Water harvesting project in the states’ (US$374 million) cover the major part of the investment envelope.

[3]The baseline year considered for the analysis is 2015. Therefore, investment in the short-term would be executed from 2015 to the end of 2018, in the medium term, from 2019 to the end of 2022 and in the long term, from 2022 onwards.

However, the spread of investment cost per project is relatively equal when comparing this distribution with the investment envelopes of other countries in Sub-Saharan Africa (SSA). As mentioned before, 42 percent of on-going projects involve an investment more than US$100 million which might indicate an equal distribution of investment in irrigation in Sudan.Figure 7 displays the distribution of investment costs of the 28 pipeline projects that will be implemented in Sudan. The construction of the Dal, Sherik and Kajabar Dam hydropower dams require the highest investment costs of the pipeline projects with respectively US$1525 million, US$970 million and US$940 million. These three hydropower dams will together generate a capacity of 1528 MW of hydroelectricity.

It can be observed that nine projects (32 percent of pipeline projects) have a planned investment cost exceeding US$100 million; 12 of the pipeline projects (39 percent) are recognized by a planned investment between US$100 million and US$10 million. Figure 7 also shows the higher average investment cost of pipeline projects with US$258 million.

The relevance numbers (relevance of the water component as a percentage of the total investment cost) were not taken into account when analyzing this project cost distribution since all components within infrastructure projects have proven to be interdependent.

Figure 6. Project Cost distribution – On-going Projects

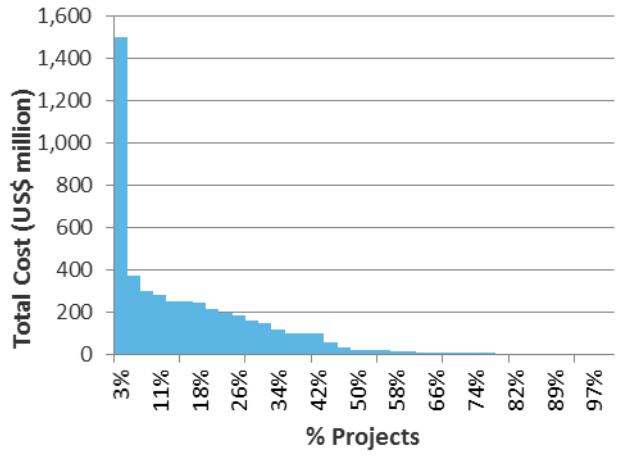
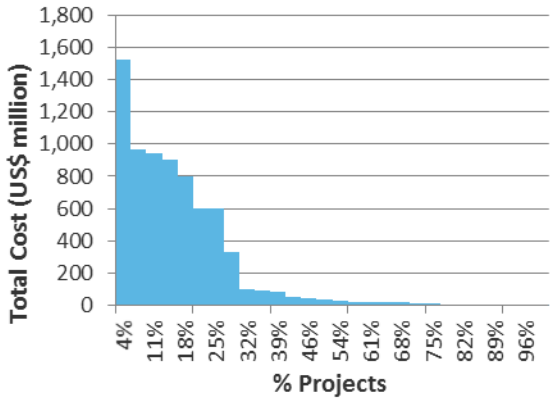


Figure 7. Project Cost distribution – Pipeline Projects



The investment envelope

The total investment envelope of on-going and pipeline projects for Sudan (Table 2) is estimated at US$9 286 million of which US$3 730 million is allocated to the development of large scale hydropower projects, US$3 223 million to the development of large scale irrigation schemes, US$1 112 million to the rehabilitation and modernization of existing irrigation schemes, US$614 million to the development of small scale irrigation projects, US$573 million to the 'others' category (used for e.g. water quality control, extension services and seed programmes), US$30 million for the development of small/medium scale hydropower projects and US$4 million for the rehabilitation of hydropower plants.

The last on-going project is scheduled to complete in 2021 (Livestock Improvement and Marketing project funded by IFAD) whereas the last pipeline project will be in full operation at the end of 2023 (Dal Dam generating 748 MW of hydroelectricity funded by the Kingdom of Saudi Arabia and other Arabic funds).

Table 2 shows that the majority (40 percent of total investment portfolio) of investment in water for agriculture and energy in Sudan is allocated to the development of large scale hydropower projects.The second priority area of the investment portfolio of Sudan is the development of new large scale irrigation schemes with 35 percent of the portfolio; 12 percent is allocated to the rehabilitation and modernization of existing irrigation schemes; 7 percent to the development of new small scale irrigation schemes; and 6 percent to the others category.

Table 2. Total Investment Envelope in US$ million and in percentage (On-going & Pipeline projects)

Time Frame	Short-term		Medium-term		Long-term		**Total**	
Type of project	M US$	%	M US$	%	M US$	%	M US$	%
Small scale irrigation development	420	5%	195	2%	0	0%	614	7%
Rehabilitation/ modernization of irrigation schemes	782	8%	330	4%	0	0%	1 112	12%
Large scale irrigation development	2 844	31%	379	4%	0	0%	3 223	35%
Small/medium scale hydropower	29	0.3%	2	0.02%	0	0%	30	0.3%
Rehabilitation of hydropower plants	2	0%	2	0%	0	0%	4	0%
Large scale hydropower development	3 152	34%	578	6%	0	0%	3 730	40%
Others	378	4%	195	2%	0	0%	573	6%
Total	**7 606**	**82%**	**1 681**	**18%**	**0**	**0%**	**9 286**	**100%**

The total amount of funding allocated to irrigation categories in Sudan is US$4 949 million (54 percent of the envelope) while the total amount of funding allocated to hydropower categories only amount to US$3 764 million (41 percent of the envelope).

Table 2 clearly shows that no budget is allocated for the rehabilitation of hydropower plants, while the focus is on developing new large scale hydropower projects. This lack of investment in rehabilitation in hydropower plants might cause a lack of investment in Operation and Maintenance (O&M) of the existing seven hydropower dams generating 3765MW comprising 66.3 percent of the total installed capacity in Sudan (CIA, 2012). A lack of investment in O&M entails risks for the supply of hydroelectricity.

The average annual agricultural budget is US$929 million, which is 1.25 percent of Sudan's GDP. This analysis has not been able to verify whether Sudan succeeded in the CAADP target of 10 percent agriculture expenditure share in total public expenditure due to limited data availability.

