AFRICAN UNION SCIENTIFIC, TECHNICAL AND RESEARCH COMMISSION

CLIMATE CHANGE IMPACT IN AFRICA

Challenges and Opportunities within the Realms of Science, Technology & Innovation

African Union Scientific, Technical and Research Commission

CLIMATE CHANGE IMPACT IN AFRICA: CHALLENGES AND OPPORTUNITIES WITHIN THE REALMS OF SCIENCE, TECHNOLOGY & INNOVATION

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STRC publication on STISA-2024

Abuja, 2017

This study was commissioned by the African Union Scientific, Technical and Research Commission and it reflects the views and opinions expressed therein, which are not necessary those of the AU and its Commission. This study was developed with the aim to improve and strengthen science, technology and innovation capacities at the national, regional and continental levels through building and upgrading research infrastructures, enhancing professional and technical competencies, promoting innovation and entrepreneurship development and creating an enabling environment for STI and ultimately to assist Member States and RECs to adopt /domesticate STISA-2024.

Published by the African Union Scientific, Technical and Research Commission
Plot 114 Yakubu Gowon Crescent, Asokoro, Abuja, Nigeria

Cover:
Locals take part in a march in Durban, against climate change ahead of United Nations Climate Change Conference in Durban, South Africa. December 2011. Telegraph

An aerial view of the area affected by floods caused by heavy rains in Khartoum August 5, 2013. REUTERS/Stringer

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People of conscience need to break their ties with corporations financing injustice of climate change – **Desmond Tutu,** ***Archbishop Emeritus***

My fear is that (western environmentalists) are not concerned about the environment in an intelligent way – **Meles Zenawi,** ***Former Prime Minister of Ethiopia***

What we are doing to the forests of the world is but a mirror reflection of what we are doing to ourselves and to one another – **Mahatma Gandhi,** ***Pre-eminent leader***

Climate Change is no longer some far off problem it is happening here and it is happening now – **Barack Obama,** ***Former President of the United States***

On climate change, we often don't fully appreciate that it is a problem. We think it is a problem waiting to happen – **Kofi Annan,** ***Former Secretary General of the United Nations***

It is the people who must save the environment. It is the people who must make the leaders change. So we must stand up for what we believe in and we cannot be intimidated - **Wangari Maathai,** ***Nobel Peace Laureate***

Some scientists believe climate change is the cause of unprecedented melting of the North Pole, and that effects these very uncertain weather patterns. I think we should listen to those scientists and experts – **Dalai Lama**

Climate change does not respect border; it does not respect who you are - rich and poor, small and big. Therefore, this is what we call 'global challenges,' which require global solidarity – **Ban Ki Moon,** ***Former Secretary General of the United Nations***

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List of Acronyms

ACMAD	African Centre of Meteorological Applications for Development
AERMS	Agricultural and Environmental Resources Management Services
AMESD	African Monitoring of the Environment for Sustainable Development
AS	Agricultural Service
AU	African Union
AUC	African Union Commission
AU-STRC	African Union Scientific Technical and Research Commission
BFMS	Bush Fire Monitoring Service
CCAS	Climate Change Assessment Service
CDM	Clean Development Mechanism
CEMAC	Central African Economic and Monetary Community
CER	Certified Emission Reduction
CHPA	Chinese Hydroelectric Projects in Africa
CMRS	Coastal and Marine Resource Services
CO2	Carbon Dioxide
CSDRRS	Climate Services for Disaster Risks Reduction Services
DS	Drought Service
DSSCFS	Drought Service and Seasonal Climate Forest Service
ECOWAS	Economic Community of West African States
EO	Earth Observation
FAO	Food and Agriculture Organization
FS	Flood Service
FMS	Forest Monitoring Services
GCF	Green Climate Fund
GDP	Gross Domestic Product
GHG	Green House Gas
GMES	Global Monitoring Environment Security
GW	Giga Watt
HRST	Human Resource Science and Technology Department of the AUC
IOC	Intergovernmental Oceanographic Commission

IGAD	Intergovernmental Authority on Development
IPCC	Intergovernmental Panel on Climate Change
LDC	Least Developed Countries
LDM	Land Degradation Monitoring
MCES	Monitoring of Coastal Environment Service
MCMS	Marine and Coastal Management Service
MESA	Manufacturing Enterprise Solutions Association
MFOCS	Monitoring and Forecasting of Ocean Conditions Services
MRMS	Marine Resources Management Service
MUWLS	Monitoring of Underground Water Levels Service
NDA	National Designated Authority
NHC	National Habitat Conservation
PIDA	Programme for Infrastructure Development in Africa
PS	Pastoralism Service
RM	Rangeland management
SIDS	Small Island Developing States
SFRMS	Support to Fisheries Resources Management Service
STI	Science, Technology and Innovation
STISA	Science, Technology and Innovation Strategy for Africa
TAD	Trans-boundary Animal Diseases
UNDP	United Nations Development Programme
UNECA	United Nations Economic Commission for Africa
UNEP	United Nations Environment Programme
UNFCCC	United Nations Convention on Climate Change
WMC	Water Management for Cropland
WRMS	Water Resource Management Service
WS	Wildfire Service

1 Introduction

It is widely accepted that both natural and human activities are responsible for the Earth's climate change. Before the industrial era the change in the Earth's climate resulted entirely from natural causes such as Earth's orbit, changes in solar activities and/or volcanic eruptions. Since the industrial era began, humans have had an increasing effect on climate, particularly by adding billions of tons of heat-trapping greenhouse gases to the atmosphere. The reality is that most of the observed warming since the mid-20th century is due to human-caused greenhouse gas emissions.

Several studies examined the Human and Natural contribution to global warming over the past 50 to 60 years and revealed the fact that Human contribution is more tangible to global warming than that of the Natural contribution which could be towards the cooling of our planet.

The Organization for Economic Co-operation and Development/ International Energy Agency, (2012) reports highlighted the fact that CO_2 approximately constitutes 76% of the total greenhouse gases, while the emission database for Global Atmospheric Research fast track 2000 project shows that power stations are producing approximately 21.3% of the total greenhouse emission and industrial activities is in the second place with 16.8% (see Figure 1 and Figure 2).

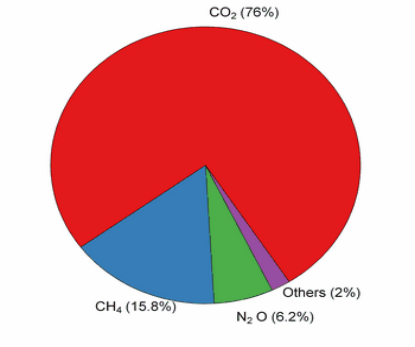

Figure 1. Greenhouse Emission by Type (UNESCAP, 2013)

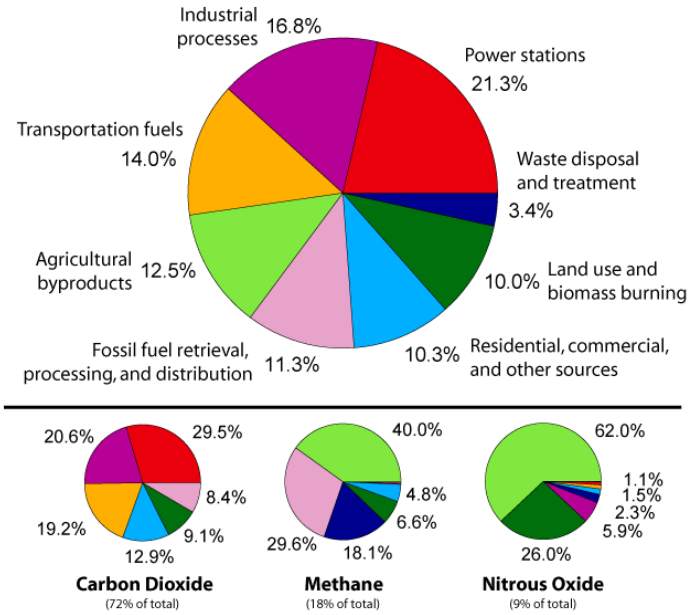

Figure 2. Annual Greenhouse Gas Emissions by Sectors/ Type (Robert, 2006)

1.1 Africa and Climate Change

Analysis was conducted on published reports of the World Bank, FAO, UNEP and other scientific references to examine Africa's contribution to the Earth's climate change and assess the impact of the climate change on Africa's resources. The thwarting gloomy picture of the continent the analysis depicted is disturbing as more need to be done to overcome the impact. The impact is so complex and dynamic that it requires urgent financial and technical assistance from both the continent and the developed world because Africa's human existence and overall development is under threat from the adverse impacts of climate change- its population and unique biodiversity will all be the major victims of global climate change.

The IPCC, 2007 Report summarized the projected impacts of climate change in Africa:

- By 2020, between 75 and 250 million people in Africa are projected to be exposed to increased water stress due to climate change.
- By 2020, in some countries, yields from rain-fed agriculture could be reduced by up to 50%.
- Agricultural production, including access to food, in many African countries is projected to be severely compromised. This would further adversely affect food security and exacerbate malnutrition.
- Towards the end of the 21st century, projected sea level rise will affect low-lying coastal areas with large populations.
- By 2080, an increase of 5 to 8% of arid and semi-arid land in Africa is projected under a range of climate scenarios.
- The cost of adaptation could amount to at least 5 to 10% of Gross Domestic Product (GDP).

1.2 Why Africa is at Risk

Temperatures: By 2050, average temperatures in Africa are predicted to increase by 1.5°C to 3°C, and will continue further upwards. Warming is to be larger than the global annual mean warming throughout the continent and in all seasons, with drier subtropical regions warming more than the moister tropics.

Ecosystems: It is estimated that, by the 2080s, the proportion of arid and semi-arid lands in Africa is likely to increase by 5-8%. Ecosystems are critical in Africa, contributing significantly to biodiversity and human well-being. Between 25 and 40% of mammal species in national preservation parks in sub-Saharan Africa will become endangered (IPCC, 2007a). There is evidence that climate is modifying natural mountain ecosystems via complex interactions and feedbacks.

