Towards Climate Resilience in the Nile Basin: The Case of the Sudan

Tarig El Gamri

Abstract:
Although Africa's share to the causes of Climate Change is insignificant yet, the continent is the most vulnerable to the impacts of the phenomenon. The Nile Basin witnesses very high population growth rates, severe impacts of climate variability and change and severe food insecurity. About 94% of the Sudan is located in the arid and semiarid regions. Desertification, climate change and other forms of environmental degradation strongly contribute to poverty, displacement and conflicts. Separation of south Sudan imposed huge economic hardships to the country which was formerly reported to achieve economic stability due to the implementation of the Comprehensive Peace Agreement. Recent projections showed that the Sudan will witness severe water shortages of about 30 billion cubic meters by the year 2027. Different factors like the ENSO Event were found to contribute to the variability of the country's rain fall and consequently, severe droughts, devastating floods and substantial socioeconomic impacts were incurred. Due to Climate Change the rain fall of the country showed 19% reduction and increased variability. Meanwhile, further reduction in rain fall coupled with south ward shift of agro-climatic zones and reduced crop productivity were anticipated. Climate resilience is maintained by creating conducive policy environment, strengthening relevant institutions and early warning systems and implementation of the relevant programs and projects. In addition to that basin (regional) cooperation is of vital importance especially promotion of regional trade, coordinated reservoir operation and joint research. The Higher Council for Civil Defense is the apex body to coordinate disaster management in the Sudan. The paper recommends that the efforts to craft the national water policy, other sectoral policies, the national IWRM plan and the NAP are to be urged.

Key words: Climate Change, Vulnerability, Impacts, Adaptation, Resilience

1.0 Introduction:

The Nile is one of the longest rivers of the globe, passing through about 6,695 kilometers from its furthermost source, the Kagera Basin in Rwanda and Burundi, through Lake Victoria, to the Mediterranean Sea (www.nilebasin.org). The basin covers an area of more than three million square kilometers which equivalent to about one-tenth of the African continent. Eleven countries are riparian to the great African river including Burundi, DR Congo, Egypt, Eritrea, Ethiopia, Kenya, Rwanda, South Sudan, The Sudan, and Tanzania. More than 238 million people reside within the watershed and anticipate benefits from the management and utilization of the shared resources of the Nile Basin.

According to HCENR, (2013) about 75% of the annual flow of the Nile occurs in the rainy season, from July to October, and only 25% during the remaining eight months of the year. The extreme annual flow variations, as recorded at Aswan, of 150 bcm (1878-1879) and 42 bcm (1913-1914), necessitated construction of storage dams. The average annual flow of the Nile recorded at Aswan in southern Egypt is 84 bcm meanwhile; 10 bcm are estimated to evaporate from the Aswan High Dam reservoir. Fig. (1) Exhibits the whole watershed of the Nile Basin.

Fig. (1): The Nile River Basin

Source: Kameri-Mbote, (2007)

Regarding Nile cooperation it should be noted that; the perception in the upstream is that development of a legal framework is of prime importance to achieve equitable sharing meanwhile, downstream perception consider legal arrangements as codification of an existing cooperation. However, according to Mason, (2004) Nile Cooperation has been accelerated since 1990s when Ethiopia acknowledged a project-by-project approach, and Egypt accepted negotiating a legal framework. Nevertheless the riparian countries are still far from reach a consensus on the Cooperative Framework Agreement (CFA) alternatively known as Entebbe Agreement.

Challenges to the Nile basin countries are similar to those faced by the vast majority of the African countries with trans-boundary rivers. In terms of water scarcity, the Nile basin is among the most problematic regions of the world it witnesses high population growth rates and many (e.g., Ethiopia, Eritrea, and Sudan) experience chronic food insecurity (NWRC, 2001). In

addition to that Sudan, Ethiopia, and Eritrea are the most vulnerable to climatic variations among the Nile basin countries (UNEP, 2005).

Due to its increasing impacts on all aspects of growth on Earth and livelihoods Climate Change is considered as the defining issue of the present age. For instance, FAO (2011), considered Climate Change as one of the major factors that affect food security other factors include population increase, rural urban migration, globalization, environmental stresses and unattractive investment environments. The phenomenon is also anticipated to hasten the hydrological cycle, and hence increased incidence of extreme events (floods and droughts) are expected especially in the arid and semiarid regions (El Gamri et al., 2009a).