The value added of the agricultural sector to GDP as a percentage has been fairly stable over the last three years (2012-2014) increasing from 28.8 percent to 29.2 of GDP (annual growth rate of 1.3 percent and 0 percent respectively) (World Bank, 2014). This means that the CAADP target of 6 percent agricultural GDP growth has not been reached in recent years.

Cost distribution

Figures 8to 10 illustrate the distribution of project costs in time by type of project for those on-going and in the pipeline. A lack of investment in the long-term can be observed from Figure 8 that might have a negative effect on the continuity of investment in irrigation and hydropower in Sudan. Investment planning with a longer time-horizon exceeding four years is therefore advisable.

This trend of underinvestment in the long-term is observed in many other countries and might be caused by governments that tend to plan their budget with a timespan no longer than eight years. Many projects in this portfolio, such as rehabilitation and modernization projects, are short-term but repeated continuously. The underinvestment in the long-term in this analysis therefore does not necessarily hold up in reality.

Figure 8. Cost distribution in time per typology – All Projects (US$ million)

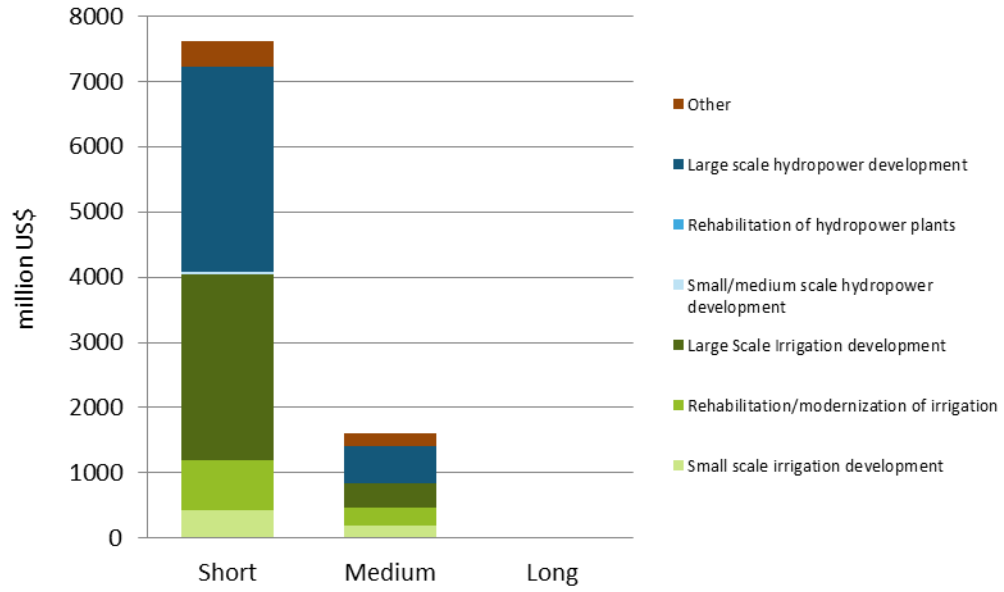


Figure 9. Cost distribution in time per typology – On-going Projects (US$ million)

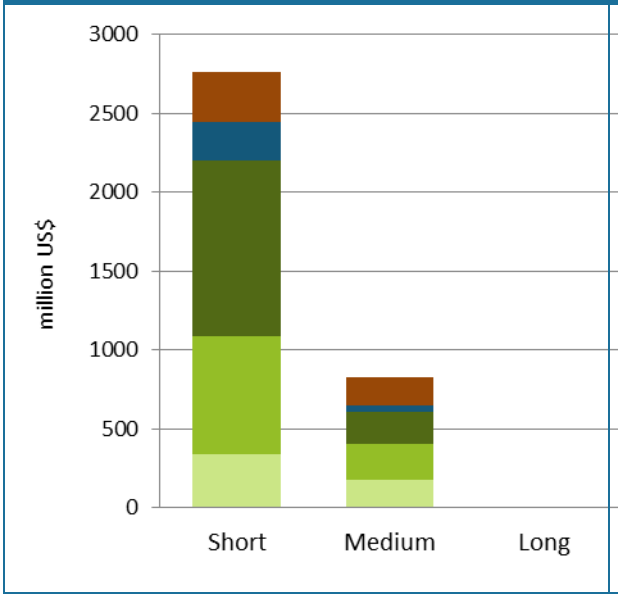
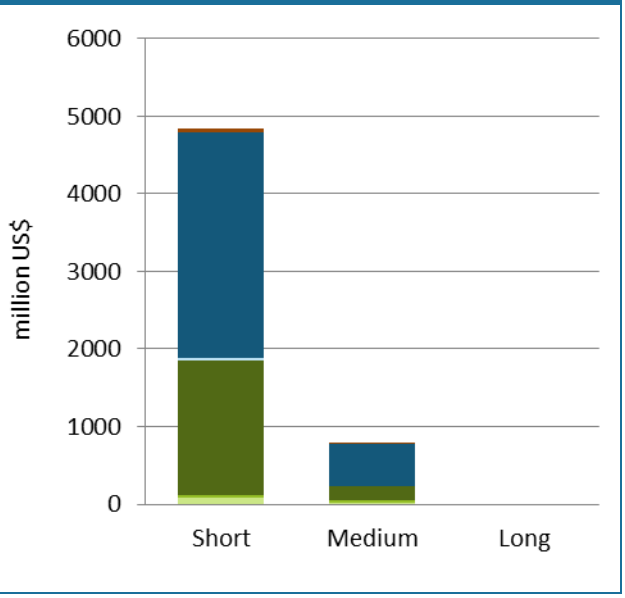


Figure 10. Cost distribution in time per typology – Pipeline Projects (US$ million)



The on-going projects of this envelope account for US$3 588 million (39 percent of total envelope) while the pipeline projects add up to US$5 631 million (61 percent of total envelope).

Figures 9 and 10 demonstrate the changing priority areas of investment from irrigation to hydropower. It can be observed from Figure 9 that on-going projects target investment in irrigation (US$2806 million, 78 percent of the on-going investment), while the pipeline projects take hydropower as priority area (US$3484 million, 62 percent of pipeline investment).

Figure 9 shows a sharp negative relation between time and investment. This negative relation imposes an adverse effect on the sustainability of agricultural growth in Sudan for both on-going and pipeline projects.

As mentioned before, governments appear to plan their budget no longer than 8 years; this might be the cause of this negative relation between time and investment. Nevertheless, a longer planning horizon is advisable.

