Ali Babiker *et al.*, Sudan Academy of Sciences Journal-Special Issue (Climate Change), Vol. 11 , 2015, 1-14
ISSN 1816-8272

The Status of Science-based Research in Influencing Climate Change Policies, Plans, and Strategies in Sudan

Imad-Eldin A. Ali-Babiker[1], Faisal M. El-Hag[1], Abass E. M. Elamin[2], Bashir A. Eltahir[3] and Abdelmotlib A. Ibnoof[4]

Abstract

This study was designed to assess involvement of researchers in climate change adaptation and their capacity to generate scientific evidence on climate change adaptation policies and plans of action. Information used for conducting study included both primary and secondary data. An inventory of research scientists working in climate change in agriculture and water resources including animal agriculture was made. The study showed a clear indication of limited scientific evidence on climate change impact assessment both in water resources and animal agriculture. Only 15.4% of the research programs (4 out of 26) had elements of climate change impact assessment on animal agriculture and water resources. Also, very limited research was conducted to contribute to the understanding of the climate change impact in animal agriculture and water resources. Research programs and projects together with development programs and projects of research involvement (both locally and externally funded) were 49 out of which only 23 were externally funded. Most of the projects handled adaptation options related to development and improvement of adapted crop varieties and enhancing livelihood/income resilience. The low percent of agricultural water management practices (20.0%) and adaptation knowledge (17.8%) may be related to few scientists with background in environmental sciences or water and agricultural engineering compared to crop and soil sciences. Potential adaptation strategies related to climate forecasts and animal agriculture were less common compared to reforestation and agro-forestry and agronomic aspects. It was concluded that there is a high pressing need to enhance the capacity of researchers to generate scientific evidence on impact assessments and adaptation options, and strengthen the communication platforms among researchers and policy makers. This would ensure that science-based research findings are communicated and thereby used in influencing climate change policies, plans, and strategies. This would assist in proper planning and implementing climate change mitigation adaptation strategies, hence improving animal agriculture under pastoral and agro-pastoral in Sudan and similar areas in the Sudan.

Keywards: Science-based Knowledge, Communication Platform, Climate Change, Policsies & Plan, Animal Agriculture.

[1] Dryland Research Centre (DLRC), Agricultural Research Corporation (ARC), Sudan, Corresponding author email: faisalelhag@hotmail.com
[2] Planning, Monitoring and Evaluation, Agricultural Research Corporation (ARC), Wad Medani, Sudan.
[3] Obied Research Station, Agricultural Research Corporation (ARC), Sudan.
[4] Faculty of Commerce, Economics and Social Studies, Khartoum, Sudan.

Introduction

Most of the human population lives in areas where food production and nature co-exist. The largest and increasing number of under- and mal-nourished in the world, the prospect of rising inequality, the decreased availability of natural resources and the uncertainty of climate change are among the main challenges facing livelihoods (Gilland, 2002).

The 2007 report of the Intergovernmental Panel on Climate Change (IPCC, 2007a) clarified that warming of the climate system is unequivocal and accelerating, and a certain amount of change in the climate is inevitable, necessitating both mitigation and adaptation actions.

Over the past 30 years, efforts have been directed to help poor rural people in marginal or unfavorable agro-ecological conditions to manage their natural resources more sustainably, increase their agricultural productivity and reduce their vulnerability to climatic shocks (Ali Babiker and Mohamed, 2010; UNFCCC, 2011; IATP. 2008). Much of this work has been conducted under conditions of change - rising population densities, deteriorating natural resources, and increasingly uncertain and unpredictable climatic conditions. Climate change will exacerbate the existing vulnerabilities of poor people, thus placing additional strain on livelihoods and coping strategies (UNFCCC, 2004). Multiple stresses related to land degradation, trends in economic globalization, and exposure to violent conflict aggravate exposure to climate risks and affect the capacity of poor people to adapt (El-Hag et al., 2011). It is clear that climate change and poverty are interlinked in complex and mutually reinforcing ways. The nature of the development pathway can have a significant impact on the level of climate change impact (Hatfield et al., 2011). As much as climate change can affect sustainable development and constrain achievement of the Millennium Development Goals (MDGs), sustainable development can reduce vulnerability.

