WCRP REPORT

World Climate Research Programme

Climate Observations and Regional Modeling in Support of Climate Risk Management and Sustainable Development[1]

REPORT OF WORKSHOP 3:

ON REGIONAL AND NATIONAL CLIMATE INFORMATION NEEDS AND APPLICATIONS

1-4 March 2011, Arusha, Tanzania

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EXECUTIVE SUMMARY

The workshop on "Climate Observations and Regional Modeling in Support of Climate Risk Management and Sustainable Development" is the third and last of a series of workshops designed to demonstrate key elements of an effective climate risk management strategy for the Global Horn of Africa region. The World Climate Research Programme, the Global Climate Observing System, the World Meteorological Organization and the Nairobi-based IGAD[2] Climate Prediction and Applications Center (ICPAC) joined together to implement this project funded by the World Bank (WB) Global Facility for Disaster Reduction and Recovery (GFDRR).

The first workshop explored changes in climate indices of temperature and precipitation extremes, derived from available observed data over the GHA region. It was held on 19-23 April 2010 in Nairobi, Kenya. The second workshop, also held in Nairobi, Kenya, on 21-25 February 2011, accessed how realistically the current climate is simulated using high resolution Regional Climate Models (RCM) and thereafter investigating the uncertainty associated with constructing climate scenarios. The outcomes of the first two workshops were examined and their usefulness in the development of effective adaptation strategies assessed, in the third workshop (Arusha, Tanzania on 1-4 March 2011) that involved scientists, users and policy makers.

The overall outcome of the three workshops was improved understanding of the ability of currently available data to characterize climate variability and change as well as the ability of regional climate models, compared with available observational data, to contribute to the development of adaptation and climate risk management strategies in the GHA countries and the region as a whole. Participants agreed that the project approach of implementing three linked workshops for a specific region was an effective means to promote understanding and dialogue amongst providers and users of climate information and to build confidence in observations and models, and that this approach should be extended to other regions of Africa and the world. There was also a recognition that fuller understanding of climate information by both the providers and users would lead to more effective communication of information to decision-makers. It was further noted that implementing the third workshop in concert with Regional Climate Outlook Forum (RCOF) was an effective means to bring together decision makers, stakeholders and technical experts.

The lessons learned, challenges and recommendations of the three workshops included the need to build capacity in understanding and using climate products in all concerned ministries and agencies, and in particular, to strengthen the capacity of the National Meteorological and Hydrological Services in downscaling to contribute to developing and analyzing climate scenarios for national, regional and IPCC assessments. It was recommended that the latest techniques in downscaling climate models, including multiple model ensembles, should be used. There was a need to rescue, digitize, and quality control existing data records and utilize "reanalysis" data to fill gaps in time series, and to develop sector-specific indices of particular value to the region. A major recommendation was that the GHA countries need to establish a commitment to data sharing for regional analyses.

2 IGAD is the Inter-Governmental Authority on Development in eastern Africa.

Background

Over 70% of the area of the GHA is classified as arid and semi-arid lands (ASALs) and the GHA countries share pronounced climatic variability and trends. They are vulnerable to extreme climatic conditions due to their very high degree of rainfall variability both in space and time. Most of the hazards resulting in disasters in the region are climate related. Agriculture is the mainstay of the economies of the region with over 78% of the total population dependent on rain-fed agriculture. The most dominant economic activity is small-scale subsistence farming in spite of low and erratic rainfall with recurrent droughts in most parts of the region.

Over 90% of natural disasters in the region are related to extreme climate events such as floods, droughts, cyclones, among others (ISDR, 2005) with the poor being most vulnerable to current hazards and to the expected climate change impacts. These climate related disasters are often associated with severe socio-economic impacts such as lack of food, water, energy, and many other basic needs. The region undergoes regular devastating droughts and floods, that often lead to near collapse of agro-based economies and livelihoods, spread of diseases and other socio-economic disasters.

Global Climate Models (GCMs) indicate that changes in climate in the region are expected in a global warming scenario (IPCC 2007). These are likely to include changes in the intensity, duration, and frequency of droughts, floods, and other extreme conditions, which will have serious implications for agriculture, human health, and many other human activities. Though GCMs can satisfactorily simulate the atmospheric general circulation at the continental scale, they are not necessarily capable of capturing the detailed processes associated with regional/local climate variability and changes that are required for regional and national climate change assessments. This is particularly true for heterogeneous regions like the GHA, where sub-GCM grid-scale variations in topography, vegetation, soils and coastlines have a significant effect on the climate. In addition, at coarse grid resolutions, the magnitude and intensity of extreme events such as cyclones or heavy rainfall (floods) are often not captured, nor realistically reproduced. Therefore, one possible solution to this model deficiency has been to combine a GCM with a high-resolution Regional Climate Model (RCM). Nesting Regional Climate Modeling to the GCMs is thus a strategy to locally increase the model resolution (Anyah and Semazzi, 2007). In this approach, the GCM simulates the response of the general circulation to the large scale forcings, while the RCM simulates the effect of sub-GCM-grid scale forcing and provides fine scale regional information.

Use of regional climate models for decision making depends on verification with observations to assess their reliability. This approach can potentially provide a means for improved guidance and an ability to assess probable climate changes over longer time scales. As such, if verification of models can be achieved and their strengths and weaknesses better understood, then climate models should be able to provide the best available projections of future climate and therefore be extremely useful tools in adaptation planning, including disaster risk reduction. Integrating the latest scientific advances into regional and national climate information delivery systems through capacity building, technology transfer and consensus approaches will help in providing effective climate inputs into adaptation planning and reduce risks from disasters and climate extremes in a sustained manner.

This project was therefore envisaged to i) assess regional climate trends and the adequacy of global and regional climate observations for adaptation purposes, ii) assess the adequacy and reliability of available model-based climate projections for adaptation needs, iii) provide qualified indications of expected climate change for assistance in developing effective adaptation and climate risk management strategies, and iv) facilitate regional ownership of climate assessments by actively involving regional experts and stakeholders in the core activities of the project. The project was inherently regional in nature since, to be useful, regional climate models need observational support from as wide a region as possible. Climate does not recognize national boundaries, so in order to analyze and validate models, it was necessary to take a regional approach.

The three workshops was thus a joint collaborative project intended to help communities in the GHA countries assemble the necessary climate observations, evaluate the simulations of current climate using regional climate modeling techniques to design adaptation policies and reduce climate-associated risks. This report provides synopsis of the presentations at the third workshop. A summary of lessons learned and recommendations from the overall project is included at the end of the report.