Rainfall: There will also be major changes in rainfall in terms of annual and seasonal trends, and extreme events of flood and drought. Annual rainfall is likely to decrease in much of

Mediterranean Africa and the northern Sahara, with a greater likelihood of decreasing rainfall as the Mediterranean coast is approached. Rainfall in southern Africa is likely to decrease in much of the winter rainfall region and western margins. There is likely to be an increase in annual mean rainfall in East Africa. It is unclear how rainfall in the Sahel, the Guinean Coast and the southern Sahara will evolve. In the tropical rain-forest zone, declines in mean annual precipitation of around 4% in West Africa, 3% in North Congo and 2% in South Congo for the period 1960 to 1998 have been noted (IPCC, 2007a).

Droughts: By 2080, an increase of 5 to 8% of arid and semi-arid land in Africa is projected under a range of climate scenarios. Droughts have become more common, especially in the tropics and subtropics, since the 1970s.

Human Health: Already compromised by a range of factors, could be further negatively impacted by climate change and climate variability, e.g., malaria in southern Africa and the East African highlands.

Water: By 2020, a population of between 75 and 250 million while the number is projected to be between 350-600 million by 2050, are projected to be exposed to increased water stress due to climate change. Climate change and variability are likely to impose additional pressures on water availability, water accessibility and water demand in Africa.

High dependence on rain fed agriculture: Agriculture is the largest single economic activity in Africa, accounting for around 60 per cent of employment and, in some countries, more than 50 per cent of GDP. Rain-fed agriculture accounts for 95% of farmed land in sub-Saharan Africa. According to the fourth UN report, Climate change is expected to cause a shorter growing season and force large tracts of peripheral agriculture out of production. The area of the continent suitable for agriculture is likely to decrease, particularly along the edges of semi-arid and arid regions.

Sea-level rise: Africa has close to 320 coastal cities (with more than 10,000 people), and an estimated population of 56 million people (2005 estimate) living in low elevation (<10m) coastal zones. Towards the end of the 21st century, projected sea level rise will affect low-

lying coastal areas with large populations. Sea-level rise will probably increase the high socio-economic and physical vulnerability of coastal cities. The projection that sea-level rise could increase flooding, particularly on the coasts of Eastern Africa, will have implications for health.

Energy: Access to energy is severely constrained in sub-Saharan Africa, according to (Energy Outlook Special Report, 2014) that More than 620 million people in the region (two-thirds of the population) live without electricity, and nearly 730 million people rely on dangerous, inefficient forms of cooking. The use of solid biomass (mainly fuelwood and charcoal) outweighs that of all other fuels combined, and average electricity consumption per capita is not enough to power a single 50-watt light bulb continuously. Further challenges from urbanization, rising energy demands and volatile oil prices further compound energy issues in Africa.

High levels of poverty: One of the major reasons why Africa is vulnerable to climate change is that many of its inhabitants are poor. According to the Third Assessment Report of the IPCC, developing countries are expected to suffer the most from the negative impacts of climate change. This is largely due to their already weakened financial capacity to anticipate and respond to the direct and indirect effects of climate change.

Limited technology for adaptation: Africa has low adaptive capacity making it particularly vulnerable and exposed because of high rates of technological constraints. This is also exacerbated by decades of complex governance. A robust technology base will provide increasingly effective options in the design of environmentally sound models for averting the projected impacts of climate change.

Low level of awareness: Capacity-building, education and training and public awareness are necessary to properly understand the mechanism of climate change and proffer globally significant solutions. Africa needs continuous high levels of awareness of the already existing and projected impacts of climate change. Policymakers must understand risks of climate change and take actions centered on mitigation and adaptation.

A high dependence on natural resources: African inhabitants are highly dependent on natural resources including soil, forest and water resources for food, shelter and survival. Unfortunately these resources are the first to be directly affected by climate change impacts. The population at risk of increased water stress in Africa is projected to be between 75 and 250 million (IPCC, 2001).

1.3 Africa's Contribution to Climate Change

Generally, Africa contributes less than 4% of the total CO_2 emissions globally. While most of the African countries are producing less than 1 ton/capita, the developed world average is more than 10 ton/capita as shown in Figure 3, (World Bank, 2008). The report shows that USA produces 17.1 while China produces 6.1 ton/capita, recognizably the report shows that AU Member States are producing within an average range of less than 1 ton/capita.

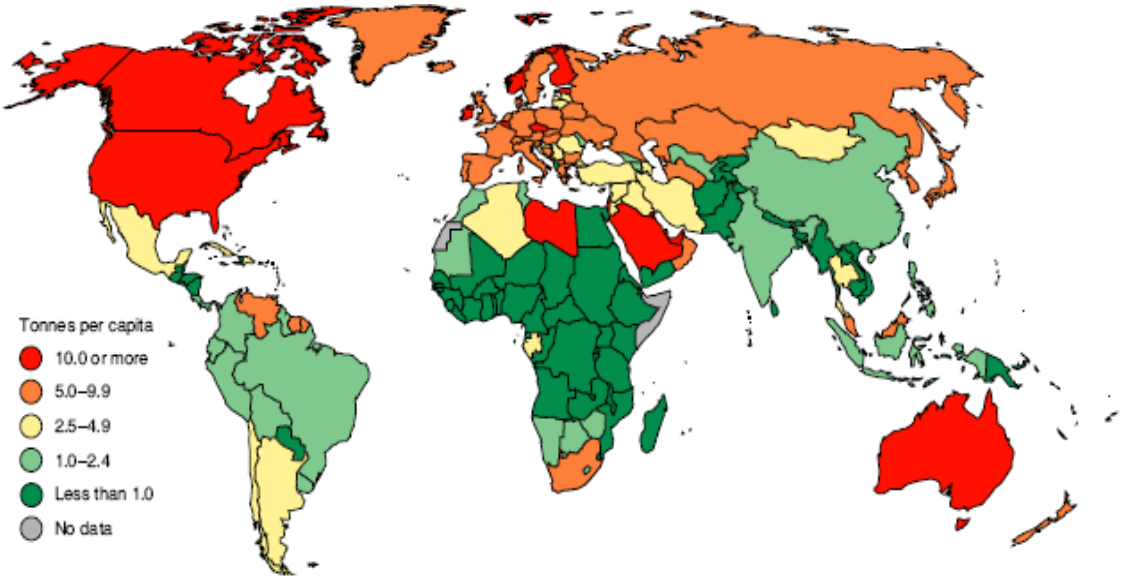

Figure 3. Carbon Dioxide Emission per Capita (World Bank, 2008)

The union of concerned scientists in 2014 analyzed the CO_2 emissions from consumption of Energy (Figure 4), where USA and China are found to be responsible for 42% of the total world emission. While, 80% is produced by 79 countries out of the 192 UN Member States; one of them is African with a contribution of 1% (Republic of South Africa). By reflecting on the 20% remaining emission produced by the rest of the world and using flat rate to calculate emission/country, 0.17% will be the average/country.

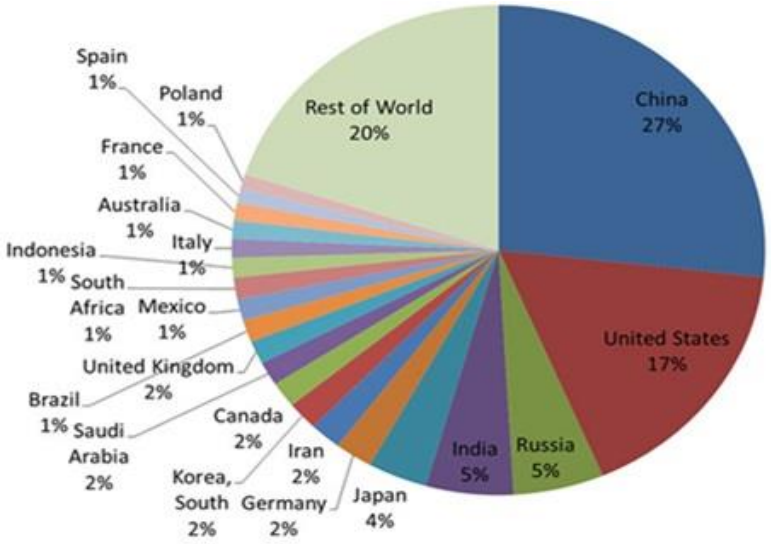

Figure 4. Individual Countries Share of Carbon Dioxide Emissions from Consumption of Energy; Baseline 2011 (Union of Concerned Scientist, 2014)

1.4 Impact of Climate Change on Africa

Africa is one of the most vulnerable parts of the world at risk to the impact of climate change. The consequences of climate change are now affecting the ecosystems and biodiversity on the continent as the projections of climate change are trend to warmer conditions in: the

inland subtropics, with frequent occurrences of extreme heat, increasing aridity and changes in rainfall (Serdeczny etal, 2016). This situation is exacerbated by modest economic development and low adaptive capacity in most of the countries in the region. Figure 5 illustrates some of the climate change vulnerabilities. The impact of climate change on Africa is likely to be severe because of adverse direct effects, high dependence on agriculture, and limited capacity to adapt.