While climate change impacts will vary from place to place, requiring locally specific adaptation strategies, there are some general indications of the ways in which climate change will affect agro-pastoralists and pastoralists (Scholes and Biggs, 2004). These include increased likelihood of crop failure, increase in diseases and mortality of livestock, and/or forced sale of livestock at low prices, increased livelihood insecurity, resulting in assets sale, indebtedness, outmigration and dependency on food aid, and a downward spiral in human development indicators, such as health and education (UNDP, 2007).

More than half Sudan can be classified as desert or semi-desert, with another quarter as arid savannah, despite the diverse ecological zones. Changes in temperature and rainfall are likely to lead to desertification in some regions. The country inherent vulnerability may best be captured by the fact that food security in Sudan is mainly determined by rainfall, particularly in rural areas, where 70% of the total population lives. Changes in temperature and precipitation could cause shifts in the precarious distribution of these ecological zones, in the productive capacity of rain fed agriculture, and thus, in the security of the nation food supply.

Historically, average annual rainfall has declined from about 425 mm/year during the period 1941-1970 to about 360 mm/year in the period 1970-2000. This represents a decrease of annual rainfall of about 0.5% per year. At the national

ISSN 1816-8272

level, there is a trend of greater rainfall variability, increasing at a rate of about 0.2% per year. For the completion of the INC, Sudan developed scenarios to project future temperature and precipitation, due to climate change, in 2030 and 2060, based on a doubling of CO_2 emissions (IS92A scenario), milestone years 2030 and 2060 are used in place of IPCC recommended 2015, 2050 and 2100) (IPCC, 2007b).

Relative to baseline expectations, the Sudan 1st National Communication (INC, 2003) indicated an average warming range of 1-3˚C and average change in precipitation of -5.8% by 2030 in some areas. As rainfall is already extremely erratic and varies widely from the northern to southern ranges of the country, the severity of drought experienced depends on the variability of rainfall both in amount, distribution and frequency.

The Sahelian belt which runs through Sudan is very likely to suffer the impact of climate change (Scholes and Biggs, 2004). Since the 1930s, the Sahara Desert has encroached southwards by between 50 and 200 km, eating into semi-desert and savannah land. Climate change is likely to exacerbate this desertification trend. According to the INC, where between 1961 and 1998, episodes of drought have inflicted Sudan with varying severity. This period witnessed two widespread droughts during 1967-1973 and 1980-1984 - the latter being the most severe. The same period witnessed a series of localized droughts during 1987, 1989, 1990, 1991, and 1993, 2003, mainly in western Sudan (Kordofan and Darfur) and parts of central Sudan. Drought threatens the remaining cultivation of about 12 million hectare of rainfed mechanized farming and 6.6 million hectares of traditional rainfed lands. Pastoral and nomadic groups in the semi-arid areas of Sudan are also severely affected (MARF, 2011).

The results of the vulnerability study conducted for the INC suggested that the nation as a whole may be hard hit by even modest changes in temperature and precipitation. In 2030 and 2060, the humid agro-climatic zones would shift southward, rendering areas of the north increasingly unsuitable for agriculture (Zakieldeen, 2009). Crop production is predicted to decline by between 15% and 62% for millet and between 29% and 71% for sorghum and large areas of rangelands would be denuded and suffering from moving sands. The most vulnerable groups are traditional rainfed farmers and pastoralists. As a backdrop to this, increased temperature and variability in precipitation, combined with growing socioeconomic pressures are likely to intensify the ongoing process of desertification in the region and beyond. The projected increases in population, desertification and assorted environmental and socioeconomic pressures, provide a warning signal to stakeholders and decision-makers and would helped to sharpen attempts at identifying and implementing adaptation measures (Thomas and Twyman, 2005). This baseline study attempted to list climate change projects in Sudan, assess involvement of researchers in climate change adaptation and their capacity to generate scientific evidence on climate change adaptation policies and plans of action.

ISSN 1816-8272

Methodology

Information used for attaining this baseline study included both primary and secondary data. Sources of secondary data included development and research projects reports in Sudan during the period 2006 up to now, that had a climate change component. An inventory of research scientists working in climate change in agriculture and water resources including animal agriculture was made and covered the Higher Council for Environment and Natural Resources (HCENR), Ministry of Environment and Physical Planning, Institute of Environmental Studies of the University of Khartoum (IES-UoK), Agricultural Research Corporation (ARC), Sudan Meteorological Authority (SMA), Ministry of Animal Resources and Fisheries. NGOs working on climate change in agriculture were also reviewed. Other secondary data sources were published and unpublished reports and documents, including internet, covering climate change adaptation and mitigation issues in Sudan and other similar areas. This was undertaken to understand the past and ongoing adaptation projects implemented by key adaptation stakeholders. Researchers' perceptions in climate change adaptation research were also obtained.