Recently the globe has witnessed the most extreme weather events in modern history (El Gamri, 2012). For instance, during the summer of 2010 about 20% of the total area of Pakistan was flooded with consequent impacts on 20 million people, destruction of 2.2 million ha of agricultural lands and inundation of thousands of schools and health centers'. Almost concurrently a heat wave in and around the vicinity of Moscow caused more than 10,000 deaths, extensive forest fires and a 30% reduction on Russia's grain harvest leading to a worldwide spikes in food prices. Meanwhile, the current prolonged drought of China is endangering its wheat production. During early 2011 torrential rains caused devastating floods in Australia where an area equivalent to the area of France and Germany combined was submerged. Moreover, heavy rains in Brazil prompted mudslides that caused more than 600 casualties, one of the country's deadliest natural disasters on record.

Developing countries witness high vulnerability to climatic changes since the majority of them are situated in the arid and semiarid areas coupled with their inability to adjust or adopt appropriate adaptation measures (IPCC, 1998 and 2007). Although the Africa's share to the cause of Climate Change is meager yet, it is the most vulnerable continent since climate is the major cause of disasters in Africa (Mutua, 2004).

UNISDR, (2009a) defines "**resilience**" as "The ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions."

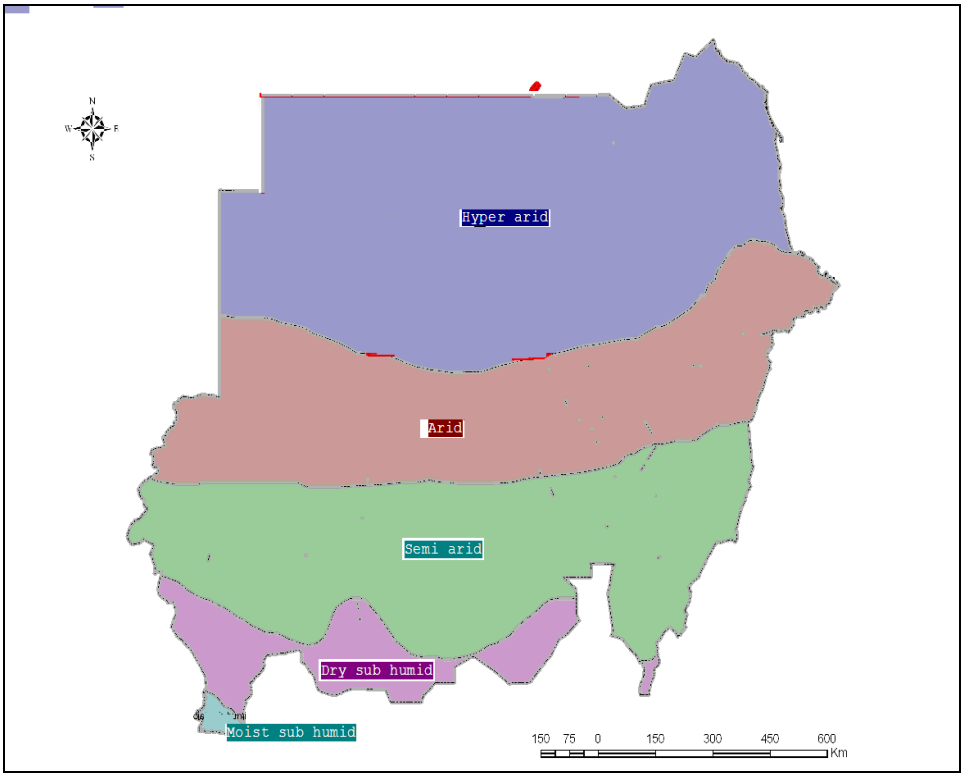
With high confidence IPCC, (2007) emphasized that the resilience of many ecosystems is likely to be surpassed by 2100 due an unparalleled combination of Climate Change, associated disturbances like floods and droughts and other global change drivers such as pollution and over-exploitation of resources. Ecosystem-based adaptation is defined by CBD (2009) as "the use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people adapt to the adverse effects of climate change." Meanwhile, it should be emphasized that strengthening of coping or adaptive capacity is crucial in ensuring a climate-resilient society (community based adaptation).

2.0 National Situation Analysis:

Sudan is located in the Northeastern part of Africa between Lat. 21.49 to 38.34 E and Long. 23.8 to 8.45 N with a total area of 1.882.000 km^2. The Nile Basin is the most conspicuous geographical feature of the country since its watershed constitutes about 67.4% of the country's total area (MoI, 2011). Generally the country is flat interrupted with some high lands the most sizeable of which are Jebel Marra, Red Sea Hills and Nuba mountains. Neighboring countries include Egypt, Chad, Eritrea, Ethiopia, South Sudan, Central Africa and Libya. As shown in Fig. 2 the majority of the country (94%) is located in the arid climates (hyper arid, arid and semi arid).