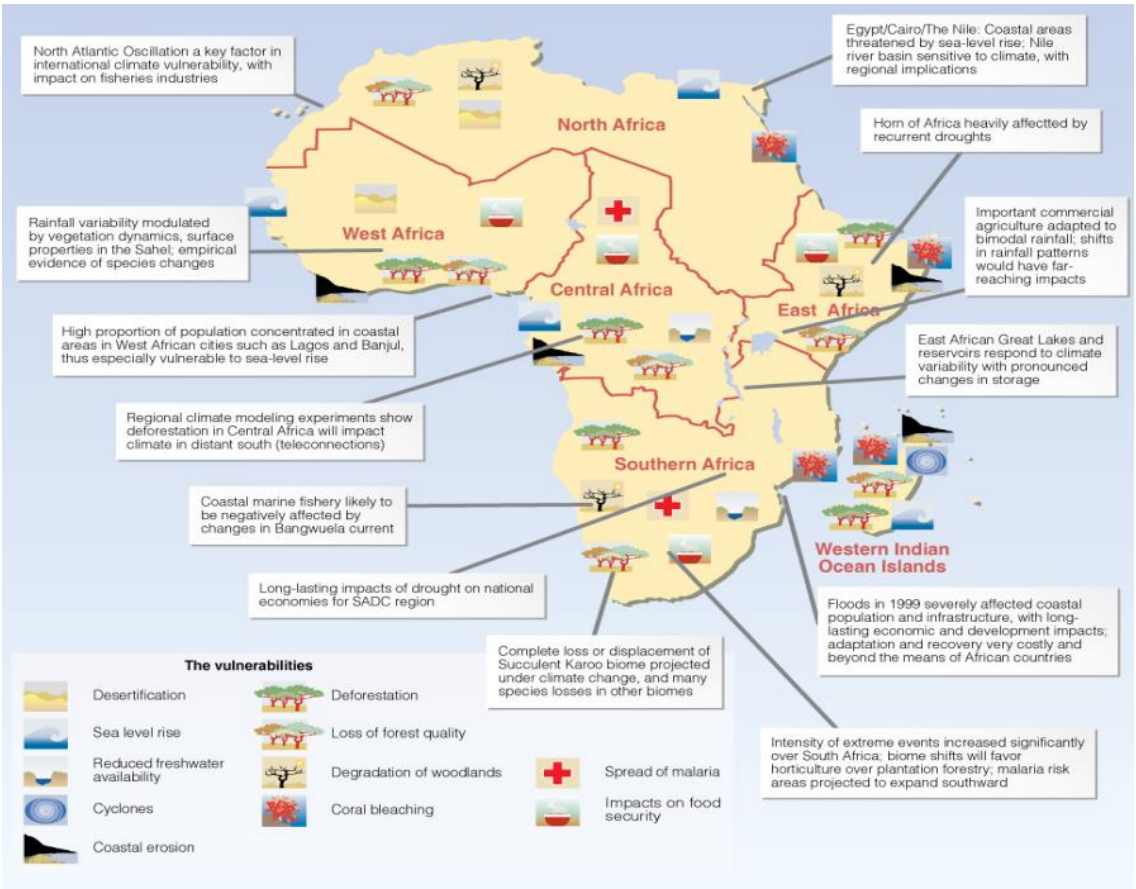

Figure 5. Climate Change Vulnerability in Africa (GRID-Arendal, 2016)

1.4.1 Water Resources, Rainfall and Drought

Climate change models shows that water stress increases particularly in North Africa and 350-600 million more people in Sub-Saharan Africa will be affected by water stress. This is evident if we consider the continued decline of the surface area of the Lake Chad where it shrunk from 22,902 km^2 in 1963 to 3,042 km^2 in 2001 as shown in Figure 6 (UNEP, 2008a). During the 20th century, the aerial extent of Mt. Kilimanjaro's ice cap decreased by about 80 %. It has been suggested that if current climatological conditions persist, the remaining ice cap are likely to disappear between 2015 and 2020 (Thompson et al., 2002).

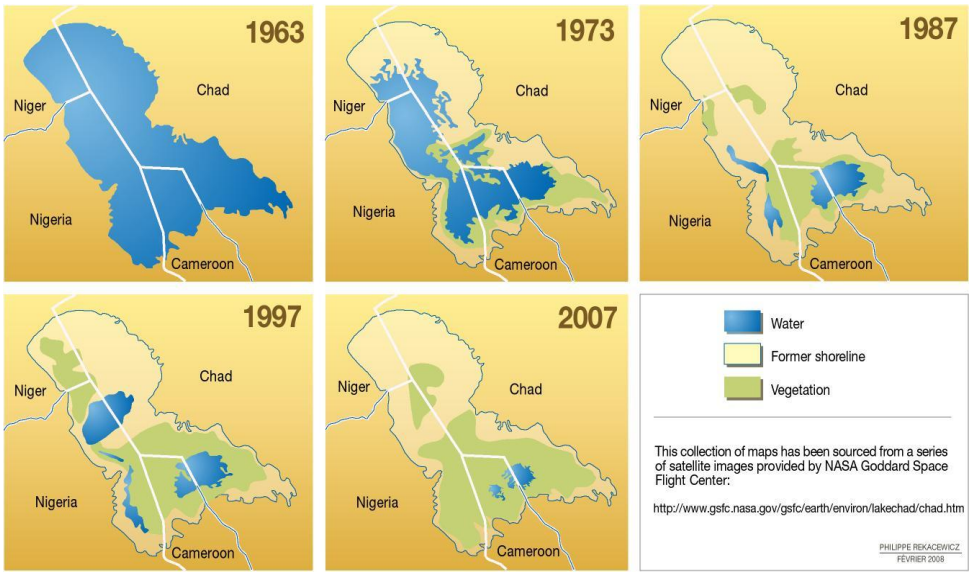

Figure. 6 Decline of the Surface Area of the Lake Chad from 1963 to 2007 (UNEP, 2008a)

In West Africa, mean annual rainfall has declined steadily since the end of the 1960s and caused a 25-35 km southward shift of the Sahelian, Sudanese and Guinean ecological zones in the second half of the 20th century (Gonzalez, 2001). One third of Africans now live in drought-prone areas, mainly in the Sahel, around the Horn of Africa and in southern Africa (Clement, 2009).

In contrary to the drought patents in most of the continent unpresented rain patents in Eastern and Southern Africa (Schreck and Semazzi, 2004; Usman and Reason, 2004) which may have a negative impact on the water mass of Africa's water ways such as the Nile and Zambezi rivers and the crops landscape and productivity. Not only that there are a considerable risk of floods to take place considering the fact that Lake Victoria rose by about 1.7 m by 1998, Lake Tanganyika by about 2.1 m, and Lake Malawi by about 1.8 m, and very high river-flows were recorded in the Congo River at Kinshasa (Mercier et al., 2002; and Conway et al., 2005).

1.4.2 Biodiversity

Africa is home to some one quarter of the world's 4,700 mammal species, including 79 species of antelope. It also has more than 2,000 species of birds – one fifth of the world's total – and at least 2,000 species of fish, alongside 950 amphibian species. The African mainland harbors between 40,000 and 60,000 plant species and about 100,000 known species of insects, spiders and other arachnids. Eight of the world's thirty four biodiversity hotspots are in Africa (UNEP 2008b). These rich and varied biological resources are not only forming the continent's natural wealth on which its social and economic systems are based upon but also it is of importance to the world's climate and for the development of agriculture, industrial activities, pharmaceutical production, construction and tourism.

Africa's biodiversity is concentrated in several unique native environments. The Cape Floral Kingdom (fynbos), which occupies only 37,000 km^2 at the southern tip of Africa, has 7,300 plant species—of which 68% occur nowhere else in the world (Gibbs 1987). The adjacent Succulent Karoo biome contains an additional 4,000 species, of which 2,500 are native (Cowling et al. 1998). These two floral biodiversity hot spots occur in winter rainfall regions

and would be threatened by a shift in rainfall seasonality. For instance, a reduction in winter rainfall or an increase in summer rainfall would alter the fire regime that is critical to the life cycle in the fynbos.

Climate change has already affected the marine animals of Africa. Coral reefs in the Indian Ocean experienced massive bleaching in 1998, with over 50 % mortality in some regions (Spalding 2001). Damage to coral reef systems has far reaching implications for fisheries, food security, tourism and overall marine biodiversity. Effects on Terrestrial Animals for example, climate change of the magnitude predicted for the twenty-first century could alter the range of African antelope species (Hulme, 1996). World antelope biodiversity—more than 90 % of the 79 species—is concentrated in Africa (Macdonald, 1987). Based on a variety of scenarios, climate change is expected to cause losses of about 5,000 African plant species, over 50% of some bird and mammal species, and decline the productivity of Africa's lakes by between 20 % and 30% by 2100 (IPCC, 2007b).

1.4.3 Agriculture

Eradication of hunger and food insecurity in Africa is a great subject of discourse among experts in and around the continent. Agriculture accounts for 65% of full-time employment in Africa, 25-30% of GDP and over half of export earnings (Government Office for Science, 2011). The monumental threat of the impact of climate change is grudgingly intruding in every effort made to curtail hunger and food insecurity in Africa. It is projected that for any global mean temperature changes of 2 to 4°C above 1990-2000 levels would further exacerbate the current climate impact that will trigger food insecurity (Schneider et al, 2007).

The IPCC projects that warming by 2˚C could reduce total crop production by 10% in Sub-Saharan Africa by 2050, while reductions in yields have been estimated at approximately 15% for Sorghum and 10% for Millet. In contrast the Sahel, Millet yields could fall by 20 % (Africa Progress Report, 2014). Another study by (Warren et al., 2006) estimated that Maize yield losses of 30-40 % in North and Southern Africa, 20-30 % in West Africa, Rice yield losses of 30- 40 % in North and Southern Africa, and about 20- 25 % loss in West Africa may occur.

Another dimension to this is the rising atmospheric CO_2 and climate change may also impact indirectly on crops through effects on pests and disease (Government Office for Science, 2011). These interactions are complex and as yet the full implications in terms of crop yield are uncertain. When these combine with significant water stress and crop yields which are already low, it will be increasingly difficult to maintain and impact severely on Africa's food security.