The search of information was based on a baseline checklist. In analyzing the capacity of researchers to generate scientific evidence on climate change impact assessments, the study collected information on type of researches being conducted, analytical tools, and if any biophysical models employed. Similarly, the study analyzed research on adaptation actions looking at research objectives that addressed adaptation, source of funds, and adaptation options examined. Further, the study wanted to know if costs and benefits of adaptions were considered and the type of tools used for economic analysis.

The study also examined existence of knowledge sharing platforms and composition of such platforms if they do exists. In addition, the study had to examine if research do communicate their results and to what type of stakeholders. However, to prove if really the communication was effective, information must then be incorporated in the policy, plans, and strategies. Therefore, this study concluded by analyzing some key policy documents on climate change and environment with specific focus on animal agriculture. Descriptive statistics, tabulations, and graphing were used as a means of presenting results (Steel and Torrie, 1980).

Primary data were collected from five States (Gadaref, Kassala, Gezira, Khartoum and River Nile) in Sudan (Figure 1) where NAPA activities were implemented during the period April 12 to September 16, 2012. These data were collected through various participatory methods including:

Direct field observations: Direct field observations were confined to visual indicators or aspects of biophysical environment such as agro-climatic zone, soil types, water sources, vegetation cover and constraints as perceived by farmers (both men and women).

ISSN 1816-8272

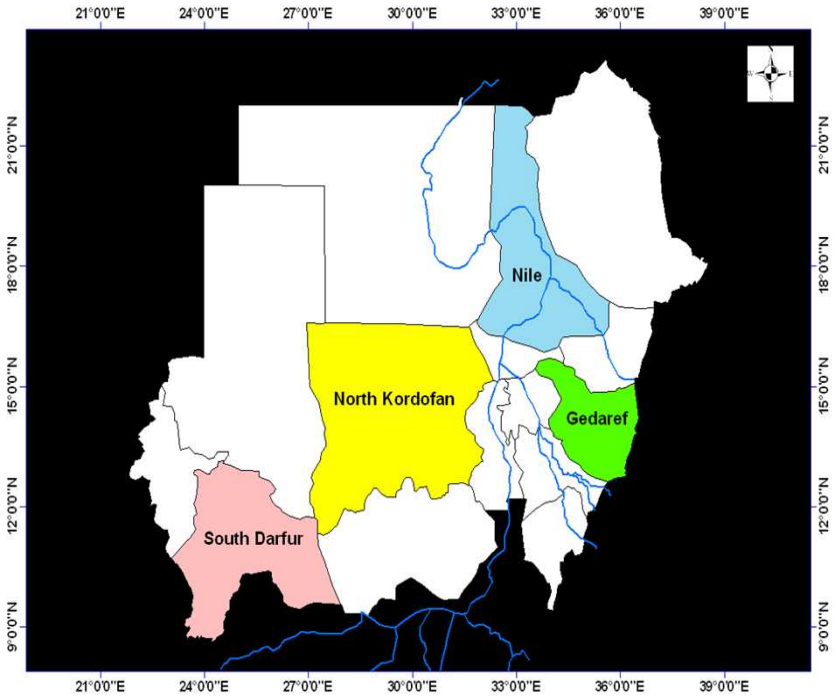

Fig. 1. Study area depicting the four States where NAPA is currently working (NAPA, 2007)

Key Informants (KIs): Key informants included individuals involved directly or indirectly in the service sector of agriculture, range-livestock, water and health, farmers and herders unions, and executive authorities and local leaders, Development Projects and Programs and NGOs working in the five States of NAPA activities.

Results and Discussion

Table 1 shows the profile of the interviewed respondents who participated in the study. Total number of persons interviewed were 54 out whom 19 (35.2%) were from research and 35 (64.8%) were from other services sectors of agriculture. Research scientist profile was dominated by agronomy and related disciplines (horticulture, agro-forestry, soils) comprising about 52.6% of within research affiliation and 18.5% of the total surveyed sample. Development and extension profile (29.6%) constituted the bulk of the surveyed sample, followed by environment/extension (25.9%) profile and policy planners professional profile (13.0%).