Figures 11, 12 and 13 display the distribution of cost share per typology and reveal the focus of investment on both large scale irrigation development and large scale hydropower development. As mentioned before, investment in rehabilitation of existing hydropower plants is insignificant which might signal underinvestment in O&M of hydropower projects.

It is observed in many African countries that a lack of investment in O&M is a cause for irrigation schemes to be inoperative; this planned budget therefore is desirable. Nevertheless, a diversification of the investment portfolio also targeting the rehabilitation of hydropower plants and is recommended to foster sustainability of growth of irrigation land and hydropower development.

Figure 11 also demonstrates the lack of investment in small-scale irrigation development. Investing in small-scale irrigation development will foster poverty eradication; and has the opportunity to directly increase the income of the Sudanese population since 45 percent of this population is working in the agricultural sector.

Figure 11. Cost share per typology – All Projects (%)

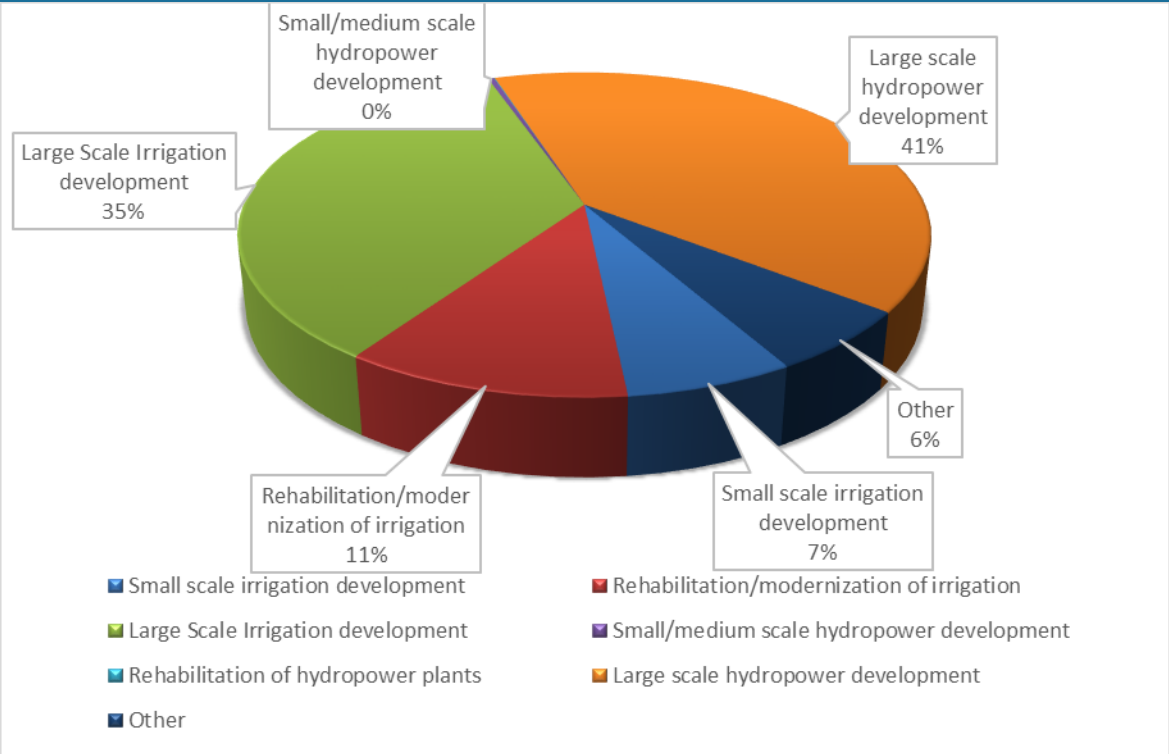


Figure 12. Cost share per typology – On-going Projects (%)

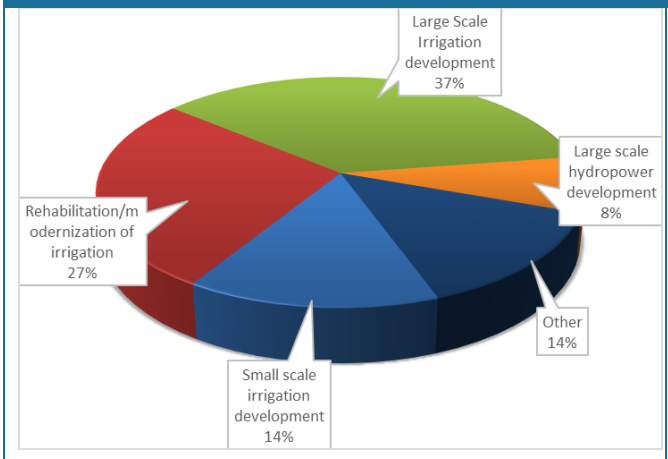
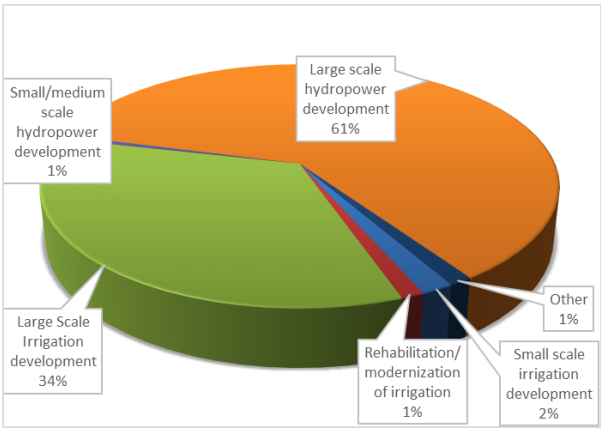


Figure 13. Cost share per typology – Pipeline Projects (%)



Source of funding

The 66 projects in this portfolio are, besides by the Government of Sudan, funded by a number of international donors and private funding partners. These donors are the: Islamic Development Bank, Islamic Relief Organization, Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA), International Center For Agricultural Research In The Dry Areas (ICARDA), Agricultural Research Corporation (ARC), International Fund for Agricultural Development (IFAD), Global Environmental Facility (GEF), Least Developed Countries Fund (LDCF) and United Nations Development Programme (UNDP).

Other significant funding partners in irrigation and hydropower in Sudan are the Kingdom of Saudi Arabia together with other unknown Arabic Funds.

The distribution of investment costs by source of financing (Figure 12) shows the predominance of public funding in on-going projects (88 percent). The pipeline projects are funded by a combination of donors (44 percent), private partners (44 percent) and public funding partners (12 percent). Despite the homogeneity of funding partners for on-going projects we do observe diversity in funding partners for the pipeline projects.