Session One: Workshop Perspectives; Regional Climate needs and challenges

Overview of the WCRP/WMO/GCOS/ICPAC/WB-GFDDR; Workshop Project Objectives and Context; and Workshop 3 Objectives - *Prof Laban Ogallo, ICPAC*

Seven countries – Djibouti, Eritrea, Ethiopia, Kenya, Sudan, Somalia, and Uganda – comprise the regional economic community in the Greater Horn of Africa (GHA) known as the Intergovernmental Authority on Development (IGAD). These countries plus Burundi, Rwanda, and Tanzania (see Figure 1) participate in the IGAD Climate Prediction and Applications Centre (ICPAC)

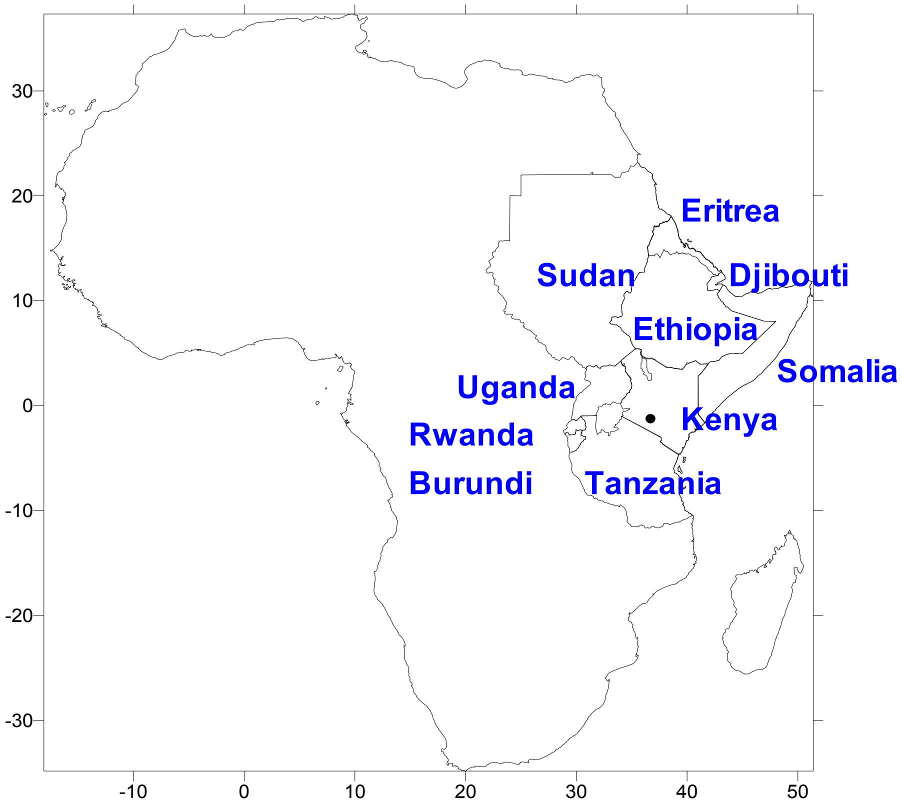

Figure 1: ICPAC participating countries

The countries in the Greater Horn of Africa (GHA) region share pronounced climatic trends and variability and are vulnerable to extreme climatic conditions. These climatic conditions are often associated with severe socio-economic impacts such as lack of food, water, energy, and many other basic needs; These impacts lead to famine; mass migration of animals and people; loss of life and property; and damage to infrastructure, among many other socio-economic miseries as represented in Figure 2. The region has regular devastating droughts and floods, that often lead to near collapse of agro-based economies and livelihoods, spread of diseases and other socio-economic disasters. These impacts can result into limited progress and/or stagnation of socio-economic growth in the region.


(a) Scarcity of water due to prolonged drought (b) Hydro energy risk

(c) Floods (d) Destruction of infrastructure

Figure 2: Impacts of extreme climatic events in the region (*file photos - ICPAC*)

This GFDRR project was an effort intended to help communities in GHA countries assemble the necessary climate observations and to understand and use regional climate modeling that can help GHA countries design adaptation policies and reduce climate-associated risks.

Workshop I examined and assessed regional observed data adequacy for climate change detection, attribution and various applications in the IGAD region. The workshop examined patterns of climate extremes by developed climate indices from the available national meteorological climate records brought to the workshop by the participants. Finally, efforts to assess data deficiencies and the difficulties and challenges for the region were examined.

Workshop II assessed the capability of regional models to add realistic regional details when forced by simulations of current and future climate by global coupled models. The participants analyzed the outputs from the regional model (PRECIS) and compared them with the climate indices derived in Workshop 1 using various statistical methods, including TREND and GIS. They provided guidance on improvements in workshops 1 and 2 and discussed the interpretation of the regional climate projections in light of the comparisons between model outputs and available data.

Workshop III brought together all climate stakeholders, users, climate experts and policy makers to share outputs from the first two workshops and also to assess their usefulness in the development of effective adaptation strategies. It also provided information on the science; impacts; vulnerability; mitigation and adaptation; disaster risk reduction (DRR) and climate change adaptation strategies.

Regional Data and Observational Needs, Gaps and Way forward - *Kijaze, Permanent Representatives (PR) with WMO, Tanzania*

Observation is the measurements of weather and climate parameters from land or surface observations, water bodies (e.g., oceans, lakes and rivers), atmosphere (e.g., upper air and surface observation). Observations are made to monitor weather and climate, understand behaviour and change of weather and climate parameters, analyze spatial and temporal distributions of weather and climate phenomena, and understand impacts to living things and non-living things together with planning of our activities under conducive environment (including adaptation).

Therefore a need exists to understand how the earth system is changing (variability), the primary forces affecting the earth system (forcing) and how the earth system responds to natural and human–induced changes (response). It is also important to know the consequences of change in the earth system due to human activities and the future civilization (consequences).

Observations have produced evidence of potential climate changes due to increases in global air and ocean temperature, widespread melting of snow and ice, and rising average of sea level showing the importance of making reliable observations.

Africa has an observation network eight times below the minimum recommended standard for the size of the continent. Only 157 surface observing stations are part of GCOS baseline surface network. Observations in Africa fall short of meeting desired climate information needs due to inadequate station network, instruments and system failure, lack of proper maintenance and calibration together with shortage of skilled staff. An additional issue is the inadequate communication infrastructure for collecting and exchanging data on the continent.

The GHA countries face major challenges in data management including the operation of instruments in harsh environments, such as deserts, which require specially designed observatories, inadequate resources to modernize equipment to cope with technological changes and to fill gaps in observing systems together with inadequate resources for training of professionals. In addition, there is a lack of adequate calibration infrastructure according to Commission for Instruments and Methods of Observation (CIMO) guidelines.

To address this evident gap, some ways forward include meeting agreed regional and international requirements for data exchange; providing products and services prescribed for regional meteorological centers and regional expertise and obtaining support to improve quality and performance of NMHSs of member countries. There is also need to establish closer and mutually beneficial cooperation amongst NMHSs in the region, including the formulation of an explicit policy on data sharing and with international aid agencies in assisting the region to build data banks.