By the virtue of its location Sudan used to be a link and a cultural and commercial route between the Northern and the Southern parts of the African continent as well as between the Arabian Peninsula and Africa. Ethnically the Sudanese people are a mixture of different ethnic groups especially Arabs and Africans (UNDP, 2006).

Fig. 2: Climatic Zones of the Sudan



Source: MoI, 2011

2.1 Socioeconomic Conditions:

Sudan is a young country since about 43% of its total population is under 14 years old. According to MoI, (2011) the total population of the country is estimated at 33.419.525. Population density per km^2 is 2-3 persons (in desert to semi desert areas) and 218 - 230 persons (in rich savanna and labour demanding areas).

Age distribution:

0-14 year 43.2%

15-65 year 53.4%

> 65 year 3.4%

Average family size: 5-6 people
Population growth rate =2.8%
Unemployment rate =11%
Severe poverty =8%
Average age 59 years
Mortality rate: 16.7/ 1000 people
Out immigration rate 0.29/ 1000 people
Maternal mortality rate = 215/ 1000 people
Child (under 5 years) mortality rate = 105/ 1000 people
Infant mortality rate = 71/ 1000 people

According to UNEP, (2007) desertification, climate change and other forms of environmental degradation strongly contribute to poverty, displacement and conflict in dryland Sudan. Infrastructure including transport, power and water supply is either completely absent or underdeveloped (UNDP, 2006).

The year 2011 was marked with the separation of South Sudan which created substantial economic challenges to Sudan (UNEP, 2011). Before separation old Sudan had maintained economic stability and was one of the fastest growing economies in Africa. MoI, (2011) presented the following indicators of the Sudanese economy:

Gross Domestic Product (GDP) = 154.494 Billion SDG (equivalent to 66.6 Billion US Dollars).
GDP per capita= 2380 US Dollars
Ratio of development expenditures/ GDP= 3.7%
Average annual inflation rate= 13%
Annual growth rate of the services sector= 42.1%

Impacts of the separation of the South are multi dimensional for instance the nationa forest cover was reduced from 30% of the total land area of Old Sudan to only 10%. Meanwhile, about 85% of the petroleum reserves are located in South Sudan (Sudan has already lost about 75% of the total petroleum revenues). Moreover, it's more likely that the new country will join the CFA since according to a government official the process of joining the agreement has started at all levels of the state apparatus in South Sudan (www.aljazeera.com).
Growth in GDP has been mainly motivated by oil production and the mounting foreign direct investment (AfDB, 2010). Meanwhile, UNDP, (2006) revealed the fact that the low national average per capita income doesn't reflect the wide regional disparities in economic and social development.

The economic dividends of peace would be great since, Sudan has great agricultural potential and promising gold and oil reserves (http://www.bbc.co.uk). Beside the relative peace and

stability achieved due the implementation of the Comprehensive Peace Agreement (CPA) El Mahdi, (2008) attributed the strong economic performance of the Sudanese economy (before cessation of the South) to the onset of oil production in the late nineties coupled with the implementation of the successive structural adjustment programs.
Such achievements can be summarized as follows:

- Strong growth rates with an average of over 8% since 2001.
- Stability of macroeconomic as reflected by the containment of public deficit
- A single digit inflation rate, and
- Stable exchange rate.

These achievements were highly commented by IMF however, public expenditures in health, education and water remain unacceptably low both at the fedral and state levels (El Mahdi, 2008).
Generally strong economic growth is usually coupled by poverty reduction the thing that has not applied to Sudan were poverty and inequalities have been seen in the rise.
El Mahdi, (2008) attributed that to the following aspects of the growth of the Sudanese economy:

- High and growing inequalities in income distribution
- Most of the economic growth occurred in the oil and services sectors rather than in the agricultural sector which is the main livelihood of the majority of the poor.

It's worth mentioning that contrary to conventional economic indicators e.g. GDP the Inclusive Wealth Index (IWI) focuses on wealth rather than income and hence conservation of productive base is considered for the wellbeing of future generations (UNU-IHDP, 2012).