1.4.4 Desertification in Africa

Desertification has been long recognized as a major environmental threat that has adverse effects on African people's livelihood, food security and socioeconomic development of the affected areas. In 2015 FAO reported that over 70% of the African population live in dry lands and other fragile ecosystems across the continent. Population growth and increasing climate change impact puts pressure on these ecosystems, exacerbating degradation and desertification of increasingly overexploited lands (FAO, 2014). It is estimated that 35% of the total land area of Ghana is prone to desertification and these areas prone to desertification/drought have almost doubled in the last two decades. In Ethiopia, approximately 70% of the total land area and 80% of those in Kenya are reported to be prone to desertification in recent years (Africa Progress Report, 2014).

According to the UN Nigeria is losing 1,355 square miles of cropland and rangeland due to desertification each year. This problem affects each of the 11 states of northern Nigeria. Nigeria loses approximately 320,000-350,000 hectares of land per year, which causes mass displacement of local communities in its Northern region. The frustration is not limited to the Member States mentioned above but it is also extended to others. For more information (see also Penny R, 2014; UNECA, 2007; Urama and Ozor, 2010). Added to desertification, soil erosion is another problem. It is believed that productivity of some lands has declined by 50% due to soil erosion and desertification. Currently there are some interventions being put in place to arrest the threat of desertification (Henao and Baanante, 2006).

1.4.5 Health

There had been plethora of health polices by UN, AU and other bodies like "Health for all by the year 2000". At the African Union level, there was African Health Strategy; African Union Science and Technology Framework for the Detection, Identification and Monitoring of Infectious Diseases of Humans, Animals and Plants in Africa; and Integrated Regional Coordinated Mechanism for the control of Trans-boundary Animal Diseases (TAD) and Zoonosis among others. Many have asserted that one of the obstacles that have hindered efforts towards achieving this dream is climate change and its associated impacts. The health sector in Africa is confronted with multi-dimensional problems including infrastructure, inadequate health personnel, and poor sanitation. But climate condition such as extreme temperature, excessive rainfall and floods, desertification and drought complicate these challenges and affect the key determinant of survival including water, food, shelter and air.

In Ethiopia and Kenya, children aged 5 or less were respectively 36% and 50% more likely to be malnourished if they were born during a drought year. In Niger, children aged 2 or less born in a drought year were 72% more likely to be stunted or short for their age – a sign of malnutrition which have direct or indirect link with the impact of climate change (UNDP, 2007).

It is agreed that Africa has the highest burden of disease in the world. HIV constitutes a time bomb that the estimated 26 million people infected in 2006 are likely to develop AIDS (Rweyemamu et al, 2006). The effect of other diseases such as malaria and tuberculosis which are already severe will be amplified. Women will be disproportionately affected, and life expectancy already reduced to 40years in some countries. The recent epidemic of Ebola hemorrhagic disease in West Africa claimed thousands of lives while one of the communication medium of the disease is fruit bats. There is no doubt that climate change affects our vegetation and estuary that will in turn affect inhabitants. It also presents a conducive breeding ground for both pathogen and vector habitats that subsequently affect human and animal lives.

Currently the Arid and Semi-arid region of Africa is experiencing increased cases of cataract disease due to low cloud cover and greater intensity of solar radiation which may further be

exacerbated thereby increasing cataract (eye diseases) cases in the arid and semi-arid regions of Africa due to low cloud cover and greater intensity of solar radiation (Anyadike, 2009). It can be seen without any stretch of imagination that economic cost of poor health to Africa is huge. Clearly, governments and development partners need to walk the talk, by supporting and developing strategies and a way-out to counter the effect of climate change on the health of its people.

1.4.6 Sea Level Rise

Globally, 40 percent of the human population lives within 100km of the coast, In Africa 36 countries are located along the coastline. The Sea Level rise is recognized as a fundamental challenge facing the African continent as the total length of the Africa's coastline including its islands is over 26,000 nautical miles it houses the most productive ecosystems which are economically beneficial to the countries therein. These areas are mostly endowed with tourist sites, fisheries, industrial, commercial and communication infrastructure as well as recreational beaches. Over a quarter of Africa's population live within 100km of the coast (IPCC, 2007b).

However, by 2080 three of the five regions projected to be at risk of flooding in coastal and deltaic areas of the world are in Africa North Africa, West Africa and Southern Africa. Also, the melting of ice sheets in the next 100 to 200 years may lead to gradual but irreversible deglaciation and a large sea-level rise over a much longer time-scale (Meehl et al., 2007). Thus, by 2100, Africa's coastlines and river deltas with densely populated low-lying areas will be affected by a sea level rise of up to 1 meter. This will lead to increased flooding, coastal erosion and unpredictable disasters may occur quickly without warning (Nkomo et al., 2006).

About 50 cm rise in sea level is also predicted in Egypt and expected to displace more than 1.5 million people and destroy 214,000 jobs in the coastal area between Alexandria and Port-Said, costing more than US$35 billion (UN-HABITAT, 2008). As Africa's population is likely to reach close to 2 billion by 2050, more people will be exposed to the consequences and cumulatively, some 70 million people could be at risk from coastal flooding in Africa

(IPCC, 2007b). Many West African Member States could be negatively affected by saltwater intrusion and damage to coastlines (IPCC, 2007b).

2 Africa Science, Technology and Innovation Response to the Climate Change Challenges

AU Member States and its Commission joined the hands to respond to the climate change impact on Africa's development sectors which resulted on several continental, regional and national policies/strategies that addresses Africa vulnerability to climate change e.g. Science Technology and Innovation Strategy for Africa 2024 and the Programme for Infrastructure Development in Africa (PIDA).

On the other hand, AU Member States participate actively on climate and environmental meetings and summits from 1987 'Burndtland report on sustainable Development to Doha Gateway 2012. This active participation can be recognized as majority of the African Union Member States (ratified, acceded, approved or succeeded) major environmental treaties (for list of treaties see, UNDP, 2007).

In early 2014 the Department of Human Resources Science and Technology of the African Union Commission concluded the development of the STISA-2024, where climate change mitigations and adaptation and Africa's development challenges were considered as the drivers. Subsequently in June 2014 STISA-2024 was adopted by the AU Assembly as continental framework for accelerating Africa's transition to an innovation-led, knowledge-based economy within the overall framework of the AU Agenda 2063 (See Figure 7).

STISA 2024 is the 1st decade incremental strategy that is designed to address Africa's challenges with the ultimate goal of contributing significantly to the AU vision "**An integrated, prosperous and peaceful Africa driven and managed by its own citizens and representing a dynamic force in the international arena**".

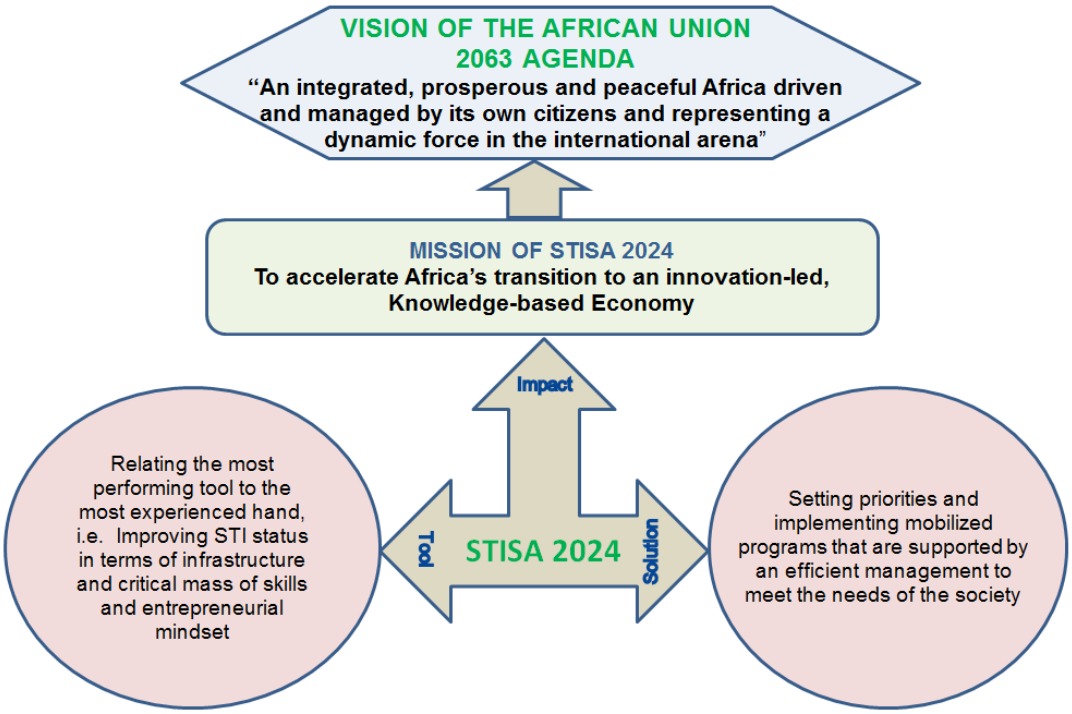

Figure. 7 Interactions between the AU Agenda 2063 and the STISA-2024

The Scientific, Technical and Research Commission (STRC) of the AU conducted a policy analysis for STISA, where there is need for African Union and its Member States to develop Green policy was among the policy gaps identified at the continent levels. A Green Innovation Policy that focuses on STISA-2024 priority areas (see Figure 8) and addressing issues related to Green Agriculture, Green Tourism, Green Energy, Green Infrastructure, Green Industry etc.

Figure. 8 STISA-2024 Priority Areas

2.1 African Union Research Grant

The African Union Research Grant is an innovative way used by the Commission to motivate the African scientific community to work together and to do research on the areas of African priorities and challenges. It presents a paradigm shift for research and innovation in the continent, as it links the regions of Africa through research; empower institutions to acquire needed infrastructure for research; builds capacity of students and researchers through

training and mentoring and promotes knowledge sharing and transfer across regions; thereby learning from each other (Research Grant Manual 2015).