AgWA is convinced that diversity of funding partners is favorable to optimize sustainability of investment in irrigation and hydropower. Figure 13 therefore demonstrates that Sudan is heading the right direction.

It is worth mentioning that a high dependence on donor financing entails risks since withdrawal for any reason from financing these projects would mean a significant fallback of investment in irrigation and hydropower projects. Policymakers should bear this in mind concerning the history of international relations of Sudan.

Figure 12. Cost share per funding partner for On-going Projects (%)

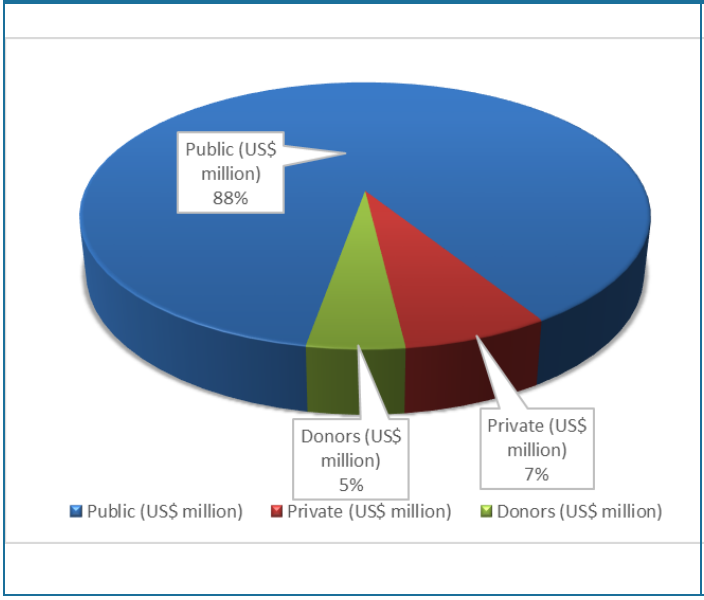
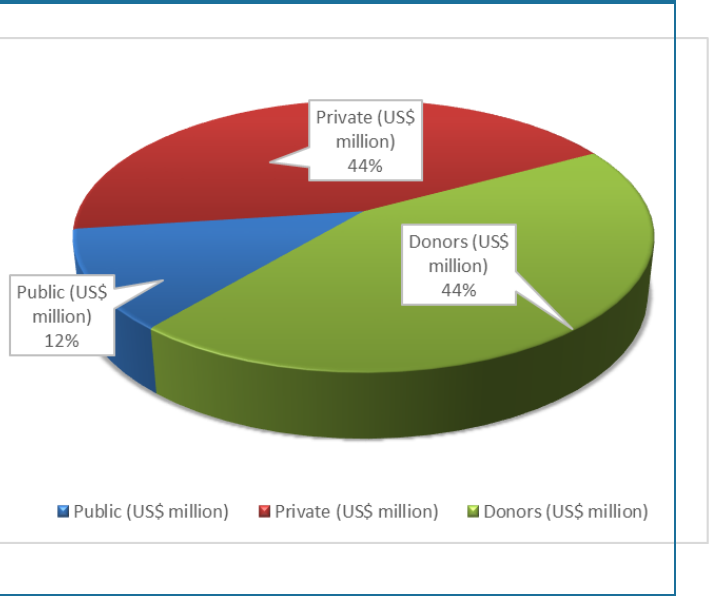


Figure 13. Cost share per funding partner for Pipeline Projects (%)



Hectares to develop/rehabilitate

The 66 projects of this investment portfolio will bring changes to about 7.8 million hectares by 2023 of which 6.97 million hectares will be developed or rehabilitated through on-going projects and 0.829 million hectares through pipeline projects.

Of these projects approximately 2.8 million hectares will be used for the cultivation of sorghum (36 percent of total number of hectares to be developed/rehabilitated); 1.19 million hectares for the cultivation of cotton (15 percent); and 1.13 million hectares for the cultivation of groundnuts (14 percent) (Figure 14).

Figure 14 also demonstrates that the on-going and pipeline projects outline a different disaggregation per crop type. As mentioned before, the priority area of investment shifts from irrigation to hydropower in Sudan in the coming years. Figure 15 demonstrates that 5 655 500 hectares will be rehabilitated (73 percent of total area to be developed/rehabilitated).