ISSN 1816-8272

Table 1. Profile of respondents who participated in the study on science-based evidence in influencing climate change policy, plans, and strategies

Profession profile	Descriptive	Affiliation		Total
		Research	Other sectors	
Agronomy and related disciplines	N	10	0	10
	% within Affiliation	52.6%	0.0%	18.5%
	% of Total	18.5%	0.0%	18.5%
Range-Livestock	N	2	0	2
	% within Affiliation	10.5%	0.0%	3.7%
	% of Total	3.7%	0.0%	3.7%
Socio-economics	N	1	1	2
	% within Affiliation	5.3%	2.9%	3.7%
	% of Total	1.9%	1.9%	3.7%
Agric. Engin./Water Harvesting	N	3	0	3
	% within Affiliation	15.8%	0.0%	5.6%
	% of Total	5.6%	0.0%	5.6%
Envrionment/GIS	N	3	11	14
	% within Affiliation	15.8%	31.4%	25.9%
	% of Total	5.6%	20.4%	25.9%
Development/Extension	N	0	16	16
	% within Affiliation	0.0%	45.7%	29.6%
	% of Total	0.0%	29.6%	29.6%
Policy/Planning	N	0	7	7
	% within Affiliation	0.0%	20.0%	13.0%
	% of Total	0.0%	13.0%	13.0%
By gender:				
Females		8		14.8%
Males		46		85.2%
Total N		19	35	54
% of Total		35.2%	64.8%	100.0%

Range-livestock and socio-economic profiles constituted the least (3.7% each) of the surveyed sample. It worth noting here that the GIS within the environment/GIS professional profile was entirely (3 persons) from the research while the other respondents (11) belonged to HCENR and SMA. Females constituted 14.8% of the respondents and males 85.2%.

Capacity of researchers to generate scientific evidence on climate change impact assessments within the Agricultural Research Corporation, twenty-six research programs were identified to respond to the various challenges and needs to develop appropriate technologies. These research programs devoted to various crops including cereals, cotton, oilseed crops, sugarcane, grain legumes, vegetables and medicinal plants, fruits and ornamentals, forages, gum Arabic, forestry, land and water, crops protection, food processing, agricultural engineering, pesticides, biotechnology, and genetic resources, together with

ISSN 1816-8272

technology transfer. In each program research thrusts were identified, weighted and prioritized according to economic importance, export potential, food security. This clearly reflected limited scientific evidence on climate change impact assessment both in water resources and animal agriculture. This was evidenced by the fact that most of the research cadre within the ARC-Sudan (414 research scientists) was composed mainly of agronomists and related disciplines (Figure 2), with very limited research staff in water resources (10.0%) and animal agriculture (2.0%).

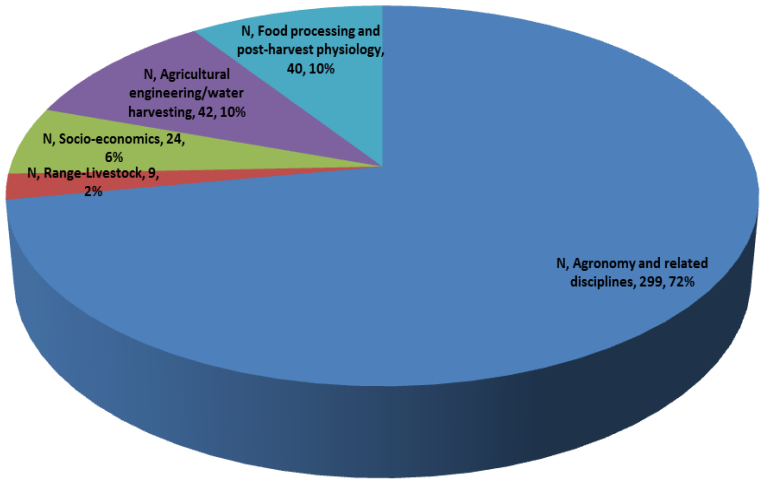

Figure 2. Research staff professional staff within the ARC-Sudan

Only 15.4% of the research programs (4 out of 26) had elements of climate change impact assessment on animal agriculture and water resources. The elements included degraded soil fertility, pests and diseases and livestock-rangelands productivity (Table 2). This indicated that very limited research is being conducted to contribute to the understanding of the climate change impact in animal agriculture and water resources (Thornton *et al.*, 2002).