With over five million internally displaced persons (IDPs) and international refugees, Sudan has the largest population of displaced persons in the world today with significant environmental impacts (UNEP, 2007). The situation improved due to the implementation of the CPA and the associated voluntary resettlement programs however, influx of international refugees is still very high. Drawn for the relief experience in the region of Darfur Bromwich et al. (2007) recommended the development of a framework of sustainable resource management in the context of the relief program/ project.

2.2 Water Resources:

Average annual rainfall of the Sudan is estimated at about 400 bcm (MoI, 2011). The amount and distribution of rainfall plays an important role in the environmental and the economic aspects of the country especially pastoralism and rain fed agriculture (MOIWR, 1999; Adam, 2000). In this respect studies based on remotely sensed data showed that the vegetative cover expands and contracts significantly following the erratic nature of the rain fall (Hellden, 1991; Giannini *et al.*, 2003).
According to Abdalla et al., (2011) the average annual discharges of the River Nile and its tributaries are as follows:

- The River Nile 83billion cubic meters (bcm) (at Aswan)
- Blue Nile 50.7 bcm
- White Nile 27.8 bcm (at Malakal)

- Bahr El Jebel 26 bcm (at Mongalla)
- Dindir River 3 bcm
- Rahad 1.09 bcm
- Atbara 12 bcm (7 bcm from setit and 5 bcm from Atbara)

On addition to that the annual discharge of wadis, seasonal stream and small rivers is estimated at about 6 bcm. Meanwhile, renewable groundwater resources are estimated at about 4.02 bcm per annum. Considering Sudan's share from the Nile waters of 20.5 bcm (as measured in Aswan) hence, the total annual available water resources of the country are estimated at about 30.8 bcm.

UNEP, (2010) estimated water withdrawal as 96,7%, 2.6% and 0.7% for agriculture, municipalities and agriculture respectively for the year 2000. It is estimated that 12 bcm are abstracted from the River Nile and its tributaries, 1.2 bcm (0.7 bcm for agriculture and 0.5 bcm for domestic use) from renewable groundwater, 2.5 bcm from Wadis with a total of 15.7 bcm (El Gamri, 2012). According to abdalla, (2010) the existing irrigated schemes which cover a total area of 4.4 million fed (1.85 m ha) are anticipated to reach up to 5.5 million fed (2.31 m ha) in the near future. The total water used by these schemes plus evaporation from the existing reservoirs' is estimated at 14.5 bcm (measured at Aswan). As shown in Table (1) irrigation water demand is projected by the Ministry of Irrigation and Water Resources under the Long Term Agricultural Strategy (2002-2027) at about 42.5 bcm. Meanwhile, domestic and animal usage and industrial needs are about 10.1 bcm. Considering evaporation from the reservoirs of the proposed hydropower projects i.e. (6.6 bcm), the total demand by 2027 would be 59.2 bcm (Yates et al., 2010).

Table (1): Water Demand Projection to 2027 (bcm)

Year	Irrigation	Domestic Supply	Animals & Others	Total
2012	27.1	1.1	3.9	32.1
2020	32.6	1.9	5.1	39.6
2025	40.3	2.5	5.3	48.0
2027	42.5	2.8	7.3	52.6

Source: Abdalla, (2010)

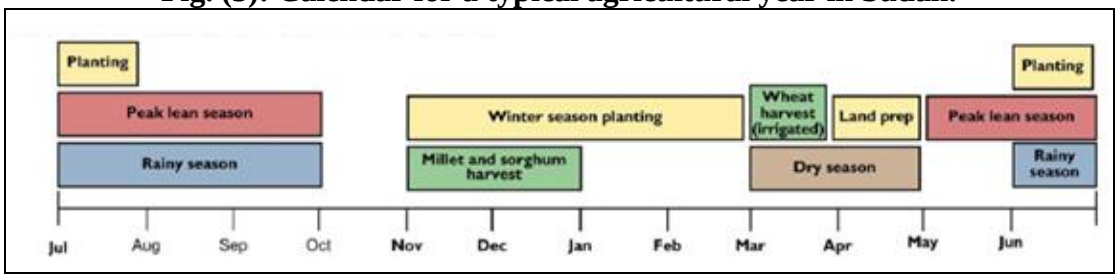
2.3 Agriculture:

Agriculture represents 31.6% of the GDP and constitutes 80% of the non petroleum exports meanwhile about 50% of the national labour force work in agriculture. Important crops of the country include; sorghum, millet, wheat, cotton, cane sugar, dates, sunflower and groundnuts. According to MoI, (2011) the total cultivable area of the country is about 200 million fed (acre), currently cultivated area is estimated at about 17.5 m ha (40 million fed) constituting about 20% of the potential. 5% of which is irrigated agriculture, 65% traditional rain fed agriculture 30% mechanized rain fed agriculture. Rain fed agriculture is mainly practiced in the Savannah and southern part of the country where rainfall exceeds 300 mm. Fig. (3) shows calendar for a typical

agricultural year in Sudan.