GCOS Regional Data Needs and Gaps and – *Thomas – GCOS*

Following the United Nations Framework Convention on Climate Change (UNFCCC) Decision 5/CP5, GCOS organized ten regional workshops (Kisumu, October 2001) and thereafter developed Regional Action Plans (RAPs) in consultation with regional and international bodies such as ICPAC.

Regional Action Plans for Eastern and Southern Africa (ESA) considered meteorological surface and upper air stations for temperature, winds, rainfall; oceanic observations such as sea level, surface and subsurface temperatures; terrestrial measurements, e.g. river runoff, lake levels, glaciers, ecology particularly from satellites, CO2, aerosols (dust, sulfur, etc.) in urban areas.

The UNFCCC called for Parties to take action to improve observing systems in non-Annex 1 countries to meet the Convention's needs. Improvements are being made in a number of countries. GCOS, with limited resources, has facilitated improvements globally but with emphasis on Africa and small island states.

WMO Annual Global Monitoring (AGM) indicated that the operation of surface and upper air stations in Africa is unsatisfactory. In Eastern and Southern Africa, many silent upper air and surface stations do not operate or report. Many surface stations do not provide at least 90% of the expected reports. Efforts are underway to add and upgrade stations in the region. For example, in 2006, the 10 African stations in the GUAN network (150 stations globally) were operating fully due to the efforts of many countries.

Most of the problems occur due to lack of adequate funding for modern equipment, consumables, and infrastructure, continuing operational expenses, and inadequate training of staff. Good observations are the basis for credible nowcasts, forecasts, climate analyses and projections and provide the basis for developing and validating the credibility and usefulness of models and analytic techniques. In turn these techniques can be used to better define the adequacy of the regional and national observation system. Observations thus influence capabilities and actions on disaster risk reduction such as protecting people and infrastructure from extreme events such as flooding, drought, climate risks, seasonal to annual variability.

National Adaptation Planning needs information on climate extremes and decadal changes in climate conditions, such as the amount of annual rainfall and length of the growing season. This provides a strong argument for the public and private sectors to support weather and climate observations and for the regional sharing of data for use in regional and national analyses and for prediction products regionally and globally.

Use of satellite data to monitor the environment in Africa – *Njoki, AMESD*

The African Monitoring of the Environment for Sustainable Development (AMESD) programme is funded by the European Union under the 9th European Development Fund up to 21 million Euros and through Intra-ACP funds. The program is hosted by the African Union Commission (Addis Ababa) and will be implement in over 47 African states and involve regional indicative programs from CEMAC, ECOWAS, IGAD, IOC and SADC. The results of the program are directed to institutions such as national environmental authorities, national meteorological services, disaster management institutions, ministries of water resources, and ministries of agriculture, biodiversity/forestry and wildlife conservation institutions in the region. The program also targets mapping agencies and institutions of higher learning in the region.

The AMESD goal is to improve decision making-processes in the fields of environmental resource and environmental risk management in Africa by increasing the information management capacity of African regional and national institutions, and facilitating access to Africa-wide environmental information derived from Earth observation (EO) technologies.

AMESD extends the operational use of Earth observation technologies and data from meteorological to environment and climate monitoring applications. The initiative will enable all African national and regional institutions focusing on environment and natural resources, as well as the continent's National Meteorological and Hydrological Services, to catch up technologically with their counterparts in Europe, the Americas and Asia, which have benefited from the use of operational space technologies in environmental monitoring for some time.

AMESD's four main area of focus include:

• Providing the African user community with better access to Earth observation, field and ancillary data, as well as the infrastructure, local capacity and services necessary to sustain long term environmental monitoring;

• Setting up operational regional information services to support and improve decision-making in environmental management;

• Establishing national, regional and continental environmental information processes, frameworks and activities enabling African governments to meet their obligations regarding international environmental treaties more effectively and to participate in strategic global environment surveillance programmes such as Europe's Global Monitoring for Environment and Security (GMES) initiative and the Global Earth Observation System of Systems (GEOSS);

• Organizing specialized training and staff exchange programmes to maintain the technical capability of African AMESD stakeholders in the long term, with the aim of ensuring self-sufficiency. More than 500 African technicians will be trained by AMESD.

There are five established Regional Thematic Actions (THEMA) that address the already prioritized decision needs in the fields of (i) water resources management (CEMAC region); (ii) crop and rangeland management; (ECOWAS region) (iii) agricultural and environmental resources management (SADC region); (iv) mitigation of land degradation and natural habitat conservation (IGAD region) and; (v) marine and coastal management (IOC region).

The African Union Commission (AUC) with funds from the European Union awarded a three year grant of over 1million Euros to its implementing partner IGAD Climate Prediction and Applications Centre (ICPAC). The signing of the grant was for the implementation of a Thematic Action Plan on "Land Degradation Mitigation and Natural Habitat Conservation" in the eastern Africa region. ICPAC is responsible for the overall management of the THEMA project and for developing the Natural Habitat Conservation (NHC) service. The Regional Centre for Mapping of Resources for Development (RCMRD), an ICPAC Partner also based in Nairobi, will be developing the land degradation assessment service.

Regional Climate Change needs and challenges for sector specific applications - *Komutunga*

Rainfall and mean surface temperature are the climatic elements of importance for rain-fed agriculture which is the mainstay of the GHA economies. Users require a range of knowledge and information, such as the start, length and end of a rainy season, intensity of rainfall among others. Challenges in data still hinder the effective use of climate information. Observed data need to be carefully blended with model scenarios forced with real data. Other activities such as data rescue, digitization, filling in of gaps should be enhanced through increasing the capacity to scientists of the region and using available global and regional techniques. New indices relevant to the local users need to be derived based on the local environment and the needs of the region. This could be achieved when scientists work together with agro-meteorologists. The Regional Climate Models (RCMs) need to be forced not only with coarse Global Circulation Models (GCMs) output but also by observations for more detailed and relevant information.

In summary, sustainable partnerships, building of complete sector specific data and skills at the regional level will reduce some of the challenges to applications of climatic information.

Global Framework for Climate Services (GFCS) – *Nyenzi*

Climate services entail the development and provision of climate data, information products and advice to assist in decision-making. Strengthened climate services will lead to improved decisions on socioeconomic development, reducing disaster risk and adapting to climate change.