Table 2. Type of impact dealt within ARC research programs

Impact	N	%
Declining yields	13	50.0
Degraded soil fertility	2	7.7
Rainfall variability	1	3.9
Livelihoods and declining farm income	2	7.7
Crop/livestock pests and diseases	4	15.3
Livestock-rangeland productivity	1	3.9
Value addition	3	11.5
Total	26	100.0

Analytical tools used to assess climate change impacts as reported by the interviewed respondents revealed that qualitative tools were the most common

ISSN 1816-8272

(Table 3), followed by statistical software packages. Software packages included Mstat-C, SAS, SPSS and GENSTAT. Excel Microsoft program was ranked third mostly used by socio-economists and for graphics. The use of GIS, remote sensing, and modeling and simulations was relatively rare. Only two reported to use GIS remote sensing and stated that they mostly use Arc-View program for map drawing, whereas modeling and simulation was reported by only one respondent.

Table 3. Analytical tools used in the analysis of impacts

Impact analytical tool	N	%
Conventional statistical software	13	14.1
GIS Remote sensing	2	3.7
Qualitative	33	66.1
Modeling and simulation	1	1.9
Excel	5	9.3
Total	54	100.0

Research programs and projects together with development programs and projects of research involvement (both locally and externally funded; totaling 49 out of which only 23 were externally funded) were thoroughly scrutinized and analyzed for their objectives, identified adaptation options, their costs and benefits, and analytical tools used to derive them. This was done to identify objectives with adaptation elements. The adaptation objectives were grouped into four major categories (Table 4). These categories included agricultural water management category (irrigation systems and management, conservation agriculture, and soil and water conservation practices), variety/breed, and livelihoods/income resilience and adaptation knowledge. Most of the projects handled adaptation options related to development and improvement of adapted crop varieties and enhancing livelihood/income resilience. The low percent of agricultural water management practices (20.0%) and adaptation knowledge (17.8) may be related to few scientists with background in environmental sciences or water and agricultural engineering compared to crop and soil sciences (Figure 2).

Table 4. Distribution of adaptation objectives by categories (%)

Adaptation objectives category	N	%
Agricultural water management	18	20.0
Variety/breed	25	27.8
Livelihood/Income resilience	31	34.4
Adaptation knowledge	16	17.8
Total	90	100.0

Potential adaptation was reported by the interviewed scientists to be higher for strategies related with agricultural water management and improvement of varieties/breeds, recording 38 and 25 counts, respectively (Figure 3). Potential adaptation strategies related to climate forecasts and animal agriculture were less common compared to reforestation and agro-forestry and agronomic aspects.

ISSN 1816-8272

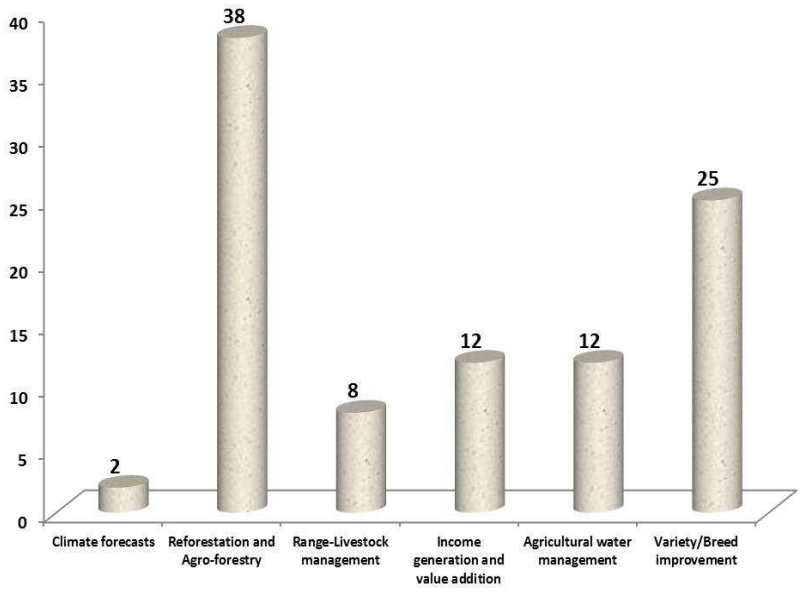

Fig. 3. Fig. 2: Potential adaptation strategies in agriculture, counts (n=97)

The potential adaptations strategies in the animal agriculture are those related with the areas of feeding management, disease control and breed improvement (Neely and Bunning. 2008). However, rainwater water harvesting for crop production purposes was the most prominent adaptation strategy in the agricultural water sector, with no efforts done for rangelands rehabilitation. For animal agriculture, the most prominent adaptation strategies followed were disease control, value addition (mainly fattening and finishing operations) and feeding management (Table 5).