The sector witnesses low and variable productivity mainly due to non conducive policies that extends through the whole production sectors. Reformed agricultural policies would generate incomes for poor farmers (El Mahdi, 2008). The low agricultural productivity combined with the recent devaluation of the Sudanese currency has contributed to the erosion of the competitiveness of agricultural products of the country, namely for sesame, groundnuts and sorghum (IFAD, 2009).

Fig. (3): Calendar for a typical agricultural year in Sudan.



Source: FEWS net

3.0 Impacts and Vulnerability:

3.1 Climate Variability:

Climate Variability: denote deviations of climate statistics over a given period of time (such as a specific month, season or year) from the long-term climate statistics relating to the corresponding calendar period.

Climate variability is found to be moderately high in upstream Nile riparians such as Uganda and Kenya, with an anticipated moderate to high changes in variability. Downstream riparians (Egypt and Sudan) have high and medium variability respectively. The sensitivity of Ethiopia to climate variability may be the lowest, as its current and anticipated variability is low (Stefano et al., 2010). According to El Gamri, (2005) and El Gamri, et al., (2009a), The position of Inter-Tropical Convergence Zone (ITCZ), the ENSO event and Climate Change were found to influence rainfall of the Sudan among others. For instance the ENSO Event was found to influence the rainfall of the Sudan with La Nina associated with above-normal rainfall and El Nino with below normal rainfall and with higher predictability for La Nina to El Gamri et al., (2007).

Vulnerability is the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude and rate of climate change and the variation to which a system is exposed, its sensitivity and its adaptive capacity (IPCC, 2007).

Despite its serious water shortages, floods are also common in Sudan. The most devastating occur on the Blue Nile, mainly due to land degradation on the Ethiopia Plateau. Associated with flooding is severe riverbank erosion in the narrow but fertile Nile riverine strip (UNEP, 2007). According to Abdalla, (2010) floods are of two sources these are namely:

- River flooding, i.e., high river waters spill over the banks, and
- Flash floods caused by torrential rainfall over villages and urban areas.

The flood damages in the country are mainly loss of property, destruction of crops, drowning of livestock with a cost that ranges between 100 and 1000 million dollars. This is beside human death incidents in severe floods such as 1988, 2007 and 2013. In addition, high floods are normally accompanied by wide spread of diseases, such as malaria, diarrhea, bilharzias, and other water borne diseases.

The most destructive river floods occurred in 1946, 1975, 1988, 1994, 1998, 1999, 2006, 2007and 2013. Although flash floods are less frequent yet they may cause severe impacts, the most destructive of which occurred in 1978, 1999, 2007, 2009 and 2013. In recent years flash floods caused more damages than river flooding such as that of 2007 which is considered as the worst flood in living memory. Overlap of the two sources of flooding complicates flood control since natural drainage to the Nile is hindered.

The existing capacity of Roseires and Sennar reservoirs is only 15% of the annual flow of the Blue Nile. Moreover, the high silt content makes water storage a risky business during flood times. The heightening of Roseires Dam together with the efforts to build large dams in Ethiopia will assist in flood management (Abdalla, 2010).

NSF, (2003) emphasized that severe drought will be a characteristic of climate in the future as it is used to be in the past with huge economic costs. This can be exemplified by the short 1988 summer drought in USA which was estimated to have cost $40 billion. During the past decades Sudan has suffered a number of long and devastating droughts with negative impacts on its' food security and triggered displacement and related conflicts. The vulnerability to drought is exacerbated by the tendency to maximize livestock herd sizes rather than quality, and by the lack of secure water sources such as deep boreholes that can be relied on during short dry spells (El Gamri, 2012).

According to El Gamri, (2004) the physical and sexual maturities of farm animals (cattle, sheep and goat) are markedly retarded during drought years due to the unavailability of feed stuff. For instance the sexual maturity of goat retarded from 8.6 months to 15.4 months

3.2 Climate Change

Climate change in IPCC usage refers to any change in climate over time, whether due to natural variability or as a result of human activity. This usage differs from that in the Framework Convention on Climate Change, where climate change refers to a change of climate that is attributed directly or indirectly to human activity that alters the composition of the global

atmosphere and that is in addition to natural climate variability observed over comparable time periods.