Since the launching of the programme, three calls for proposals were made in 2011, 2012 and 2016 with a total envelop of €15 Million focusing on Post-Harvest and Agriculture where €7 Million was granted while for Renewable and Sustainable Energy; and Water and Sanitation €3.5 Million were granted for each (Figure 9), which resulted in 46 projects, executed in 46 locations across Africa and 54 research networks were established (Figure 9).

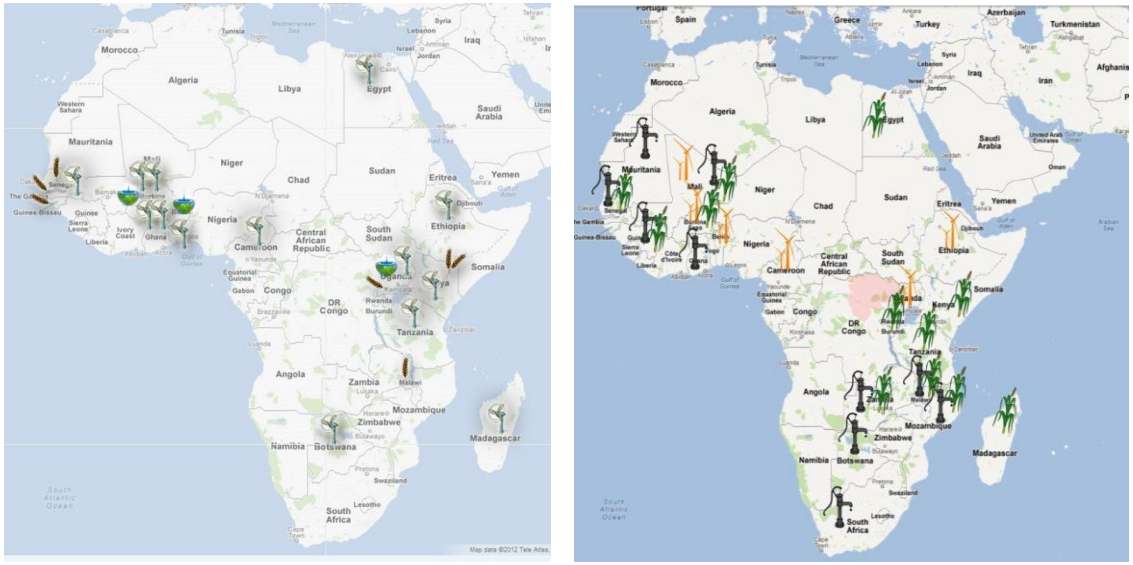

Figure. 9 Location of the Actions Granted under the Research Grant's Two Calls on the Left is the 1st Call (24 Beneficiaries) while on the Right 2nd Call (22 Beneficiaries) (HRST, 2013)

Figure 10. Partnership Established Between Research Institutions in and Outside Africa (HRST, 2015)

The aim of the projects within this programme is to provide solutions to challenges and that goes back to the local communities which is clearly reflected in the output of the granted projects such as Enhancing food security and well-being of rural Africa households through improved synergy between Agro-forestry systems and Food-crops; Fostering renewable and sustainable energy in Africa through R&D; Development of cost effective, modular and dry concentration solar power for Africa including designing and testing the components;

Groundwater resource in basement rocks of Africa, etc. (for further information on the projects see HRST, 2015).

2.2 GMES Africa and MESA

GMES Africa was launched in Lisbon, Portugal in December 7, 2007 during the 2nd EU - Africa Summit following the Maputo Declaration in 2006 as a long-term framework for cooperation on Earth Observation (EO) through the integration and deployment of the Union requirements and needs in GMES Services. The GMES Africa is to promote institutional, human and technical capacity building for the access and exploitation of Earth Observation information systems for security and sustainable development in Africa (HRST, 2010).

The programme looks at the whole range of development challenges such as impacts of climate variability; natural and man-made disasters; rural development and food security; infrastructures and territorial development; management of conflicts and political crisis; and health issues among others. The GMES is to give the opportunity for African scientists to observe and analyze land cover/land use practices that result to climate change and advise accordingly; to carry out carbon mapping and monitoring; to monitor and analyze forest biomass; observe and identify underground water mass; and monitor ground water utilization; and etc. (JEG 8 report, 2010). Figure 11 depicts the cross cutting issues and the thematic areas of the GMES Africa.

An agreement has been signed on April 2014, between the African Union and European Union to kick start the implementation of agreed cross-cutting areas along with predefined three thematic priorities dealing with (a) long-term management of natural resources, (b) marine and coastal areas monitoring, and (c) water resources management while working to finalize the remaining chapters of GMES Africa Action Plan (HRST, 2014).

By the time GMES Africa is in the initial phase/stage to respond to Africa climate and development challenges; MESA is considered to be a successful tool in utilizing space-based and in-situ data to enable an improved management of the environment and food security at continental, regional and national levels in Africa.

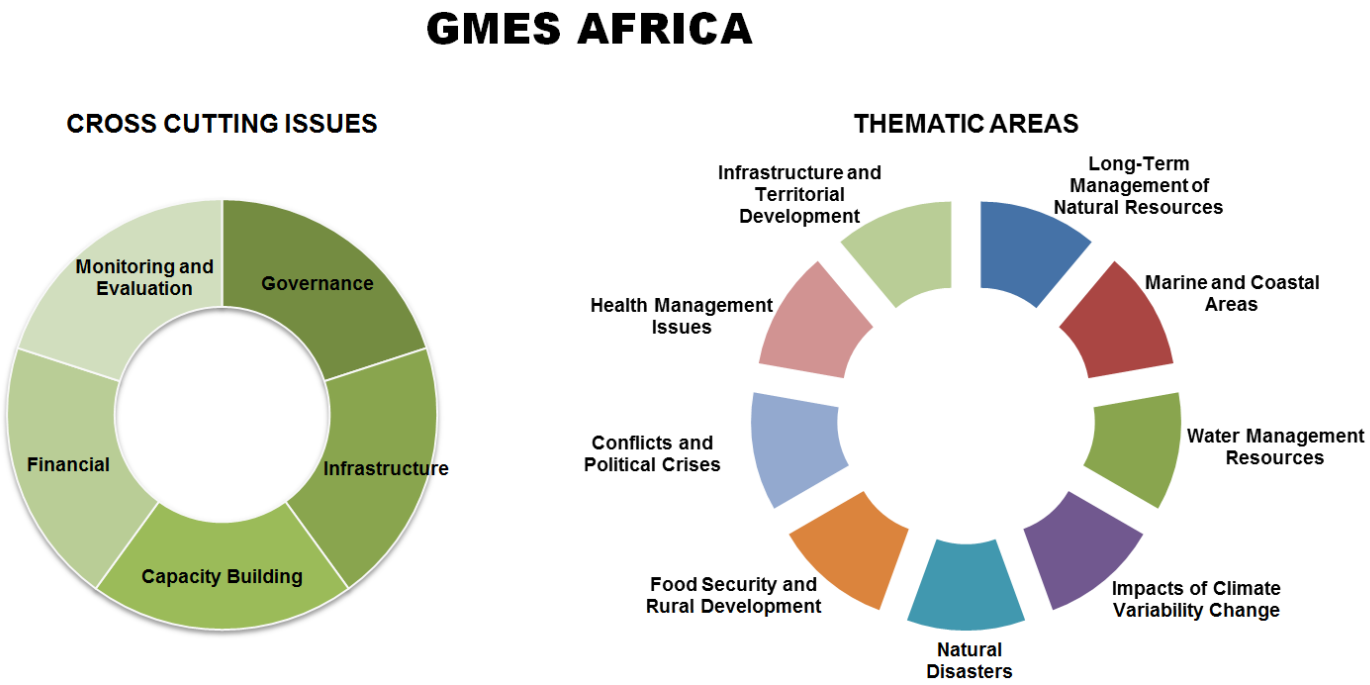

Figure. 11 Cross Cutting Issues and Thematic Areas of the GMES Africa (EU Africa Partnership, 2007)

MESA was found in 2010 to consolidate and widen the operational environmental services developed by AMESD with the aim to increase the capacity in information management, decision making and planning of African continental, regional and national institutions mandated for environment, climate and food security. This is being achieved by enhancing access to reliable, timely and accurate land, marine and climate data and information for Africa.

The following are the regional thematic (priorities) MESA ongoing activities (MESA catalogue of activities, 2016):

IGAD THEMA Land Degradation Monitoring, Natural Habitat Conservation, Forest Monitoring Services

- Land Degradation Service the service will consist of regional and country specific information giving an index of potential land degradation. Time series data will be available to detect the change in potential soil erosion;
- The Natural Habitat Conservation Service the service is to provide an assessment tool on the state of the natural habitats to support conservation policies in the region;
- The Forest Monitoring Service that to assess the deforestation, degradation and vulnerability of forest ecosystems in the region.

SADC THEMA Agricultural and Environmental Resource Management Services

- Agricultural Service it monitors the state of crops and rangelands with new application include a range of livestock products and yield outlooks in the region;
- Drought Service the service monitors droughts during the whole year and delivers decadal "Drought Maps" and a "Drought Outlook";
- Wildfire Service the service provides daily wildfire risk indication, active wildfire maps (real time during the wildfire season, refreshed every 15 minutes) and monthly burnt area assessments;
- Flood Service the service provides flood risk indications, flash flood forecasts (before floods), flood modelling (during the floods) and flood damage assessments (after the floods).

ECOWAS THEMA Water Management for Cropland; Rangeland Management; and Coastal and Marine Resources Services

- Crop monitoring service the service is to monitor the status of cultivated areas' vegetation to identify agricultural production risk areas. It provides forecasts of main crops yields;
- Pastoralism Service the aim of the pastoralism service is the qualitative and quantitative monitoring of pasture during the growing season and their accessibility;
- Bush Fire Monitoring Service the service aims to monitor Active fires, determinate their impact on productions and the environment;
- Support to Fisheries Resource Management Service the service will monitor the potential location of fish and to monitor fishing vessel activities on the western coast of Africa;
- Monitoring and Forecasting of Ocean Conditions Services the service will monitor ocean conditions and provide information/ disseminate information on forecast of ocean conditions wave heights, temperature, salinity and currents, sea surface heights and winds along the coast of West Africa.