The World Climate Conference–3 (WCC3) established a Global Framework for Climate Services (GFCS) to strengthen the production, availability, delivery and application of science based climate prediction and services. WCC-3 recommended as a way forward the establishment of a High Level Task Force (HLT) to define terms of references to the Global Framework for Climate Services (GFSC). One of the terms of references of GFSC is to serve as a global, policy neutral, operational, capability to facilitate more effective use of climate information. A framework for Climate Services was needed because there are many gaps in the observation networks supporting climate services (Figure 3)

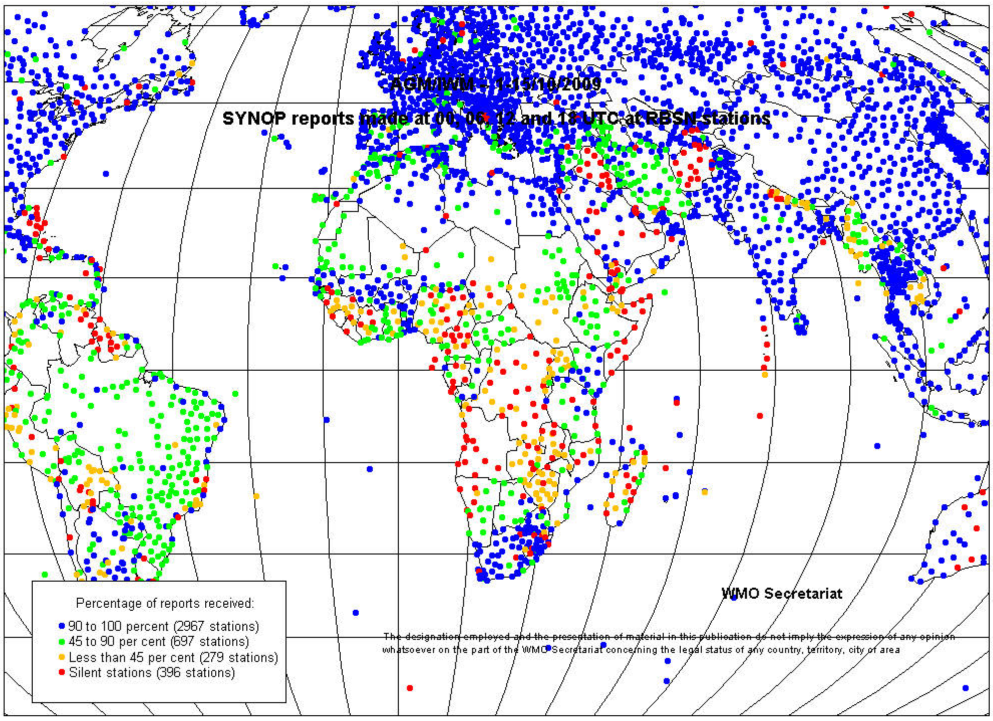

Figure 3: Some surface observatories (GCOS)

The framework is critical because important research does not move rapidly enough to the most vulnerable communities and yet they have the greatest need for these services. The Framework also must address the large gaps in the global distribution of scientists, engineers and other tertiary educated people.

The High Level Taskforce developed the components of GFCS (Figure 4) which outlined a plan for its implementation and entailed options for governance.

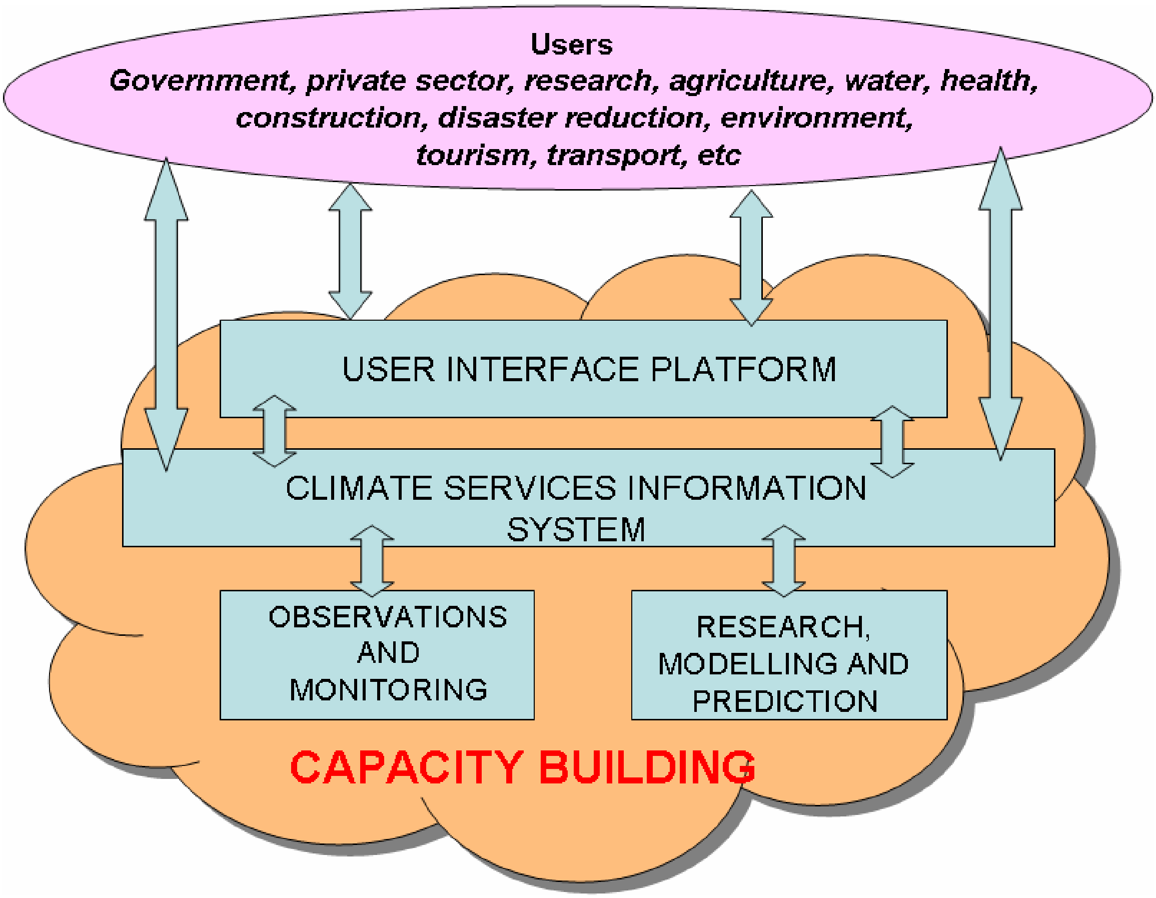

Figure 4: Components of the Global Framework for Climate Services (GFSC).

In building these components, the High Level Task Force consulted users and providers of climate services and reviewed their current capabilities and needs. To close the gap between needs for and provision of climate services, the Task Force proposed that the GFCS should have achieved:

By 2016, global, operational climate services system; continuous upgrading of climate services in developing countries; user oriented creation of new services and a governance mechanism that drives Framework development.

By 2021, access to improved climate services globally across all climate-sensitive sectors.

Once operating, the GFCS can assist the implementation of the UN Framework Convention on Climate Change (UNFCCC) and the development of all aspects of the regional climate services delivery system in the GHA region from facilitating the resource aspects of improving and sustaining regional climate services activities including the RCOFs.