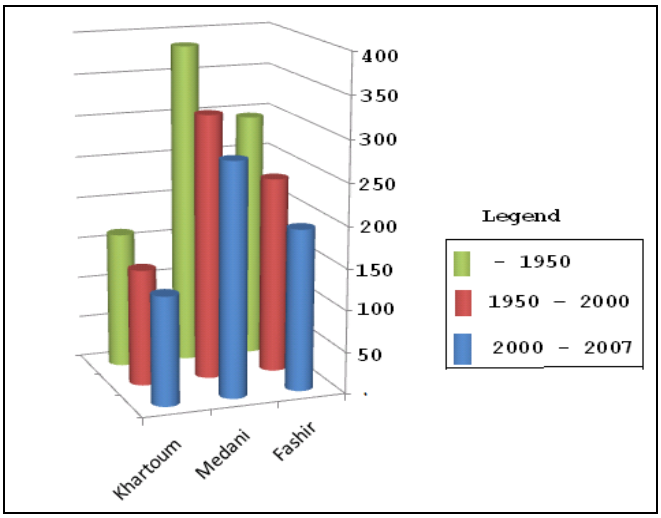
According to HCENR, (2013) in the Sudan air temperature have been steadily increasing during the period 1960 – 2009. On average temperatures in 2000-2009 are approximately 0.8^{O} C and 1.6 ^{O} C higher than they were in the 1960-1969 period. Climate change is also projected to reduce average rainfall by about 6 mm per month during the rainy season. Such changes in temperature and precipitation are likely to undermine economic development in Sudan (HCENR, 2003; Zakieldeen, 2009).

Osman *et al*., (2001) revealed the fact that rainfall of Old Sudan witnessed significant reduction since early sixties of the previous century with strong coincidence between dry seasons and the ENSO event. This is consistent with Adam, (2000) who proved that dry Sudan experienced a 19% reduction in rainfall when comparing the two climatic normals of (1941-1970) and (1970-1999).

According to El Gamri and Abdalla, (2012) during the second half of the previous century rainfall for Fashir, Khartoum and Medani have declined by 20%, 14.3% and 17.5% respectively. As shown in Fig. (4) the trend is more obvious in Fashir which is located in the region of Darfur. Meanwhile, a significant southward movement of isohyets was observed during the two climatic eras' of 1941-1970 and 1971-2000. Similar results were obtained by UNEP, (2007) which reported that the ten year moving average for Fashir has declined from 300 mm per annum to approximately 200 mm since records began in 1917, while the last time rainfall exceeded 400 mm was in 1955.
UNEP, (2007) estimated that a southward shift of 50 to 200 km of the boundary between semi-desert and desert has occurred since rainfall and vegetation records were first started during the 1930s'. A further southwards movement is expected due to declining precipitation (HCENR, 2007). The remaining semi-desert and low rainfall savannah on sand, which represent some 25 percent of Sudan's agricultural land, are at considerable risk of further desertification and significant drop in food production of about 20%. In addition, future droughts threaten 19 million ha of mechanized and subsistence rain fed farms, as well as pastoralist societies, predominantly in Darfur and Kordofan, and potentiate conflict HCENR, (2013).
Arable lands, as well as the important gum Arabic belt, are also expected to decrease in size, with negative impacts for both local incomes and food security (HCENR, 2003; 2007).

Ground water recharge is anticipated to be reduced under future climate change due to the decreased precipitation and/or increased temperatures and evaporation. Similarly, soil moisture is also likely to decline. When coupled with increased water consumption, population growth and high rainfall variability, these effects suggest that the country could face a serious water crisis (HCENR, 2003; Zakieldeen, 2009).

Fig. (4): Impacts of Climate Change on the rainfall of dry Sudan



Source: El Gamri et al., (2012)

The forecasted changes in temperature and precipitation could adversely alter the current distribution and intensity of ***malaria*** incidence in the country and hence increased burden will be added to the nation's health care system.

4.0 National Climate Resilience Framework

Resilience of a community is a resultant of various interacting factors mainly vulnerability which in turn depend on the duration of exposure, environmental and socio-economic conditions as well as technological and political factors. Policies, strategies and the enabling environments are also crucially important. Additionally, the ability of a society to organize itself both prior to and during the disaster is of prime importance (UNISDR, 2009b).