Figure 14. Hectares to be developed/rehabilitated per crop

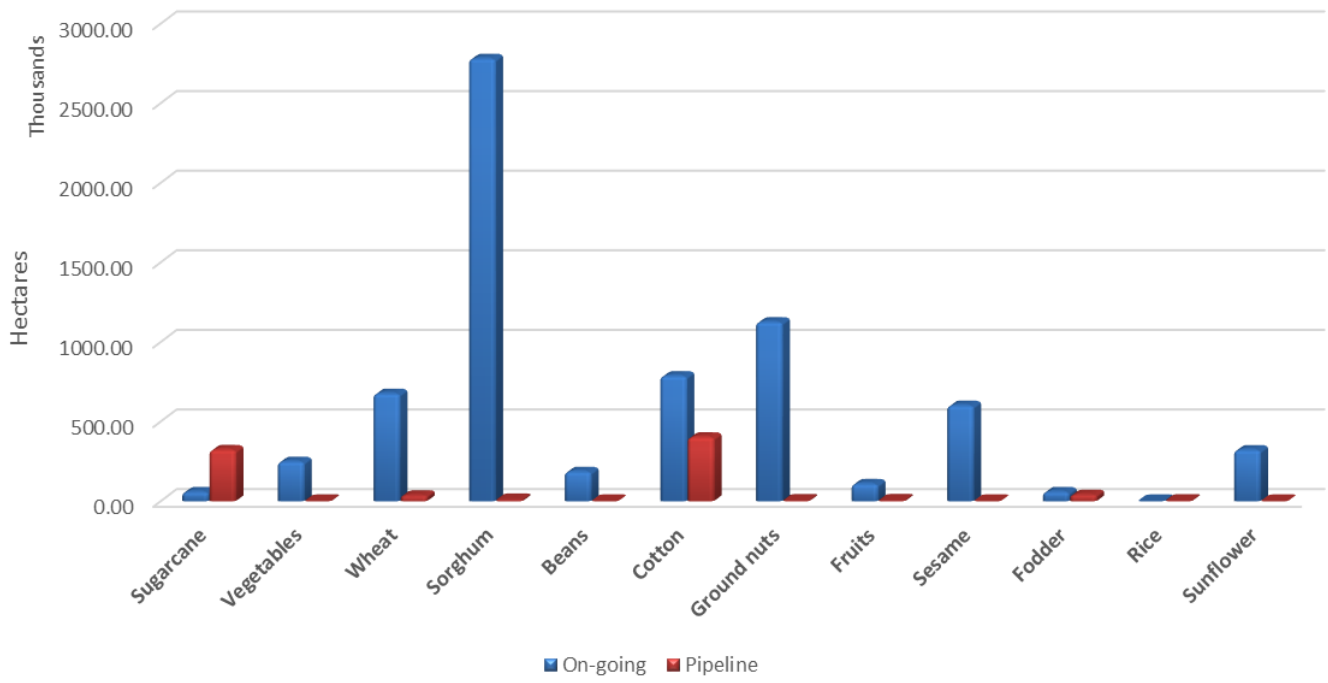
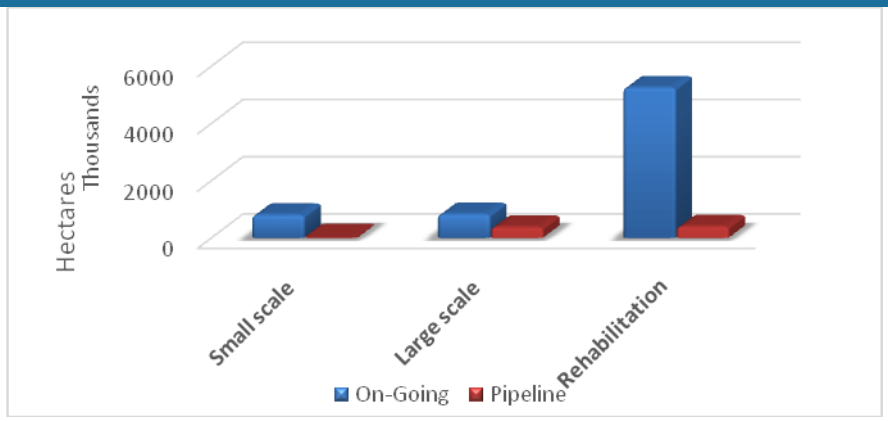


Figure 15. Hectares to be developed/rehabilitated for On-going and Pipeline projects



4 CONCLUSIONS

Based on the information and analysis presented in this report, the following can be concluded:

a) The agricultural sector has been disadvantaged and its contribution to the economy is not matching its potential. Negligence of the sector has resulted in high levels of food insecurity and nutrition.

b) While recent developments in the irrigated sector have been highly affected by the oil wealth, dwindling of oil resources have induced increasing attention to the agricultural sector, which is an encouraging sign with promise for development with expected reduction in food insecurity and poverty as well as more contribution to the economy.

c) Government's current plans have paid attention to the agricultural sector with focus on agro-processing in the sector. Implementation of the plans is crucial, for which foreign investment aid is needed while the domestic private sector is required to participate.

d) The investment envelope reveals high allocation to large scale hydropower projects, indicating changing priority areas of investment from irrigation to hydropower while allocation to the development of small scale irrigation is low. Amendments are needed towards boosting these projects so as to maximize the efforts to reduce poverty and enhance food security.

e) Short-term investments reflecting on a negative relation between time and investment entails redesign of longer-term investment portfolio.

f) Investment in rehabilitation of existing hydropower plants will need to be reconsidered for its increase due to an expected negative effect on O&M and consequently a jeopardy to the operation of existing irrigation schemes.

g) A positive signal from the investment envelope is the diversity of funding partners, which a favorable situation for sustainability and should be kept and expanded.

h) High dependence on donor finance is risky because of likely withdrawal. This should be taken into consideration with necessary precautions to be in place.

ANNEX 1: PROJECT PORTIFOLIO

Table 1.1. On-going Projects

#	Project title	Funding Partners	Time Scale	Total Budget (million US$/EUR)	Description
1	Upper Atbara And Setit Dams Projects: Construction of irrigation structures to irrigate one 420,000 ha	KSA and other Arab Funds	2015-2020	US$1,500.0	The project aims at supporting Malawi's efforts of increasing agriculture water efficiency and strengthening the irrigation potential in order to increase farmers income and enhance food security in addition to mitigating the effects of climate change. Typology: Small-scale irrigation development (40%) and large scale Irrigation development (60%)
2	Rehabilitation of irrigation structure in Rahad, New Halfa and Suki irrigation schemes	Government finances	2015-2019	SDG1,802.0	Rehabilitation of doors of all irrigation channels; improve the activities of de-siltation of the irrigation system
3	Rehabilitation of Gezira irrigation system	Potential: development fund; foreign finance; bank loans	2015-2019	SDG1,540.0	Located in Gezira state, rehabilitation of the irrigation system. Achieve cultivation of scheme whole area
4	* Electrification of pump irrigation schemes (River Nile (144 schemes),	Government finances	2015-2019	SDG1,113.0	* Electrification of pumps; improve irrigation efficiency and reduce cost; improve cropping intensity; improve productivity *Rehabilitation of irrigation infrastructure of big schemes: 6 in Northern, 10 in River Nile, 129 schemes spreading over 269 km

	Northern State (180 schemes), White Nile (129 schemes) * Rehabilitation of irrigation infrastructure in Northern, River Nile, White Nile and Sennar States				along the White Nile and 29 Schemes in Sennar State
5	* National Wheat Programme * Raising wheat production and productivity in irrigated schemes	Government finances	2015-2019	SDG984.0	* Promotion of wheat productivity and production to reduce dependence on imports and utilize unused natural resources * Increasing production to 3.4 million tons and productivity from 2.9 to 3.9 t/ha
6	Wheat production in high terrace soils	National investments with private sector share and foreign investments	2015-2019	SDG350.0	Expand wheat production to reduce dependency on imports through sourcing investment means and encouraging policies of seed availability, timely price announcement and marketing arrangements
7	Support to the horticultural sector and promotion of promising horticultural crops	Government finances	2015-2019	SDG110.0	Increase and diversify production of vegetables and fruits and promising crops
8	Horticulture Project	Government finances	2014-2018	SDG201.0	Popularization of horticultural culture such as in unutilized areas, residencies, popular squares, schools etc. via demonstration and provision of support material
9	Sudan Sustainable Natural resources	Donor Finance: GEF	2014-2018	US$8.30	World Bank shared implementation under a GEF grant to the Government of Sudan (GOS) through the Ministry of