Table 5. Potential adaptation strategies in animal agriculture

Adaptation strategy in animal agriculture	N	%
Water harvesting	12	24.5
Disease control	13	26.5
Feeding management	9	18.4
Breed improvement	5	10.2
Value addition	10	20.4
Total	49	100.0

Knowledge sharing platforms are ranked into four categories (Table 6). Effective platforms were those that had regular meetings. Those are expected to be effective as they are devoted to a particular subject like national technology release committees of the ARC-Sudan and steering committees of programs and projects. Percentage distribution of responses on effective knowledge sharing platforms, as reported by respondents, was 24.1%. Over forty-four percent of the respondents

ISSN 1816-8272

were with less effective (33.1%) and not effective (11.1) categories of knowledge sharing platforms. This entails high need for strengthening workshops, seminars and publications.

Table 6. Level of effectiveness of knowledge sharing platforms

Ranking	N	%	Knowledge sharing platform
Effective	13	24.1	Technology release committees, steering committees
Moderately effective	17	31.5	Field days, field schools, extension campaingns
Less effective	18	33.3	Workshops, seminars, media
Not effective	6	11.1	Scientific publications, bulletins, posters and leaflets, States Legislative Councils

The most prominent platforms (Table 7) were those dominated by scientists and NGOs (35.2%), followed by Federal and State ministries (25.9%) and policy and decision makers (24.1%). No media or private sector appeared to be in the composition of knowledge sharing platforms in Sudan. It is a tendency in the country to call media people to cover meetings, workshops and seminars; mainly opening sessions, and not as members in such platforms. Farmers, extension and local communities comprised about 11.1% of knowledge sharing platforms whereas government commissions' representation was found to be limited (3.7%). There is a high need to involve media and private sector in knowledge sharing platforms.

Table 7. Composition of knowledge sharing platforms

Composition	N	%
Farmers, extension, local communities	6	11.1
Policy/decision makers	13	24.1
Scientists, researchers, research institutions, NGOs	19	35.2
Federal and State ministries	14	25.9
Government commissions	2	3.7

Stakeholders mostly communicated with research findings were other researchers within or outside the ARC, followed by farmers/herders and their groups, policy and decision makers, then government agencies and development projects (Table 8). Communication of research results to consultancy agencies was ranked fifth and the least communication was with private sector and NGOs.

ISSN 1816-8272

Table 8. Recipients of communication messages

Recipient	N	%
Farmers/herders and their groups	91	22.0
Policy and decision makers	34	8.2
Other researches (universities, ARC)	214	51.7
Government agencies and development projects	30	7.2
NGOs, CBOs	10	2.4
Private sector	12	2.9
National Consultancy firms and groups	23	5.6
Total	414	100.0

Use of scientific-based evidence in the adaptation planning process

Documents that were reviewed to determine the extent of used of scientific information in developing policies and strategies on climate change and environment in Sudan included National Communication of 2003, National Adaptation Plan of Action (NAPA) of 200, National Action Program (SNAP) for combating desertification of 2006, and Sudan Agricultural Revival Strategy Program of 2011.

Sudan First National Communication (INC, 2003): This work was done by a team of researchers who were organized by the Higher Council for Environment and Natural Resources (HCENR) of the Ministry of Environment and Physical Planning (MEPP). The team was formulated from the HCENR, SMA, Institute of Environmental Studies (IES) of the University of Khartoum, Ministry of Agriculture and Forestry, Ministry of Animal Resources and Fisheries and the Agricultural Research Corporation (ARC).