The national climate resilience framework is analyzed into four dimensions these are namely: regional cooperation, national policy environment, relevant institutions, early warning systems and implementation of the relevant programs and projects.

4.1 Regional/Basin Cooperation:

Realizing the importance of basin (regional) cooperation NBI (2012) suggested the following basin-wide adaptation measures:

- Coordinated reservoir operation.
- Promotion of basin-wide agricultural trade and with other regions.
- Power and transport interconnection.
- Establishment of a joint mechanism for resource solicitation.
- Joint research.

According to NBI, (2012) the Nile Decision Support System (Nile DSS) will enable the riparian countries to assess the trade offs and consequences of basin wide developments. Meanwhile, the

Eastern Nile Technical Regional Office (ENTRO) is implementing the Eastern Nile Flood Preparedness and Early Warning Project. The project is implemented with a view of improving the regional and national capacities in flood forecast and mitigation.

Since the boundaries for a river basin constitute a natural unit for water resources management hence Cap-Net, (2008) advocated adoption of integrated watershed management and establishment of river basin organizations. However, the Nile riparian countries are still negotiating the legal framework for Nile Cooperation.

4.2 Policy Environment:

As mentioned earlier non conducive policies extends through the whole production sectors especially agriculture and is the cause of low productivity and loss of competitiveness. In addition to that, HCENR, (2007) identified institutional instability, Lack of capacities and inadequate investment as major constraints to the implementation of national strategies and programs. The situation is compounded by lack of cooperation and coordination between the different sectors and levels of governance, the NAPA document added (HCENR, 2007).

The First National Communications suggested an outline for Sudan's National Strategy to implement the United Nations Framework Convention on Climate Change (UNFCCC) with a major aim of integrating action into national development activities (HCENR, 2003). The country also produced its NAPA, Second national communication and currently actively working to craft the NAP.

The first national water policy was developed in 1913 to allow for the construction of Sennar Dam and the Gezira Irrigation Scheme. The development of the Water Policy of 2007 was based on the Transitional Constitution of Sudan, the water policies of 1977, 1992 and 2000, macroeconomic and social development strategies (Abdalla and Mohamed, 2007). Other directives include promotion of the role of women and creating incentives for sustainable use of water resources. The relation of this policy to ***resilience*** can be traced in many policy objectives including adoption of integrated watershed management, promotion of international and regional cooperation and consideration of the environmental factors. However, despite the great efforts to craft the water policy of 2007 it's not yet endorsed by the government meanwhile, state water policies are still underway. A comprehensive water resources act was adopted in 1995 that applies to all water resources and covers water uses for all purposes (El Gamri, 2005).

4.2.1 National IWRM Plan:

According to Bates et al., (2008) “the consequences’ of climate Change may alter the reliability of current water management systems and water related infrastructure”. However, El Gamri, (2012) emphasized that adoption of IWRM will promote ecosystem based adaption which is one of the vital strategies to achieve climate resilience. Beside that it will strengthen local governance and the role of civil society specially women (GWP, 2000). Hence, Sudan as represented by the Ministry of Water Resources and Electricity (MWRE) is working together with UNEP to develop the National IWRM plan. The first phase of the process i.e. the vision/policy development phase is almost concluded.

4.3 Institutions:

4.3.1 High Council for Civil Defense:

It is the apex body in the Sudanese Government to coordinate disaster management in the country. The Council is composed of 16 Ministries, the Governor of Khartoum State and the Civil Defense Administration. It is the main decision maker in case of disasters (www.un-spider.org).

4.3.2 Ministry of Water Resources and Electricity:

Since last decade the responsibilities of water resources monitoring, assessment, development and management were brought down to the Ministry of Irrigation and Water Resources (MIWR). According to Abdalla, (2010) the former Ministry of Irrigation and Water Resources (MIWR) normally forms a committee from high officials within the Ministry, called the High Flood Committee (HFC), when the River stage and discharge thresholds are exceeded. The HFC is responsible for the day to day management of the flood, including the interpretation of the FEWS results and the information provided by the satellite imagery and levels of the key stations along the Nile and its' tributaries. The Committee also decides on proper operation of the dams' reservoirs, and the need for construction/enhancement of flood bunds. Affected states by floods play an important role in flood mitigation, e.g., Sennar State, Gezira State, Khartoum State, as well as other less affected states. The Flood Early Warning System of the MIWR encountered some technical problems and hence unreliable (Abdalla, 2010).