IOC THEMA Marine and Coastal Management Services

- Marine Resources Management Service, this service will provide oceanographic charts for the detection of potential fishing zones and monitor the state of the ocean biological and physical parameters;
- Monitoring of Coastal Environment Service, is to provide operational marine information through the deployment of wave data buoys and assess the vulnerability of the coastlines using the Coastal Vulnerability Index.

CEMAC THEMA Water Resource Management Services

- Monitoring Underground Water Levels Service the service is to forecast the underground water level and to determine the amount of water resources;
- Map out the Underground Water in Particular Regions to monitor the underground water resources in Oubangui, Kasai and Sangha regions and its evolution in the context of climate changes.

- Climate Change Assessment Service. This service is manly to detect regional and local climate change signals to support the development of informed long term adaptation policies and strategies;
- Drought Service and Seasonal Climate Forecast Service. The Service will provide drought monitoring and 3 months seasonal climate forecast every month.

There are numerous activities and projects carried out since setting up of MESA and was built on regional priorities where the application of EO in monitoring environment is varied from one region to another depending on the environmental parameters measured. The expedition of implementing GMES-Africa will help all Member States to build from the EO application on all the priority areas of MESA and beyond.

2.3 Africa Green Wall

Africa Green Wall is a robust project that reflects the solidarity and the common vision of the African Union Member States in addressing desertification as one of the major threats of climate change (Figure 12). The wall is extended from Djibouti at the East to Senegal at the West. With 7,775 km length and 15 km width is not solely aimed at creating forest from East to West Africa, despite being greatly focused on strengthening the land cover. It mainly consists of a set of integrated action addressing the multisectoral problems affecting the lives of people in African Sahel-Saharan areas.

These multisectoral and multidimensional actions transversally address a wide range of concerns, including natural resource management, sustainability of rural production systems (agriculture, breeding, forestry, etc.), and the development of rural production and trade infrastructures, diversifying economic activities and wealth creation; taking into account gender and wealth issues in development (African Union Commission, 2012).

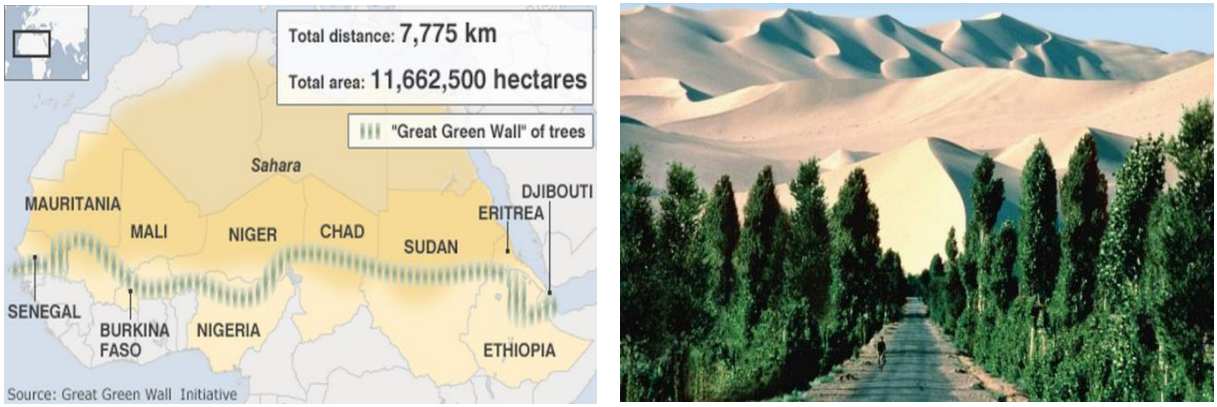

Figure 12 Africa Green Wall

2.4 Other Ongoing Initiatives

The African Union Member States also engage in several initiatives, which are aimed at promoting transparency, efficiency, and integration in innovation, science and technology responses to climate change in Africa.

The initiatives have led to research investigations and investments in the areas of power, erosion, diseases, etc. to enhance in the bid to overcome any potential challenges and to keep abreast with the latest developments.

2.4.1 Power Stations/ Electricity

Realizing that power stations/electricity are contributing considerably to greenhouses emissions, the African Union Member States encouraged Member States to utilize Renewable Energy to respond to the needed power demands (present and future), e.g. Kenya as at 2014 produced more than 60% of the total needed energy from renewable sources which includes wind, biomass, small hydros, geothermal, biogas, solar and municipal waste energy (Kenya Energy Regulatory Commission, 2014).

The maximization of the use of the abundance of renewable energy sources in Kenya will be able to provide electricity in areas not connected to the national grid and reduce the cost of power for heavy consumers. Another good example could be the Ethiopia where more than 70% of electricity generated from renewable resources (IRENA, 2012) and by 2025 Ethiopia is projected to be on a zero carbon emission level (Ethiopia's Climate-Resilient Green Economy Strategy, 2011).

Considering countries with high electricity access rates like Egypt (access rate is 99%) producing 10.1% of its demands from renewable resources with the projection to produce 20% of electricity from renewable by 2020 out of which 12% will be wind-derived (IRENA, 2012).

The Egyptian Zafarana Wind Farm is one of the largest onshore wind farms in the world. Not only is Egypt utilizing wind farms for its energy demands but Africa has 52 operational wind farms and 17 other Member States with a total capacity of 2.4 GW while 10 more stations are to be added with a capacity of 1.2 GW (see Figure 13).

Figure. 13 Wind Farms in Africa (IRENA 2012)

There is no doubt that with thousands of miles of waterways in Africa and its enormous untapped hydro potentials (see Table 1), the continent is poised for an explosion of hydropower growth as the continent gradually develops. The development pathways in Africa has shown potential hydropower development, with a good number of hydropower development and associated power export projects under way or planned, Africa is becoming a more attractive place to invest in power infrastructure development.

Despite these progresses, it remains in desperate need for hydropower development with the vast majority of the population lacking access to reliable electricity supplies. Africa holds about 12% of the world's hydropower potential, with a technically feasible output of 1,800 TWh/year. Yet Africa produces only about 3% of the global hydropower and exploits less than 10% of its technical potential, the lowest proportion of any of the world's regions as shown Table 1.

Country	Hydropower potential (MW)	Installed capacity (MW)	Percentage %	Electricity Access Rate %
Angola	18,000	527	3	15
Cameroon	20,000	720	4	47
Congo DR	100,000	2446	2	6
Ethiopia	30,000	796	3	15
Gabon	6,000	170	3	47
Madagascar	7,800	150	2	15
Mozambique	13,000	2199	17	6
Nigeria	20,000	1301	7	40
South Africa	10,000	*2,000	20	>70
Zambia	6,000	1,760	29	19

Table 1. Showing Hydropower Potentials and Installed Capacities in Africa (SIRIX, 2015)

The recent growth in the hydropower development in Africa is dominated by Chinese investment as shown in Figure 14. In the period from 2003 to 2013, seventeen hydropower projects were financed under China's African engagement, 2003 to 2013

Figure. 14 Chinese Hydroelectric Projects in Africa (SIRIX, 2015)

Also, the Africa Union and its Member States have harnessed the huge potential for power generation from its natural water habitat (see Table 2). Still most of these investments are financed or co-financed with Chinese Institutes see (Brautigam et al, 2015 and SAIS-CARI, 2015, SIRIX, 2015).

#	Year of Loan Signing	Country	Project Name	Added MW	Chinese Lender	Total Cost in US$ mn	Chinese Financing (US$mn)	Contractors	Rivers	Actual Start Date
1	2012	Cameroon	Memve'ele	200	Eximbank	637	541	Sinohydro	Ntem	2012
2	2011	DRC	Zongo II	150	Eximbank	367.5	360	Sinohydro	Inkisi	2012
3	2006	E. Guinea	Djiploho	120	Eximbank	257	257	Sinohydro	Wele	2007
4	2007	Ethiopia	Finchaa-Amerti-Neshe	97	Eximbank	154.67	116	Gezhouba	Neshi	2007
5	2010	Ethiopia	Genalle-Dawa III	254	Eximbank	451	270	Gezhouba	Genalle	2008
6	?	Ethiopia	Gilgel Gibe III	1,870	ICBC	1,888.4	400	Salini Costruttori, China Dongfang	Omo	2006
7	2008	Gabon	Grand Poubara	160	Eximbank	398	300	Sinohydro	Ogooue	2008
8	2007	Ghana	Bui	400	Eximbank	809.6	749.6	Sinohydro	Black Volta	2007
9	2011	Guinea	Kaleta	240	Eximbank	446.2	335	Three Gorges/ CWE	Konkoure	2012
10	2013	Ivory Coast	Soubre	275	Eximbank	600	500	Sinohydro	Sassandra	2013
11	2013	Mali	Gouina	140	Eximbank	430	345	Sinohydro	Senegal	--
12	2013	Nigeria	Zungeru	700	Eximbank	1,300	910	CNEEC & Sinohydro	Niger	2013
13	2003	R. Congo	Imboulou	120	Eximbank	306.8	238	CMEC	Léfini	2004
14	2003	Sudan	Merowe	1,250	Eximbank	2,945	608	Alstom; CWE/ Sinohydro/ CWHEC, Harbin Electric	Nile	2003
15	2011	Sudan	Upper Atbara	135	Unclear	1,575	104	Three Gorges, CWE	Atbara, Setit	2011
16	2007	Zambia	Kariba North Ext.	360	Eximbank	420	315	Sinohydro	Zambezi	2009
17	2013	Zimbabwe	Kariba South Ext.	300	Eximbank	355	320	Sinohydro	Zambezi	2014
		Totals		6,771		13,341.2	6,668.6			

Table 2. Details of Projects Financed Under China's African Hydropower Engagment, 2003 to 2013 (Brautigam etal 2015)

2.4.2 Coastal Erosion

Coastal erosion has devastating consequence, inducing loss of infrastructure such as roads, threatening populations, who can no longer live close to coastline, salinization of water and soil, degradation of ecosystems and flooding. These problems will further be compounded with the rising sea level. The protection and restoration of Africa's coastal and marine ecosystems and their services are long-term objectives for local to global communities.