Climate change and Agriculture – Hakuza, Ministry of Agriculture, Animal Industry and Fisheries, Uganda

More than 95% of agricultural production in Africa is subsistence in nature with its high dependence on rainfall and its high vulnerability to changes in climate variability, seasonal shifts and precipitation patterns. The majority poor are more vulnerable because they have limited capacities to cope and adapt to the impacts of climate change on agriculture. Many African countries have inadequate adaptation strategies due to deficiencies in their institutional, economic and financial capacities, which further exacerbate the situation for the poor. (FAO, 1999).

Agriculture contributes about 20% of human-made emissions of greenhouse gases (Figure 5). Large amounts of CO_2 are emitted from burning of fossil fuels, deforestation and burning of forests, grasslands and other wastes.

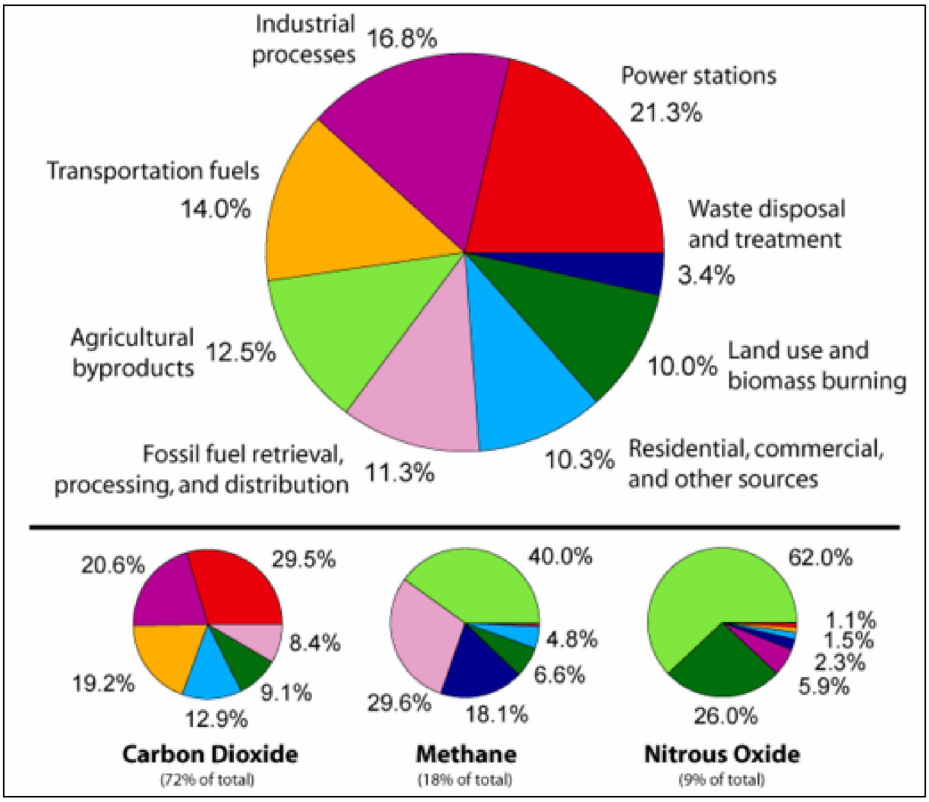

Figure 5: Annual green house gas emission by sectors

Methane (CH_4) enters the atmosphere from natural (30%) with methanogens (CH_4-producing bacteria in swamps and wetlands) as the largest natural sources. Anthropogenic (70%) sources of CH_4 include biomass burning, rice agriculture, raising livestock. Cattle, sheep, goats, buffalo and camel account for 15% of annual anthropogenic CH_4 emissions[3]. Kabasa et al., (2007)

[3] In the rumen chamber bacteria break down food (enteric fermentation) and generate CH_4 as a by-product which is exhaled.

indicated that to meet the demand for meat and milk for Uganda's growing population over the next 30 years, the number of cattle[4] will have to increase significantly over the next 30 years.

Impacts of climate change and extreme weather events in Uganda include flood risks, drought, land slides/mudslides (Figure 6). Increased incidences of crop and livestock pests and diseases that affect agriculture production and food security are prevalent. Agricultural production interacts with natural resources (land, water, forests). Maintaining soil fertility, using of water resources efficiently, and practicing sound land management are all important measures in adapting to climate change and enhancing agricultural production.

Figure 6: A strong storm and mudslides in Bushenyi, western Uganda 2009 destroyed banana plantation

Floods have devastating effects on livelihoods, destroy agricultural crops, disrupt electricity supplies and demolish basic infrastructure such as roads, homes and bridges (UNEP-Atlas, 2005). Drought, defined in general terms as a 50-% shortfall in rainfall over three months (UNDP, 2004), affects the Africa Sahel most. One third of African people live in drought-prone areas and around 220 million people are annually exposed to drought. Impacts of climate change on agriculture in Uganda include:

[4] Uganda would require a cattle population of 10.4, 13.9, 18.7, 27.4 and 40.2 million during 2010, 2015, 2020, 2025 and 2030, respectively, which would produce 0.32, 0.57, 1.03, 1.52 and 2.25 million tons of CH_4. The Ankole, Zebu, Nganda and improved cattle breeds will produce 899.8, 803.6, 798.3 and 82.1g CH_4 kg^{-1} of milk, suggesting a strong reason for adoption of improved breeds to increase productivity while reducing CH_4 emission. Feed quality and quantity effect the amount of CH_4 emitted: lower quality feed increases CH_4 emission, and higher quantity of feed increases CH_4 emissions.

- Reduction in soil fertility
- Decreased livestock productivity directly (through higher temperatures) and indirectly (through changes in the availability of feed and fodder)
- Increased incidence of pests due to rising temperatures
- Manifestation of vector and vector-borne diseases
- Negative impacts on human health affecting human resource availability

Climate variability and change are likely to disrupt food security due to changes in the suitability of land for different types of crops and pasture; loss of arable land due to increased aridity and associated salinity, groundwater depletion and rise in sea level; increased risks of more serious widespread flooding in low lying areas, drought in arid and semi-arid areas and land slides in highland areas. Other consequences include:

- Loss in biodiversity and ecosystem functioning of natural habitats together with change in health productivity of forests, wetlands etc;
- Changes in distribution of good quality water for crop, livestock and aquaculture;
- Threats from increasing incidence of pests and diseases[5] due to distribution of disease vectors.
- Poor accessibility to food due to destruction of marketing infrastructure and reduction of incomes of people hit by floods and drought.

Coping strategies and adaptation measures for climate change in agriculture include early planting; planting of drought and flood tolerant crop varieties; reduction in herd sizes; water storage for agricultural production; appropriate food storage; crop and animal diversification; early maturing crops; planting high yielding and pest and disease resistant varieties; water and soil conservation practices among others.