4.3.3 Sudan Meteorological Authority:

According to Abdalla, (2003) the Sudan Meteorological Authority (SUMA) started to issue seasonal rainfall forecasts since the year 1999 the most important of which is the rainfall forecast for the period June through September which constitutes the main agricultural season in the country. Using the Principle Component Analysis the country was first divided by SUMA into 6 homogenous rainfall zones. El Gamri, (2005) concluded that these forecasts are reasonable and can be used in strategic planning in the different sectors including food security, environmental protection and disaster mitigation.

4.4 Early warning systems (EWSs'):

Early warning is identified as the first tool in dsiaster management. A survey executed in 2011 revealed that quarter of the countries of the globe is not equipped with EWSs' while others require significant improvements (Pearson, 2012).

The location of Sudan, at the central part of the basin, allows relatively long lead times for flood prediction. Eltahir, (1996) emphasized that inclusion of ENSO as one of the predictors improved the predictability of the Nile flood. Similar results were obtained by El Gamri et al., (2009b) and Musa, (2011) in wadi and Nile flood discharges respectively. The high skills of SSTs' in hydrological forecasts were revealed by El Gamri et al., (2010) and Habeib, (2011) and in rainfall forecast by Giannini, et al., (2003) and El Gamri et al., (2009b).

Realizing its importance some authors called for recruitment of indigenous knowledge in the development process (Gibbon and Pain, 1988; Reij *et al*., 1996). For instance, recent research proved that the traditional believe that "early starting rainy seasons are poor rainy seasons" is valid (El Gamri, 2005).
The roles of both MWRE and SUMA in early warning were discussed under each respective institution and that of NBI under regional cooperation.

4.5 National strategies and programs and programs:

4.5.1 The 25-year Comprehensive National Strategies outlines:

The policies which were developed to guide implementation of First Quarter Century Strategy (FQCS) and concurrently support national climate resilience can be summarized as follows:

- Development of legislations for the liaison between drinking water and environmental sanitation.
- Promotion of coordination and fund raising specially for drinking water and capacity development.
- Adoption of low-cost appropriate technologies, renewable energy and engineering manipulation for water treatment instead of chemical treatment.

4.5.2 Links to MDGs' and other MEAs':

According to El Gamri, (2012) achievement of MDGs' and the implementation Multilateral Environmental Agreements (MEAs)' will enhance climate resilience in the country. For instance, Goal 7 target 10 of the MDGs' aims at halving by 2015 the proportion of population without sustainable access to safe drinking water. According to Elgizoli, (2004) achievement of this target is well supported by the National Comprehensive Strategy, FQCS and consequently with the NAPA.

4.5.3 Sudan NAPA:

Priority adaptation measures which were identified across five ecological zones during the NAPA consultation process and mutually support climate resilience include promotion of water harvesting, water conservation in the agricultural sector, capacity building and microfinance (HCENR, 2007).

4.6 Microfinance:

At the global level microfinance is considered an efficient approach to assist low income people and hence, enhancing their coping capacities. It implies provision of financial services to poor and low-income people whose low economic standing excludes them from formal financial systems. In Sudan an escalating attention is given to microfinance as an efficient tool for poverty alleviation however; current practices are meager compared to the size of the problem. This attention culminated by the establishment of the Microfinance Unit of the Central Bank of the Sudan. The objectives of the Unit are, to supervise the sector, develop conducive policies and legislations and introduce applicable models (http://www.mfu.gov.sd). However, Unicons, (2006) recommended the formulation of a development strategy for the Sudanese microfinance sector together with some legal amendments and integration into the national policies.

Other major links to climate resilience are those of the Agricultural Revival Program and the Eastern Nile Watershed Management Project.

5.0 Concluding Remarks:

The Nile basin is among the most problematic regions of the world as it witnesses high population growth rates and chronic food insecurity. Sudan is sparsely populated country with poor economic situation as measured by GDP. Infrastructure either completely absent or underdeveloped meanwhile public expenditure in development is unacceptably low. The country is one of the most vulnerable countries to climate variability and change in the Nile basin. Significant southward movement of the isohyets was observed during the previous century which is also accompanied by a southward shift of the agro-climatic zones as well as reduced agricultural productivity with severe socioeconomic impacts that led increased poverty, displacement and conflict in dryland Sudan. The country also witnessed severe floods and droughts. To strengthen climate resilience the paper recommends development of conducive sectoral policies, enhancement of basin wide cooperation, adoption of climate resilience strategies, mobilization of political will, expedite the craft and endorsement of the national IWRM plan and NAP and development of an efficient national early warning system.

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