The Intergovernmental Oceanographic Commission of UNESCO is implementing the project Adaptation to Climate Change in Coastal zones of West Africa (ACCC) which is a tentative response to the problem of coastal erosion with the regional involvement of five countries Mauritania, Senegal, Gambia, Guinea Bissau and Cape Verde. National components are

developing pilot activities in selected sites – one per country – with the aim of reducing the threat of coastal erosion, while increasing biodiversity and strengthening the adaptive capacities of local communities and ecosystems.

One of these pilot projects is taking place in Varela, Guinea Bissau, where extremely rapid coastal erosion is occurring. Activities on the site include cleaning the beach (mostly material left by a former tourist industry infrastructure), mangrove restoration and afforestation; in Cape Verde the anti-salt dyke construction in the Ribeira Lagoon estuary to trap flood borne sediments, remove salts in order to reclaim salty soil and prevent the lagoon from bursting its banks in the event of flooding, and reduce sea-water infiltration into the estuary. While in Mauritania there are ongoing project on "soft" techniques to fix the shoreline breaches in the dune ridge on the fringes of the capital Nouakchott.

The AU Member States are signatory to many Multilateral Environmental Agreements (MEAs) and framework one of which is the framework of integrated management of coastal resources. Member States party to the Convention for the Protection of the Mediterranean Sea against Pollution (the Barcelona Convention) or the Jeddah Convention (Red Sea and Gulf of Aden), Nairobi Convention and Abidjan Convention. These MEAs focus on cooperation for a coordinated approach to protection and enhancement of the marine environment and coastal zones.

Among the North African States, Tunisia has passed specific coastal zone legislation and has established the Tunisian Agency of Coastal Protection and Management while Algeria is drafting such legislation and creating an agency. In Nigeria the government has built some physical barriers to flood and coastal erosion at Bar Beach while there are many Member States that have built similar dykes in defence of sea level rise. Most Member States recognized the value of their coastal and marine biodiversity and have gazetted marine and wetland protected areas to ensure their sustainability (Russell et al 2006).

There are many ongoing support programmes for capacity-building for the sustainable management of coastal and marine resources is offered by the World Bank's Mediterranean Environmental Technical Assistance Programme in the continent.

2.4.3 Infectious Diseases

The early impacts of climate change include several infectious diseases. The health implication of extreme temperature and impacts of extreme climatic and weather events as described in the Table 3

Environmental Changes	Example of Diseases	Pathway of Effect
Dams, canals, irrigation	Schistosomiasis	^ Snail host habitat, human contact
	Malaria	^ Breeding sites for mosquitoes
	Helminthiasies	^ Larval contact due to moist soil
	River blindness	˅ Black fly breeding, ˅ Diseases
Agricultural intensification	Malaria	^ Crop insecticides and ^ Vector resistance
	Venezuelan haemorraghic fever	^ Rodent abundance, contact
Urbanization, urban crowding	Cholera	^ Sanitation, hygiene; ^ Water contamination
	Dengue	^ Water-collecting trash, Aedes aegypti mosquito breeding sites
	Cutaneous leishmaniasis	^ Proximity, sand fly vectors
Deforestation and new habitation	Malaria	^ Breeding sites and vectors, immigration of susceptible people
	Oropouche	^ Contact, breeding of vectors
	Visceral leishmaniasis	^ Contact with sand fly vectors
Reforestation	Lyme disease	^ Tick hosts, outdoor exposure
Ocean warming	Red tide	^ Toxic algal blooms
Elevated precipitation	Rift valley fever	^ Tools for mosquito breeding
	Hantavirus pulmonary syndrome	^ Rodent food, habitat, abundance

^ Increase ˅ Reduction

Table 3 Examples of how Diverse Environmental Changes affect the Occurrence of Various Infectious Diseases in Humans (World Health Organization 2013)

There are plethora of studies that showed wide range of possible disease drivers and climate change in addition to the ones shown in Table 3. Increased temperature, rainfall, and droughtt are seen as potential drivers of diseases currently and in the near future (Rweyemamu et al, 2006). Climate change is considered as a predisposing factor for diseases while the disease is considered as the problem.

The African Union has devised a strategy for the prevention, control and management of disease framework endorsed by the AU Assembly of Heads of State and Government EX.CL. 776 (XXII) called 'African Union Science and Technology Framework for the Detection, Identification and Monitoring of Infectious Diseases of Humans, Animals and Plants in Africa' that led to the formation of African Union Network of Infectious Disease Surveillance (AUNIDS) and further linked to the African Centre for Disease Control and Prevention (ACDC). The implementation closely looked at proffering innovative and technological solutions to cost effective management and controls of diseases.

3 Africa and Climate Change Related Funding Issues

For Africa to be in the forefront in ameliorating the impact of climate change at the national and continental level huge resources need to be available and deployed to proper priority sectors.

At the national level, AU Member States are mobilizing resource to launch their own programmes and projects that addresses the mitigation and adaptation of the climate change; e.g. Naira 16 billon ≈ 100 million USD were allocated from the Nigerian National Budget as a seed fund for the Great Green Wall of Africa while more resource to be mobilized from Local Governments and Private Sector (Nigerian Ministry of Environment, 2012).

Another good example is Kenyan Government allocation of 50% of the total cost of 1.2 billion USD for the establishment of 9 solar power plants while private partners contributed the rest; this project will provide more than half of the country's electricity by 2016 (PV-Magazine, 2014) not only that but other alternative source of funds has been introduced for the energy market such as power purchase agreements; build operate and transfer agreements.

Considering the resource constraint that AU Member States had and the challenges they are facing which may not be particularly limited to climate change but also extended to other socio-economic challenges. It is imperative to identify funding opportunities within the national and international systems. The Clean Development Mechanism (CDM) and the Green Climate Fund (GCF) could be a support to address the raising need of funds for climate response.

The CDM, established under Article 12 of the Kyoto Protocol, is the primary international offset program in existence today. However, imperfect, it has helped to establish a global market for Greenhouse Gas (GHG) emission reductions. It generates offsets through investments in GHG reduction, avoidance, and sequestration projects in developing countries. These offset credits, called Certified Emission Reduction credits (CERs), represents a reduction in one metric ton of carbon dioxide CO_2 emitted to the atmosphere, (Gillenwater and Seres, 2011).

CDM is intended to help channel private sector investment towards climate friendly projects that might not otherwise have taken place. In its relatively short eight years of existence CDM has managed to establish a credible, internationally-recognized, $2.7 billion carbon offset market with participation from a large number of developing countries and private investors. 2.8% of the carbon offset market was received by Africa as shown in, Figure 15 (UNFCCC 2012).

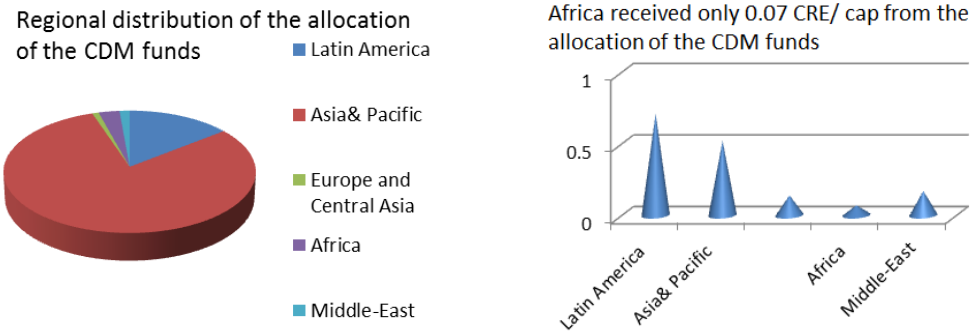

Figure. 15 CMD Fund Allocation per Region and Amount Received/Cap (UNFCCC 2012)

Generally the meagre percentage received by Africa as stated in Warsaw, 2013 conference is that CDM is fairly complicated for some Least Developed Countries LDCs in Africa where many African countries lack the capacity to develop and process projects that could qualify for the funding under the CDM modalities.

Furthermore, bureaucratic hurdles on the level of Member States for example Egypt ratified the United Nations Framework Convention on Climate Change in 1994 and appointed the Egyptian Environmental Affairs Agency as National Designated Authority (NDA), the number of CDM projects however is low. Even in times where carbon prices were high, the bureaucratic hurdles made the use of the CDM in Egypt not very attractive (Balz, 2012).

The low price of the CERs (Figure. 16) and the failure of the governments to ensure its future existence is endangering the CDM to the level it may collapse (Climate Change, Carbon Markets and the CDM Report, 2012); for more details see (Nordhaus, 2011 and Clò et al., 2013).

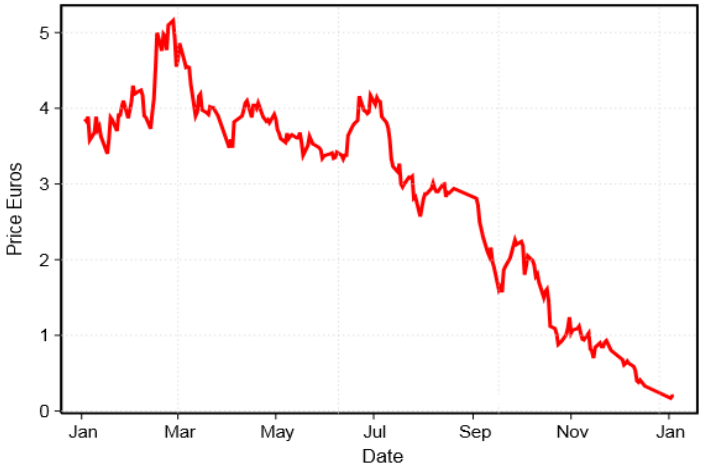

Figure. 16 Certified Emission Reduction Spot Prices 2012 (Clo, 2013)

In summer 2014, the Green Climate Fund became operational with the aim to complement many of the existing multilateral climate change funds (e.g., the Global Environment Facility, the Climate Investment Funds, and the Adaptation Fund). However, as the official financial mechanism of the UNFCCC, some Parties believe that it may eventually replace or subsume other funds (Lattanzio, 2014).