	Management Project				Environment, Forests and Physical Development - the national implementing agency. The Project is part of the Great Green Wall Initiative (GGWI) under the World Bank Umbrella Program for the Sahel and West Africa countries in support of the GGWI. The objective is to increase adoption of sustainable land and water management practices in targeted landscapes in three states: Kassala, Gezira and White Nile. External financing, primarily from Global Environment Facility (GEF), will be made available for the SSNRMP.
10	Climate Risk finance for Sustainable and Climate Resilient Rain-fed Farming and Pastoral Systems	Donor Finance: GEF, LDCF, UNDP grants	2014-2018	US$24.5	UNDP-shared implementation under a GEF LDCF UNDP grant with government contribution. Aims at supporting the development of a range of financial mechanisms to incentivize investments in climate change adaptation and risk reduction measures via rainfall modeling and simulations in six vulnerable agro-ecological regions of Sudan ((River Nile, Gedarif, North Kordofan, and South Darfur, Kassala and White Nile States) to enable local flood forecasts and climate projections). Executing Entity/Implementing Partner: The Higher Council for Environment and Natural Resources.
11	Promoting Use of Electric Water Pumps for Irrigation	Donor Finance - GEF	2015-2019	US$5.0	UNDP-shared implementation in North Sudan, PIF approved, project document under preparation.
12	Sudan Livestock and Rangeland Resilience Program	Donor Finance: GEF, LDCF Project Grants	2015-2019	US$10.1	IFAD-led programme under GEF LDCF Project Grant, project document available, PIF approved.
13	Enhancing the Resilience of Communities Living in Climate-Change	Donor Finance: GEF	2015-2019	US$4.9	UNDP-shared implementation under a GEF grant, Project PIF approved, project document under preparation.

	Vulnerable Areas of Sudan using econ-system based approaches to adaptation				
14	Sudan Rural Livelihood's Adaptation to Climate Change in the Horn of Africa - Phase II	Donor Finance: GEF, LDCF Project Grants	2015-2019	US$7.6	AfDP-shared implementation under a GEF LDCF grant, Project PIF approved, project document under preparation.
15	Control of Land Degradation in the Gum Arabic Belt	Donor Finance: GEF Grant	2015-2019	US$3.03	GEF Grant, restoration of the gum Arabic belt, promoting livelihood through agro-silvo pastoral systems, rehabilitation of degraded land in the belt.
16	Rural Electrification from Renewable Energy	Government and donor finance from GEF and UNDP; Partners Ministry of Environment and Physical Planning; Implementation: Ministry of Water Resources and Electricity.	2015-2019	US$217.486	Objective is to reduce GHG emissions by promoting the use of wind energy in Sudan. Provides direct technical assistance to a wind farm to be established in Dongola (Northern State) to aid in the replication of experiences to be applied to subsequent farms in Red Sea State, Nyala and Khartoum. The project also aims to put in place legislation and a framework to promote private sector involvement in renewable energy in Sudan. Dongola Power Farm will be developed to produce 100 KW at the end of the five years.
17	Conservation and Sustainable Use of Biodiversity	Donor Finance: UNDP	2015-2019	US$4.37	GEF Grant, establishment/rehabilitation of new protected areas to be identified by Wildlife Authority, conservation of biodiversity in oasis with documentation of indigenous knowledge for sustainable of biodiversity in forests and rangeland, management of invasive species.

18	Integrated Water resources Management as an Approach for Adaptation to Climate Change in Kordofan	Donor Finance: LCDF	2015-2019	US$10.6	LCDF grant, catchment basin management for building resilience for communities in the catchment areas; ground water resources assessment, monitoring and management.
19	Rehabilitation of Rangelands	Donor Finance: UNDP/GEF	2015-2019	US$10.6	Improvement in capacity, design and policy measures (capacity building, raising awareness); Implementation of EBA measures (natural resource management, pilot schemes, diversifying livelihoods, changing management practices).
20	Amtar company for investment - First Phase	Ginan for multi-activities (Emirates company)	2015-2017	US$100.0	Located in Northern state; first phase area 6200 ha – to produce fodders and vegetables using ground water irrigation.
21	Certified seed production project	Investment fund for social welfare	2015-2016	US$10.0	Located in Elgolid locality; Northern state. 630 ha; production of improved seeds (wheat, sunflower, alfalfa, maize); ground water irrigation and pivot irrigation system.
22	Water Harvesting Project in the States	Government finances	2015-2019	SDG2,260.0	Establishing structures to harvest water from rain, seasonal streams and ground water for the purposes of human and livestock drinking and irrigation of crops in states and rain-fed areas prone to drought. Structures include surface dams, deep bore wells, hafirs, dykes.
23	Water harvesting project - Gedarif State	Islamic Development Bank	2015-2019	SDG1,501.0	Located in Gedarif state; construction of 3 surface dams; and 27 hafirs, To increase storage capacity of rain water for animal consumption.
24	Water harvesting project	Islamic Development Bank	2015-2019	US$24.34	Located in Darfur states; for improved water supply for human and animal drinking. drilling and construction of 126 deep bore wells; rehabilitation of 142 wells; construction of 30 hafirs; rehabilitation of 20 hafirs; construction of stony dykes and 19

					earthy dykes.
25	Integrated solution to agricultural sector program	Government of Sudan	2014-2019	SDG1450	Located in 18 states; focusing on water harvesting and conservation works; supplementary irrigation and conservation agriculture for improving and stabilizing crops yield.
26	Sustainable Agricultural Water Productivity Enhancement for Improved Food and Nutrition Security in Eastern and Central Africa	ASARECA, Government of Sudan	2014-2016	SDG1.38	Sudan is one of the seven African countries in ECA implementing this project in two watersheds in Sennar and N. Kordofan States for enhancing AWP through adoption and scaling up of market - driven AWM technologies and innovations.
27	Diversification and Sustainable Intensification of Production Systems Program	ICARDA, ARC	2015-2018	SDG2.45	The project has evolved from Sudan membership contribution to CGIAR, which focus on NRM in Kordofan, Gadaref, Gezira and River Nile and Northern States.
28	Improving the livelihood of Rural Communities in the Nile Valley and Sub-Saharan Africa Region "Sustainable Crop and Livestock Management"	ICARDA, IFAD, ARC	2013-2017	SDG2.7	In Sudan the project located in Lower Atbra area. It aims at improving irrigation water use efficiency, cropping intensity and diversification. Installation of small-scale irrigation schemes (digging shallow wells, provide irrigation pumping units and modern irrigation systems- drip, bubbler, sprinkler and pipe conveyance).
29	Fangoga Hafir (earth dugout reservoir)	Islamic Relief Organization (NGO)	2015-2016	SDG1.5	Located in Shaikan locality, North Kordofan state; water capacity 30,000 m3; improve water availability for human and animal drinking.