Climate change and water resources – *Artan (USGS)*

IPCC has provided estimates of how the climate may change, although the changes differ regionally. Since the changes will likely affect fundamental drivers of the hydrological cycle, climate change may have a large impact on water resources. Additionally, climate change will bring more variable weather patterns that can lead to more severe droughts and floods conditions.

Effects of climate change on the water resources reveal that the amount of water available will be determined by the frequency and magnitude of precipitation and evaporation. In the short-term, weather conditions determine the state of water resources, while in the long-term, the climate conditions determines the amount and distribution of the water resources.

Current projections of climate changes and their potential impacts have many uncertainties. To develop good strategies for adaptation to a changing climate for water resources, better hydrologic models are needed that can make credible future projections. In addition, calibration and validation is necessary for these models before they are applied in day to day operations.

[5] Such pests and diseases include Cassava brown streak – 2005, Banana bacterial wilt – 2001, Coffee wilt disease – 1993, Coffee mealybugs, Coffee stem borers, White flies, Leaf rusts on coffee in highland areas, Lantana camara in rangelands.

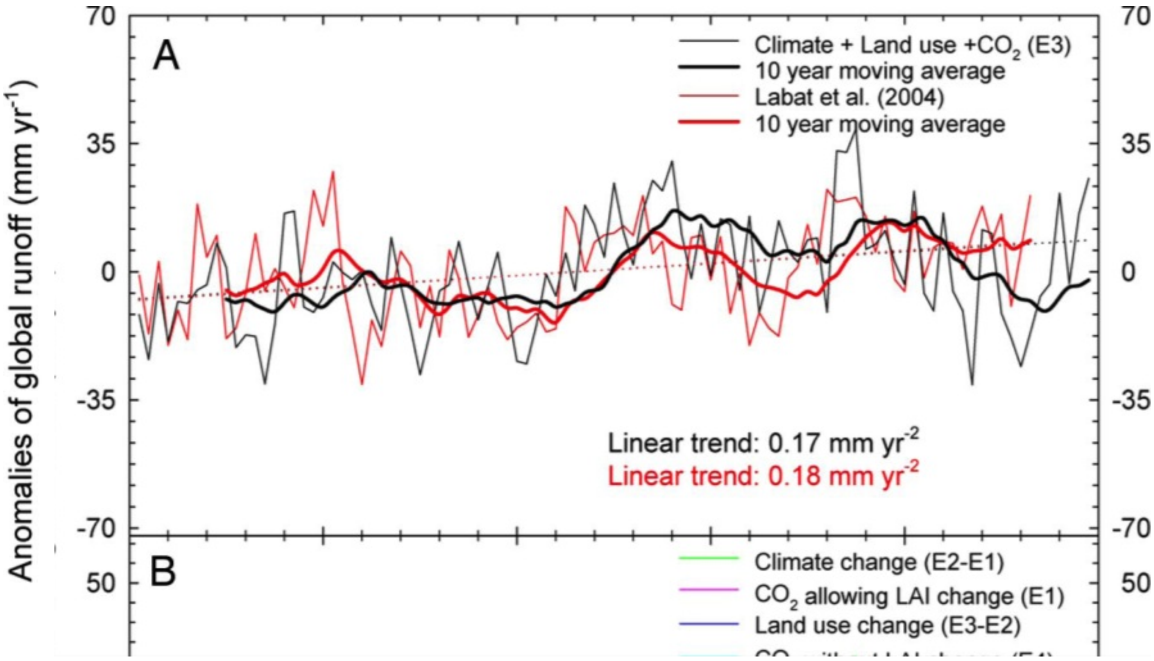

Figure 7: Climate Change results into Change in Global Runoff Anomalies from 1901 to 1999 (Paio et al 2007)

Hydrometeorological data from long-term monitoring networks are essential for establishing baseline conditions to track any changes over time. Continuous long-term streamflow and meteorological records are critical for detecting trends or shifts in the statistics of historical hydroclimatic variables (Figure 7).

Exposure of sectors to climate and nature of sector decision making – *Gallu (FEWS NET – East Africa)*

The Greater Horn of Africa has sparse meteorological observations to support comprehensive Agro-Hydro-Climatic monitoring in chronically food insecure regions. Global Telecommunication System (GTS) disseminated observations are inconsistent and irregular and impact on our basic products (RFE and surrogate) for trends and change analysis.

In Kenya and Ethiopia (Figure 8), productive crop areas receiving more than 500 mm during the March-May long rainy season are shrinking due to warming in Indian Ocean.

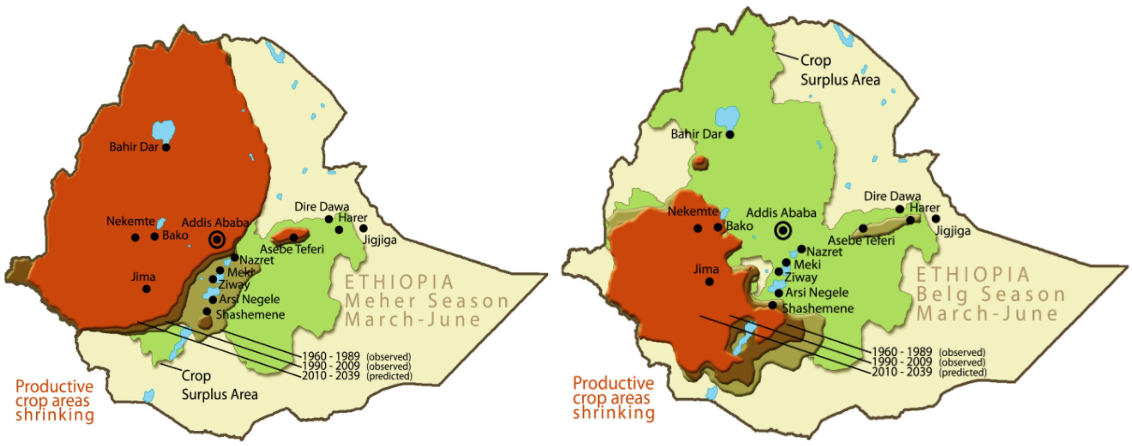

Figure 8: Productive crop areas of Ethiopia shrinking due to warming in Indian Ocean.

Session Two: Review of workshop 1 and 2 outcomes and local climate trends and variability

In this session, brief reports on the first and second workshops were given. As highlighted in the executive summary, in workshop 1, the participants examined changes in climate indices of temperature and precipitation extremes, derived from available observed data over the GHA region.

Global and Regional Climate information for risk mitigation over the Greater Horn of Africa– *Anyah, UCON*

Global Climate Models (GCMs) are the most appropriate tool for addressing future climate change. However, in order to formulate adaptation policies in response to climate change impacts, reliable climate change information is usually required at finer spatial scales than that of a typical GCM grid-cell (which is usually about 300 x 300 km). The attractiveness of GCMs for climate studies is their ability to model the evolution of the atmosphere in response to external forcing mechanisms - for example, a doubling of carbon dioxide, increase in soil moisture, and increase in SST. However GCMs do not capture the detail required for regional and national assessments. This is particularly true for heterogeneous regions like eastern Africa where sub-GCM grid-scale variations in topography, vegetation, soils and coastlines have a significant effect on the climate.