Sudan's First National Communication (INC) to the UNFCCC, submitted in July 2003, provided an assessment of likely impacts of climate change on several sectors including decreasing annual rainfall, increasing rainfall variability, and increasing average annual temperatures. An examination of Sudan's ecological zones indicated that the majority of its land is quite vulnerable to changes in temperature and precipitation (INC, 2003). Changes in temperature and rainfall patterns also represent a priority threat to food security in Sudan's agriculture-based economy. Current increasing variability is a manifestation of long term change of climatic conditions in the country, region, and globally. Changes in average temperature or precipitation often do not show strong signals, but the well-observed trends of decreasing annual rainfall and increased rainfall variability have contributed to drought conditions in many parts of Sudan (El-Hag, *et al.*, 2012). The INC (2003) identified agriculture, water and health as the highest priority sectors where urgent and immediate action is needed. Consistent with guidance for the LDCF (GEF/C.28/18, 2006), the NAPA process also yielded a consensus that the highest priority intervention should be a program of adaptation interventions with a major focus on the enhancement of food security by building the adaptive capacities of the rural population, particularly of rainfed farming and pastoral communities, relative to current and future climate risks.

Sudan National Adaptation Plan of Action (NAPA): This plan was developed by a multi-disciplinary and multi-sectorial team from various government

ISSN 1816-8272

institutions (Ministries, Universities, agencies, etc). Some of the key institutions that were involved included HCENR, IES of the University of Khartoum, Agricultural Research Corporation. Four States with Sudan (Figure 1) were chosen as being most vulnerable to climate change. Consultations were undertaken at federal, State, as well as locality levels. Among the stakeholders who were consulted are public and private sector organizations such as government ministries and departments, academic and research institutions, local authorities, local administration, farmers/herders groups and NGOs. Stakeholder consultations at grassroots level helped to prioritize the 27 top most possible adaptation activities that could address the country's most urgent needs from all sectors.

Sudan National Action Program (SNAP) for Combating Desertification (NDDCU, 2006): The program document was prepared by staff from Ministry of Agriculture and Forestry, HCENR, University of Khartoum, Agricultural Research Corporation, UNDP-Sudan, UNISCO-Sudan, and Arab Organization of Agricultural Development (AOAD). The document provided background information on the present environment and natural resources conditions. It covers climate, renewable natural resources, energy, land use, biodiversity and national heritage. Attention has also been drawn to the impacts of the frequent drought periods that inflicted the country in recent decades on the socio-economic status of the population. The document focused on actions in the form of programs and projects within the context of SNAP and in accordance with the objective of the UNCCD, based on guidelines from the NCS and the Agricultural Sector Strategy.

Sudan Agricultural Revival Strategy (SARS): Recently, the Sudan has taken a new and strategic direction to support agriculture. This new direction is manifested in the declaration of "The Green Mobilization" and the preparation of the Five-Year Strategic Plan. This was followed by a fully integrated program that constitutes a national strategy for the Agricultural Revival as well as a compass for correcting the current program and plans of ministries and institutions in the center and the states, besides establishing a monitoring and follow-up system for assessing the results and impacts. All staff in federal and state ministries of agricultural, forestry and animal resources together with research institutions and universities had been mobilized to develop the SARS.

Use of scientific based evidence

The use of science-based evidence in developing climate related policies, plans, and strategies, is low (Table 9). NAPA used the least number of references compared with the communication strategy and Sudan National Adaptation Program despite being developed four years after the former and one year after the latter. It is surprising to notice that Sudan Agricultural Revival Strategy reported no references in its main document. National communication (34.8%) used the highest number of research related findings followed by SNAP (29.7%).

ISSN 1816-8272

Table 9. Use of scientific-based evidence

Category	National Communication		SNAP		NAPA		SARS	
Year	2003		2006		2007		2011	
	N	%	N	%	N	%	N	%
Books	4	5.6	3	11.1	0		0	0
Referred journals	8	11.3	1	3.8	0		0	0
Proceedings	5	7.0	2	7.4	2	13.3	0	0
Research reports	7	9.9	2	7.4	4	26.7	0	0
RoS documents	23	32.4	10	37.0	7	46.7	0	0
IO documents	24	33.8	9	33.3	2	13.3	0	0
Total	71	100.0	27	100.0	15	100.0	0	0

RoS = Republic of Sudan
IO = International Organizations

Acknowledgment
This work was part of the Project *"Enhancing Climate Change Adaptation in Agriculture and Water Resources in the Greater Horn of Africa" (ECAW)* which was funded by the *International Development Research Center (IDRC) Grant No. 106552-003*.

References

Ali Babiker, I. A. and Mohamed, A. A. W., 2010. Climate change current activities in Sudan. The Regional Workshop on the Status of Climate Change in the Nile Basin countries. Entebbe, Uganda, Feb. 8-9, 2010. Pp 19.