The Fund had the objective to contribute to the achievement of the ultimate objective of UNFCCC in the context of sustainable development, by promoting a paradigm shift towards low-emission and climate-resilient development pathways by providing support to developing countries to limit or reduce their greenhouse gas emissions and to adapt to the impacts of climate change, taking into account the needs of those developing countries particularly vulnerable to the adverse effects of climate change (GCF, 2014).

To maximize its impact for funding the GCF will focus primarily on three issues Adaptation policy and planning; Mitigation policy and planning; Measurement, reporting and verification of mitigation actions. The GCF also addresses the capacity building for Adaptation and Mitigation including Monitoring and Evaluation activities. The capacity building for Adaptation includes Risk management approaches to address adverse effects of climate change; Maintenance and revision of a database on local coping strategies; and Maintenance and revision of the adaptation practices interface. While the areas for Mitigation covers technical assistance and policy planning support among others.

According to GCF 2014, the fund envelop is apportioned equally between mitigation and adaptation, out of the adaption allocations, 50% will be channelized to LDCs, Small Island Developing States (SIDS) and Africa (see Figure, 17) i.e. AU Member States have great chances of accessing such funds. This could be achieved if AU Member States are accredited to the fund of which the process is a lengthy and complicated one, while the weakness of financial controls and bureaucracy are a hindrance at the Member States level that as well hinders the accreditation process.

Funding accreditation does not necessarily guarantee receipt of fund by Member States for adaptation projects; rather Member States are illegible to submit funding proposals in response to calls published by the GCF (GCF, 2014). However, it is a challenge for Member States considering that some of them do not have the capacity or the required competitive expertise to develop proposals. As at January 2016 GCF has received 137 initial NDA or focal point designations, out of which 47 are from the AU Member States (GCF, 2016); *see complete list Appendix 1*. It is advised for those Member States yet to be registered to work hard since the process is lengthy and complicated.

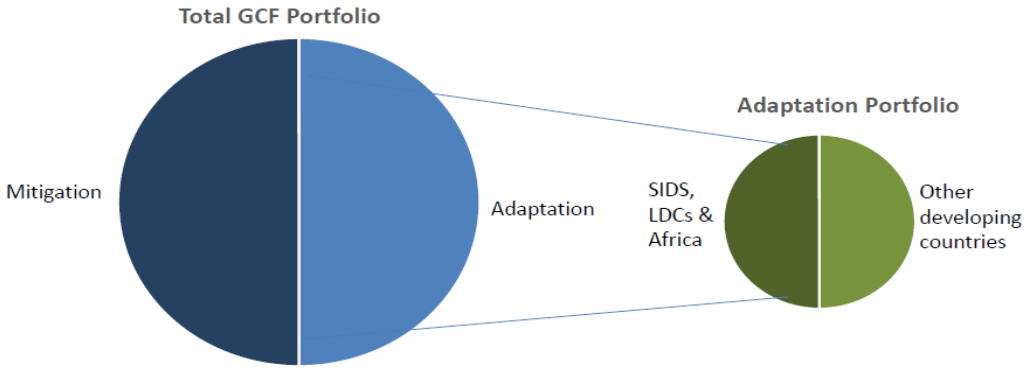

Figure. 17 GCF Fund Allocation for Adaption and Mitigation (GCF, 2014)

Other way of financing mechanisms under the GCF is providing direct finance to developing countries' institutions through so-called direct access. The approach allows national and sub-national institutions in countries seeking finance from these funds to gain access to such funding without going through an international intermediary institution, such as the World Bank or a regional development banks. That in this regards the GCF Board agreed to implement a pilot program aimed at "further enhancing direct access." This program would allow accredited entities and NDAs, instead of the GCF Board, to make decisions together as to whether specific projects or programs should go forward, in order to be granted such access (GCF 2015).

Direct access can improve the results of climate finance, it also entails challenges hence the need for national institutions to undergo significant institutional reconfiguration to meet the relevant standards. This can be tedious and expensive, particularly for those that cannot immediately meet the requirements without significant additional investment of financial and human resources. There are three stages that national institutions generally need to go through in order to gain direct access to climate finance which are Planning for engagement with the relevant fund; Securing accreditation; Designing and implementing effective projects or programs. These stages although presented sequentially, will often not be linear in practice.

Countries seeking direct access to finance are required to create an institutional arrangement to support such access; these arrangements are

National Designated Authority (NDA) is responsible for overseeing all funding coming into the country from the fund. The NDA is the point of communication with the GCF and undertakes a wide range of functions, which include aligning activities with national sustainable development objectives and frameworks.

National Implementing Entities (NIEs) are responsible for overseeing implementation of individual initiatives supported by the funds. Under direct access, these institutions can be public or private, sub-national, national, or regional, as long as they meet the GCF's accreditation standards.

Executing Entities (EEns) are responsible for the initiatives implementation. The EEns could be composed of government agencies, civil society, community organizations, and the private sector.

The biggest challenge of the GCF will be to secure adequate and sustained financial resources to respond to current and future demands and funding requests. Other challenge that is facing the GCF is the concern expressed by some of the stakeholders on the need to find inclusive and accountable processes to reach an agreement on funds' priorities; GCF process, including

the transparency, diversity and balance of the GCF's accredited entities. Where, the multilateral and bilateral development agencies and financing organizations are the majority among the first 20 accrediting Entities rose concerns within the Developing country Board members. These challenges adds to the fact that although GCF is one of the largest sources of climate finance, its guideline for submission of proposals is still unclear all through the various rigorous approval and accreditation processes makes up the complicity of the GCF.

In order for GCF to boost its success and enhance transparency several studies suggested that

- The access modalities for the GCF should be defined as soon as possible, as it will ensure that ongoing initiatives, such as national climate funds, can align with them, and help to focus and frame readiness activities and support to prepare recipient countries for these standards
- The GCF should consider the experience of other international climate funds when developing the GCF's accreditation process and fiduciary and other standard as these may provide ideas for improving the accreditation process and for determining countries' needs in terms of readiness support.

There should be a transparent process for completing accreditation, for example, providing anonymous information about the submitted accreditations or detailed, non-confidential information about the accreditation application.

4 Discussion and Conclusion

AU and its Member States need to work together by linking their centers of excellences to address common challenges and to exchange experiences and knowledge in different thematic areas of STI and Climate Change. It is also imperative to functionalize the concept of community based research and to ensure that the national research centers/universities are linked to their communities. AU is to foster the development of the Green Innovation Policy and advocate for carbon friendly technologies and practices. The successful implementation and impact of the African Union Research Grant as a mitigation and adaptation tool that bring consortium of actors from different Member States need to be explicitly broadened.

The laudable Great Green Wall initiative in the continent that received commendation within and outside Africa as a mechanism for combating desertification and enhancing socioeconomic development in the wake of climate change impact, need to receive more overarching support at the national and international level, particularly the implementation of the initiative to fruition.

Earth Observation Systems need to be in the forefront for the monitoring of the Africa's climate and resources. AU with the support of its Member States to take the lead in the GMES Africa process and to develop local climate models for better understanding of the effects and the impact of climate change.

The African scientific community must focus on building the required capacity to confront myriad of challenges of the impact of the climate change that will encompass development of research plans and proposals that targets mainly the improvement of our seeds to be resistant to drought; pest and disease; salinity and vagaries of climate to ensure that the African Seed Bank is full of such varieties. The African scientific community needs also to map water resources in the continent and to introduce effective research work to develop irrigation, water supplies and rain water harvest systems among others to find a sustainable means for better utilization of our resources.

It is well documented that, change in rainfall pattern along with its spatial distribution and vegetation may results in epidemic of diseases such as dengue fever, malaria and other related diseases in areas that never experienced before. It is essential for AU to strengthen the African network of infectious diseases surveillance and to ensure that Member States share best practices and expertise while, the scientific communities need to work on identifying more effective surveillance, detection, diagnoses, identification and preventive measures.

Recalling the role of NDAs in endorsing the applications by national entities for GCF, it is a golden opportunity for the AU scientific communities to ensure that their NDA endorses proposal that include component of STI and research addressing the issues of climate change mitigation and adaptation.

African Union; GCF and the NDAs need to work together to advocate and educate national entities and privet sector on the GCF modalities and to establish informal network between the African NDAs for exchanging experiences and thoughts; a yearly report to be produced by the African Union on Member States that benefited from the GCF will add value to avoid and alleviate the concerns that resulted in the meagre allocation Africa received from the CDM.

The climate change challenge is the greatest challenge the world will ever be faced with because of its complexity in approach and solution as it cuts across diverse fields of expertise. It is believed that because of the nature of its complexity and dynamism it requires urgent financial and technical assistance from both the continent and the developed world to confront the challenges.

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I am very delighted to have been given the opportunity to revise the Climate Change Impact in Africa: Challenges and Opportunities within the Realms of Science Technology and Innovation.

The authors' purpose for the writing was well achieved. The rationale for the writing is germane as it comes at a time when most nations of the world are showing great commitments to ensure that the long odyssey of the conference of parties yields significant but enduring and sustainable solutions in the mitigation and adaptation to climate change. I am convinced that the content of the text has adequately addressed the title

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