A Regional Climate Model (RCM) is a comprehensive physical model representing the important components of the climate system. It has a higher resolution than a GCM and covers a limited area of the globe.

Projected mean surface temperature changes over East Africa is well-modeled by the global models since it does not vary very much in space and therefore spatial averages may be representative of the general change.

Mean surface temperature is projected to warm between 1^{o}C and 3^{o}C by the middle of the century, especially during the March-May and June-August seasons for both A1B/A2 IPCC scenarios. Scenarios chosen for impacts and vulnerability analysis should reflect plausible range for key variables used as input to application models. Scenarios/projections are not predictions, and so there is need to consider the 'tolerable' uncertainty for a system. Adding delta change (surrogate) on 'baseline' may not be adequate. Regional models are expensive to run, so one should choose based on validation, and representativeness of contemporary climate.

Due to the paucity of observational data networks over the GHA region, Dr. Anyah recommended that as many complimentary datasets as possible be used in order to evaluate regional model simulations comprehensively. Therefore sparse observed data over the region should be augmented with satellite and other sources of remotely sensed data.

Major outputs from Workshop 1: climate indices from WS1, regional climate extremes – *Pyuzza, ICPAC*

Workshop 1 was on "Exploring Changes in Temperature and Precipitation Extreme Indices for the GHA Region" and was held on 19-23 April 2010, Nairobi, Kenya. Participants brought with them their country's best digital long-term daily station series of precipitation, maximum and minimum temperature. The spatial coverage of the National Meteorological and Hydrological stations analyzed is shown in Figure 9. On average, most stations had observations in digital form starting from 1961 until end of 2009, while some from 1971 to 2009.

16 Temperature indices and 11 Precipitation indices were calculated based on the daily data from the participating countries using Rclimdex1.0, a user-friendly software package. These Rclimdex indices were developed by the Expert Team on Climate Change Detection and Indices (ETCCDI). Particular attention was placed on those indices that reflected climate extremes due to the fact that the vulnerability of society to climate variability and change is likely to depend more on changes in the intensity and frequency of extreme weather and climate events than on changes in the mean climate. The country by country results are published separately.

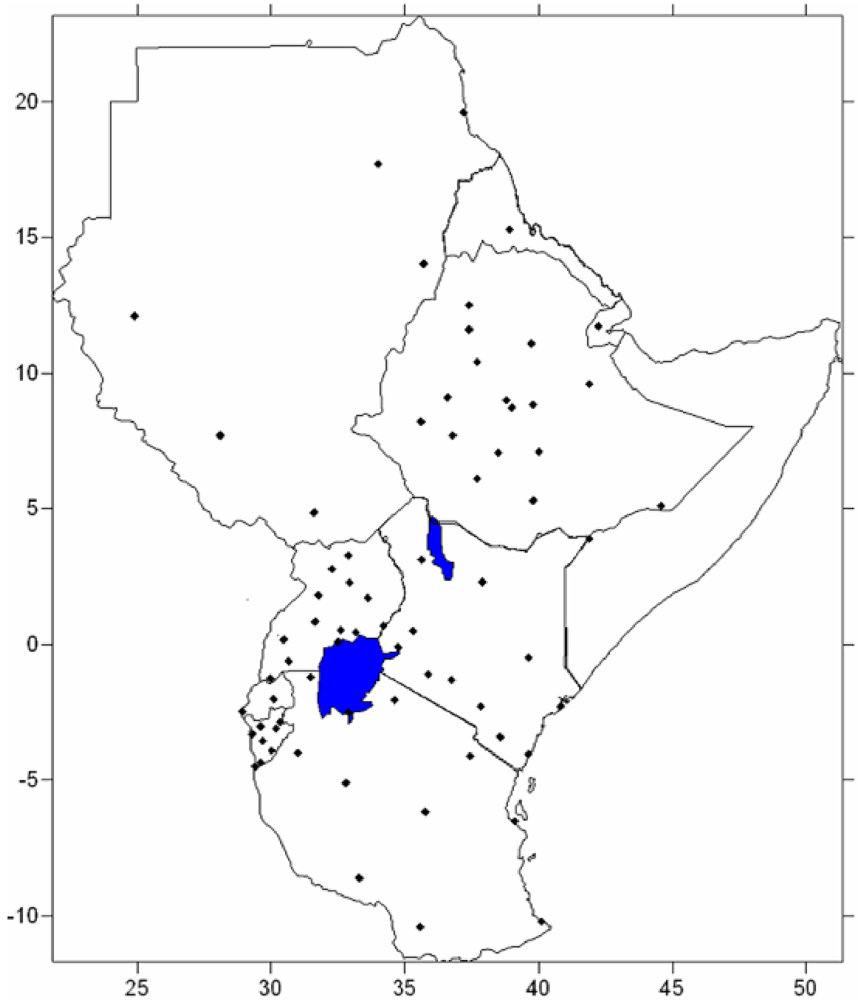

Figure 9: Location of stations with Daily Rainfall and Temperature over the Greater Horn of Africa region

Quality control analyses revealed the existence of many erroneous values, outliers and missing values in the data sets to the extent that some stations were not recommended for use in the Rclimdex analysis. Total annual rainfall (PRCPTOT) showed a decreasing trend for many of the stations except for Khartoum in Sudan and over the northern stations of Ethiopia. Generally, consecutive wet days (CWD) showed a decreasing trend while the consecutive dry days (CDD) showed increasing trend.

Temperature indices vary from station to station, but the dominant features seemed to be increasing trend for TN10p (cold nights) and decreasing trend for TN90p (warm nights) leading to decreasing Diurnal Temperature Range (DTR).

A decreasing trend for TX10p (cold day times) with an increasing TX90p (warm day times) led to an increasing DTR (i.e. Mombasa, Lodwar, Makindu and Asmara/Djibouti).

Major outputs from Workshop 2: Regional model outputs for climate change impacts, vulnerability and adaptation studies - *Instiful, UNDP AAP*

The objectives of Workshop 2 were to:-

- introduce participants to the concepts and tools in regional climate modeling and analysis;
- provide hands-on experience on the use of tools, methods, data and model products in the CRM Modeling Toolkit;
- establish a community of practice on climate risk management for the IGAD region; and
- To bring together the relevant stakeholders to discuss the strengths and limitations of model results and their applicability to various sectors.

The methods/concepts/tools presented in this workshop can be applied to any time series data, but the focus of the workshop was mainly on the WMO hydro-climatic extreme indices based on Rclimdex.