El-Hag, F.M.; Elhassan, S.M. and Khatir, A. A. 2012. Documentation of National Adaptation Program of Action (NAPA) Best Practices, for the UNDP-HCENR Project on Implementing NAPA Priority Interventions to build resilience in the agriculture and water sectors to the adverse impacts of climate change in Sudan. Higher Council for Environment and Natural Resources (HCENR), Ministry of Environment and Physical Planning. Khartoum, Sudan.

El-Hag, FM, Osman, AK, El-Jack, FH, Wagiyalla, NA, Mekki, MA and Khatir, AA., 2011. "Changes and threats facing nomads under drylands – the case of the Shanabla tribe in Western Sudan". Drylands Coordination Group, Miljøhuset G9, Norway. 85 pp.

Gilland, B. 2002. World population and food supply. Can food production keep pace with population growth in the next half-century? Food policy. Food policy v. 27 (1) p. 47-63.

Hatfield, J.L., Boote, K.J., Kimball, B.A.,Ziska, L.H.,Izaurralde, R.C.,Ort, D.,Thomson, A.M.,Wolfe, D. 2011. Climate Impacts on Agriculture: Implications for Crop Production. Agronomy journal. 2011 Mar., v. 103, no. 2 p. 351-370.

IATP. 2008. The changing climate for food and agriculture. A literature review. IATP (Institute for Agriculture and Trade Policy). Minnesota, USA. 17 pp.

ISSN 1816-8272

IPCC (Intergovernmental Panel on Climate Change). 2007a: Climate change 2007: Climate Change Impacts, Adaptation and Vulnerability, IPCC WGII Fourth Assessment Report, online: http://www.ipcc.ch/ SPM6avr07.pdf

IPCC (Intergovernmental Panel on Climate Change) 2007b. Synthesis Report. An Assessment of the Intergovernmental Panel on Climate Change. IPCC, Geneva. http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf.

INC. 2003. Sudan's First National Communications under UNFCCC, The Republic of Sudan (2003). Follow-up to Sudan's report for the third UN conf. on Least Developed Countries (LDC) presented to ECOSOC, Genava, Sudan Program of Action for Devlopment. 106 pp.

MARF. 2011. Federal Ministry of Animal Resources and Fisheries (MARF) Reports, Khartoum, Sudan.

NAPA. 2007. National Adaptation Program of Action. Republic of the Sudan, Ministry of Environment and Physical Development, Higher Council for Environment and Natural Resources, Khartoum. 54 pp.

NDDCU. 2006. (Natioal Drought and Desertification Control Unit) Sudan National Action Program (SNAP). A framework for combating desertification in Sudan in the context of the UNCCD (United Nations Convention to Combat Desertification), Khartoum, Sudan. 54 pp.

Neely, C. and S. Bunning. 2008. Review of Evidence on Dryland Pastoral Systems and Climate Change: Implications and opportunities for mitigation and adaptation. FAO – NRL Working Paper. Rome, Italy.

Scholes, R.J., Biggs, R., (Eds.), 2004. Ecosystem services in southern Africa: a regional assessment. Millennium Ecosystem Assessment. Online at http://www.millenniumassessment.org.

Steel, R. G. D. and Torrie, J. H. 1980. Principles and Procedures of Statistics: Abiometrical approach. McGraw-Hill Co., New York, USA. 633 pp.

Thomas, D.S.G., Twyman, C., 2005. Equity and justice in climate change adaptation amongst natural-resource-dependent societies. Global Environmental Change 15, 115–124.

Thornton, P.K., Kruska, R.L., Henninger, N., Kristjanson, P.M., Reid, R.S., Atieno, F., Odero, A., Ndegwa, T., 2002. Mapping Poverty and Livestock in the Developing World. ILRI (International Livestock Research Institute), Nairobi, Kenya

UNDP. 2007. Adaptation to climate change in poverty reduction strategies. Human Development Report, Office occasional paper, UNDP, 20 pp.

UNFCCC. 2011. Assessing costs and benefits of adaptation options: An overview of approaches. UNFCCC (United Nations Framework Convention on Climate Change. Germany. 47 pp.

UNFCCC. 2004. Climate change: Impacts, vulnerabilities and adaptation in developing countries. The Information Service of the UNFCCC Sectariat, Bon, Germancy. 59 pp.

Zakieldeen, S. 2009. Adaptation to climate change: A vulnerability assessment for Sudan. IIED Gatekeeper Series, No. 142. 18 pp.

ISSN 1816-8272