30	Abu Sonoon Hafir (earth dugout reservoir)	Islamic Relief Organization (NGO)	2015-2016	SDG1.5	Located in Shaikan locality, North Kordofan state; water capacity 30,000 m3; improve water availability for human and animal drinking.
31	Rehbilitation of Gash Delta	Sudan Government, Islamic Bank	2015-2019	SDG 619.0	Rehabilitation of water delivery canals and flood basins (Mesgas).
32	Rehabilitation of Tokar Delta	Sudan Government, Islamic Bank	2015-2019	SDG618.0	Rehabilitation of water delivery canals and flood basins.
33	ARP Programme	Sudan Government	2015-2019	SDG 1,180.0	Projects of the Agricultural Revival Programme.
34	Support to the agricultural season	Sudan Government	2015-2019	SDG 1,720.0	Funds allocated to be used for various agricultural activities during the agricultural season.
35	Livestock Improvement and Marketing Programme	IFAD (principal funder), Sudan Government, Developed Countries Fund, the Adaptation for Smallholder Agriculture Programme, the Central Bank of Sudan (CBS), Commercial Banks and Microfinance Institutions, Beneficiaries at grassroots level, Public Private Partners, and	2015-2021	US$119.2	IFAD-funded and led programme to increase livestock productivity, support value addition and marketing for more sustainable management and utilization of natural resources, improved animal health and access to animal health services, and increased marketing of primary and secondary livestock products. The project has national coverage but area-specific for direct community-level interventions, initially in selected Localities in the five States of West Kordofan, North Kordofan, White Nile, Sennar and Blue Nile.

		participation of The Arab Authority for Agricultural Investment Development (AAAID) and Islamic Cooperation for the Development of the Private Sector			
36	Small Farmers Support Project in Rain-fed Sector - Sennar State	IFAD - DSF grant/Government	2010-2017	US$21.1	IFAD-funded and led project covering 100 villages in three of Sennar State's seven localities with the goal of reducing poverty and increase food security including for smallholder households. Focus is on technology transfer, market access and post-harvest management, and capacity building and institutional strengthening.
37	Seed Development Prgramme	IFAD - SDF grant	2011-2017	US$17.5	IFAD-funded project to develop production of good seeds for various crops. Covers four localities in North and South Kordofan States with an overall goal to improve food security, incomes and resilience to shocks among smallholder producers in rainfed areas. The programme will increase agricultural productivity and provide sound foundation for the seed industry in the Sudan.
38	Rural Water Projects (Hafirs and Dams)	Sudan Government (Ministry of Water Resources, Electricity and Irrigation)	2015-2019	SDG914.0	Project implemented by the Ministry of Water Resources, Electricity and Irrigation to supply water in rural areas for human and livestock use.

Table 1.2. Pipeline Projects

#	Project title	Funding Partners	Time Scale	Total Budget (million US$)	Description
1	Kajabar Dam	Kingdom of Saudi Arabia and other Arab funds	2016-2020	US$940.0	Located in Northern state at Third Nile Cataract, 111 km north of the Northern State's capital - Dongola. Construction of 10 hydropower generating units for production of 360 MW.
2	Dal Dam	Kingdom of Saudi Arabia and other Arab funds	2018-2023	US$1,525	Located in Dal area, Northern state at Second Nile Cataract. Construction of hydropower generating units with production of 748 MW.
3	Sherik Dam	Kingdom of Saudi Arabia and other Arab funds	2016-2020	US$970.0	Located in River Nile State, at the 5th Cataract lying north of the confluence of the Nile and Atbarah Rivers. Construction of hydropower generating units 420 MW.
4	Dinder Canals Inlets	Kuait Fund + Government finances	2016-2020	US$100	The project is located in Blue Nile State. Construction of hydropower generation unit at Kenana and Rahad Canals Inlets; production of 60 MW.
5	Local Choice Schemes	Government finances	2016-2020	SDG305.0	Agricultural schemes to accommodate displaced people due to Merowi Dam.
6	Quality control labs for water strategies & monitoring	Government finances	2015-2019	SDG36.0	Establishment of laboratories for quality control in water monitoring and water strategies.

7	Sudan Programme for productive capacity building in irrigated agriculture		2016-2020	SDG72.0	Nurse producers organizations, extension, new agriculture concepts, agriculture business.
8	Follow up and evaluation of agricultural activities		2015-2019	SDG266.0	Monitoring of implementation of planned agricultural projects and activities, assessment of implementation and taking remedial actions.
9	Integrated solutions to develop rain-fed agriculture		2016-2020	SDG 225.0	Development and modernization of rain-fed agriculture to raise productivity and provide basic infrastructure such as branch roads, good seeds, finance, pest control; with first focus on less developed areas.
10	Raising rain-fed cotton production		2016-2020	SDG1,990.0	Revival of rain-fed cotton production particularly the rehabilitation of the former Nuba Mountains Public Corporation.
11	Blue Nile Sugar factory	Mainly Foreign finance	2015-2019	SDG555.0	Located in Sennar state. Rehabilitation of existing irrigation system; modernization of mechanization equipments; establishment of sugar factory 32,000 ha to produce cotton, ground nut, sorghum and sugar cane.
12	Mashkour Sugar Factory	Sudan Government and Private Sector most likely recruitment of foreign investors	2015-2019	SDG532.0	Located in the western bank of the White Nile in the White Nile State involving a shift in an existing agricultural scheme from growing field crops to sugar production in an area of 12500 ha to produce 200,000 tons of sugar. An agreement was signed in December 2010 with two Indian companies for providing equipment and factory installation. The project is government initiated, still waiting for partners and foreign finance.
13	Bran Project	Private sector	2016-2018	SDG2.1	Located in Dongola area, Northern state; construction of irrigation system; 840 ha; fodder, wheat.

14	Malik Land	(national)	2016-2018	SDG63.4	Located in Dongola area, Northern state; construction of irrigation system; 840 ha, wheat, fodder, fruits.
15	Onti project	Private company (national)	2016-2018	SDG1.6	Located in Dongola area, Northern state; 180 ha; underground water – fruits, fodder and wheat.
16	Elrasheed project	Private company (national)	2016-2018	SDG10.78	Located in Dongola area, Northern state; 84 ha, fodder, wheat, fruits.
17	Habab project	Private sector (national	2016-2018	SDG1.3	Located in Dongola area, Northern state; 84 ha fodder, wheat, fruits.
18	Abdelrahman Elsanei Project	Private sector (national)	2016-2018	SDG5.0	Located in Burgaig locality, Northern state; construction of underground water irrigation system; 6100 ha; fodders, wheat, fruits.
19	Elragihi International for agric & Investment	Private sector (Saudi)	2016-2018	SDG150.0	Located in Eldaba locality, Northern state; 40,000 ha; underground water; fruits, fodders, wheat.
20	Elragihi for agriculture	Private company (Saudi)	2016-2018	SDG20.0	Located in Eldaba locality, Northern state; 4,370 ha; underground water; fruits, fodders, wheat.
21	Ibn Gahlan project	Private company (Saudi)	2016-2018	SDG26.3	Located in Elgolid locality, Northern state; 6,275 ha; underground water; fruits, fodders, wheat.
22	Nasr Shiekh Mustafa project	Private sector (national)	2016-2017	SDG162.9	Located in Marawe locality, Northern state; 10,070 ha; fruits, fodders, wheat.
23	Elmanfooha project	Private sector (national)	2016-2018	US$25.0	Located in Kareema locality, Northern state; 12,590 h; underground water; fruits, fodders, wheat.
24	Elsaila project	Private sector	2016-2020	US$600.0	Located Guli area, white Nile state; 51,600 ha; pumps irrigation system from the white Nile to produce sugar cane.

25	Sabina company	Kuwaiti investors	2016-2020	US$900.0	Located in Elslam locality, white Nile state; 103,150 ha; pumps irrigation system to produce sugar cane.
26	Crown company	Egyptian Investors	2016-2020	US$20.0	Located in Edwaim locality, White Nile state; 2,935 ha; pumps irrigation system; rice production.
27	Elridaise Sugar	Pakistani investors	2016-2020	US$800.0	Located in Elsalam locality, White Nile state; 83,900 ha; pump irrigation system; sugar cane production.
28	Gafa Sugar	Foreign credit + government funds	2016-2020	US$600.0	Located in Rabak locality, White Nile state; 57,500 ha; pump irrigation system, sugar cane production.

REFERENCES

Abdelrazig Elbashir and Hamid Faki (Consultants) (2014). Poverty Reduction And Food Security In Sudan: A Policy Background Paper. Prepared for: the Institutional Capacity Building for Poverty Reduction and Good Governance Project (ICBPRGGP), Draft 17 February 2014.

Adam, I. (1993). *Hydraulic Structures of Surface Water Resources in Darfur*. Hydraulic Research Station Report, Wadmedani, Sudan.

Ali, M.A. 1996*. The natural resource base. In: Proceedings of the Agricultural Conference*. Ministry of Agriculture and Forests, 2–3 March 1996, Khartoum (in Arabic), pp 9-25.

Central Bank of Sudan (2014). *Annual Report No 54, 2014*. Central Bank of Sudan WDI (2015). *World Development Indicators (http://data.worldbank.org/country/sudan).*

Elteyeb, M. (2001). *The Long Term National Agricultural Strategy (2002-2027): Wadis Waters Utilization (Arabic)*. Report submitted for Ministry of Agriculture and Forests, Khartoum, Sudan.

HCENR (Higher Council for Environment and Natural Resources) (2014). *Sudan's Fifth National Report to the Convention on Biological Diversity*. Ministry of Environment, Forestry and Physical Development, Republic of Sudan.

High Council for Agricultural Revival (undated). *Second Phase of Executive Programme 2012 – 2014.* General Secretariat.

High Council for Agricultural Revival 2008. *Executive Programme for Agricultural Revival 2008-2011*, General Secretariat, Second Edition, October 2008 (in Arabic).

IFAD (2013). *Republic of the Sudan: Country strategic opportunities programme*; EB 2013/110/R.14, 18 November 2013.

Mekki A. Omer 2012. Crop Production Improvement for the Traditional Rain-fed Sector. Working paper presented for the “Strategy for Development of Traditional Rainfed Agriculture”, Mamoun Beheiry Center for Economic and Social Studies and research in Africa, October 2012.

MEPD (Ministry of Environment and Physical Development), Republic of Sudan 2003. *Sudan’s First Communications under the United Nations Framework Convention on Climate Change,* vol. 1: *Main Communication,* Higher Council for Environment and Natural Resources, Khartoum.

Ministry of Agriculture 2014. Comprehensive National Food And Nutrition Security Policies, Food and Nutrition Security Technical Secretariat, Ministry of Agriculture, Khartoum, June 2014.

PRSP *(2012). Sudan Interim Poverty Reduction Strategy Paper, 2012*. Khartoum, Sudan.

Republic of Sudan (2006). *National Drought and Desertification Control Unit (Nddcu); Sudan National Action Programme (SNAP): A Framework for Combating Desertification in Sudan in the Context of the United Nations Convention to Combat Desertification*; Ministry of Agriculture and Forestry, Khartoum – March 2006.

Samar Shams Elddin. 2008. The effect of technological production package on the yields of major crops in Sudan during seasons 1985/1986–2004/2005. Draft Annual Report 2007, Agricultural Economics and Policy Research Center, Agricultural Research Corporation, Sudan.

SSCCSE, CBS, SIFSIA/FAO (2010). Food and Nutrition Security Assessment, Analysis of 2009 National Baseline Household Survey, Khartoum, Sudan, August 2010.

Taha, Abdelmoneim, Timothy Thomas and Michael Waithaka 2013. *Chapter 10: Sudan, In East Africa Agriculture and Climate Change: a Comprehensive Analysis*. International Food policy Research Institute (IFPRI).

SUDNAIP (2015). Sudan National Agriculture Investment Plan (SUDNAIP) 2016-2020. Ministry of Agriculture and Forests, Khartoum, Sudan.

Yagoub Abdalla Mohamed (2013). *Environmental Considerations for Preparation of Strategy for rain-fed agriculture in Sudan*. Background paper for the Strategy for Development of Traditional Rain-Fed Agriculture, Republic of Sudan, Mamoun Beheiry Center for Economic and Social Studies and Research in Africa.