The scope of the workshop included use of the knowledge acquired to undertake trend analysis of relevant extreme climatic indices for selected stations in each country, modeling and analysis of regional climates, statistical analysis and visualization of trends in climate extremes, introduction to the use of key tools such as Rclimdex, GIS visualization and methodology including trend analysis, quality control, validation, interpretation and application of model results to specific sectors. Examples of results obtained for the PRECIS model compared with observed data for Bole in Ethiopia is shown in Figure 10.

In general, the model results and the observed trends showed good agreement for the temperature-based indices. The model results and the observed trends for the precipitation-based indices were in less agreement than for temperature-based indices. More accurate and realistic results could be obtained by using re-analysis driven model data (e.g. ERA-40). Introduction of GIS was found to be a very useful tool for spatial-temporal representation of the climatic trends.

Generally reports from across the countries indicate signs of increased rainfall variability but reduction in amounts. Rising temperatures and prolonged droughts have been observed to be more frequent and severe.

Some significant challenges encountered during the workshop include:

- The workshop duration was too short to complete hands-on work. A longer duration (1.5 – 2 weeks) would enable participants to complete comprehensive country reports
- Generally the workshop was a success (beyond expectations) but more work still needed to be done
- There was insufficient data for adequate model validation

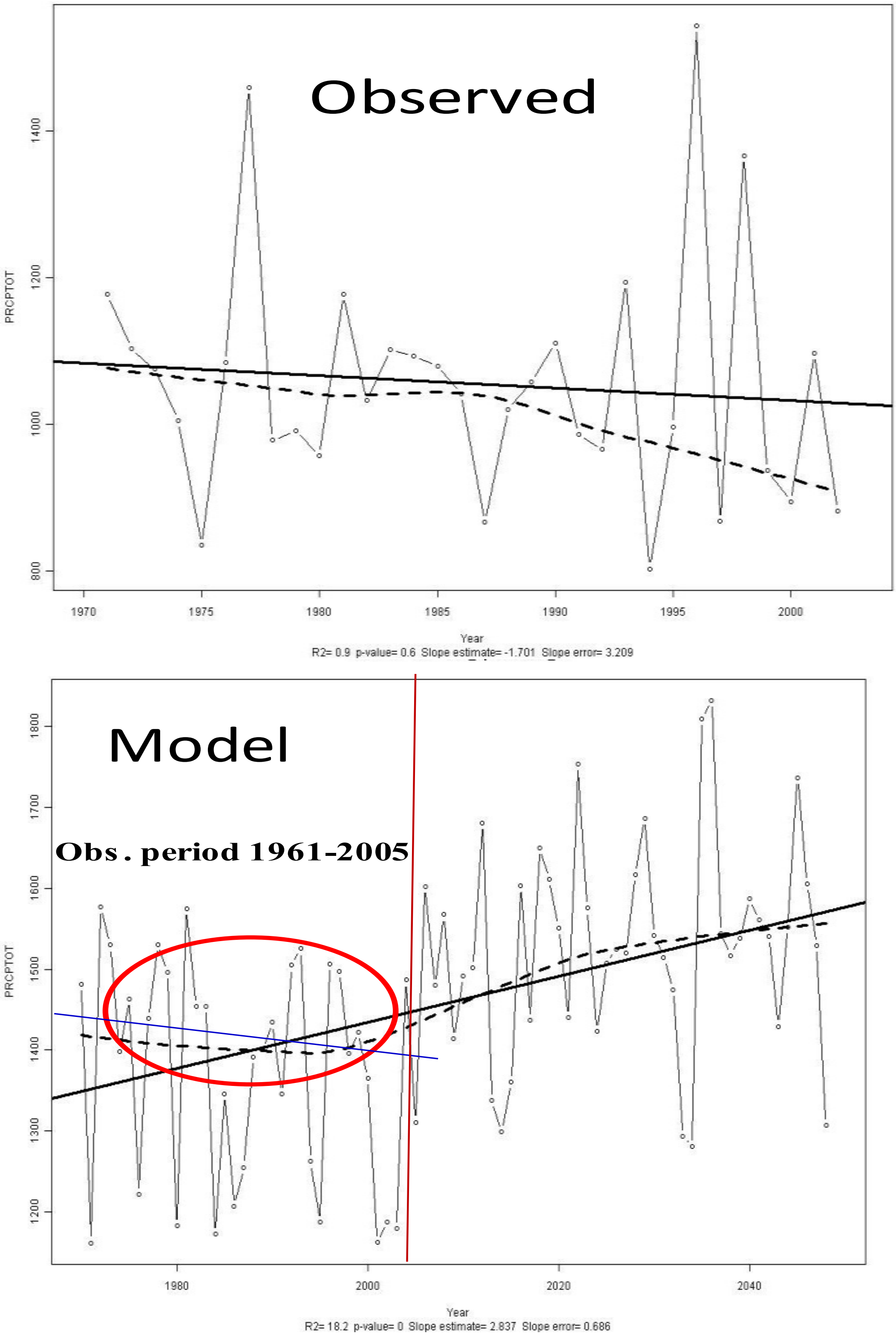

Figure 10: Comparison between model and observed data as represented by Bole, in Ethiopia.

Participants were very motivated and dedicated and would need further support/engagement, especially from their directors, to apply the knowledge acquired from the workshop. A community of practice on climate extremes analysis (CRM) was been established. The results of this workshop would be a major contribution to knowledge on climate change and application to decision making e.g. in the next IPCC assessment.

Recommendations for the workshop include:

- Adequate resources and enabling environment should be provided to support the community of practice
- Post-workshop activities should be undertaken to support in-country work
- There is a need a strong commitment and more resources from IGAD
- A need exists for data rescue and digitization
- WCRP and partners should sponsor a follow-up conference
- Participants should fully complete their country reports

During session two discussion, the participants were informed that regional climate model output will soon be available online from the Coordinated Regional Climate Downscaling Experiment (CORDEX) and were encouraged to use these outputs. The work from the two workshops were said to be a good beginning but a lot was still needed to be done. WCRP was requested to facilitate the completion of this exercise. It was agreed that the work from the two workshops be finalized and a refereed paper be published prior to the IPCC deadline in 2012 for submissions for AR5.

The workshop noted that NMHSs are still not free and willing to share data but they were encouraged to complete indices derivation and share the results with others.

Session Three: Impacts and vulnerability of the region to climate variability and climate extremes

Review of the ongoing La Nina and La Nina impacts atlas for the region – *Mutemi, ICPAC*

The seven post-La Niña events preceding March – May seasonal rainfall in the GHA region were reviewed. These were 1964/65, 1970/71, 1973/74, 1975/76, 1988/89, 1998/99 and 2007/2008. Analysis of recorded rainfall showed that four years recorded below normal rainfall (~57%), two years normal to below normal (~29%) and one normal (~14%) rains.

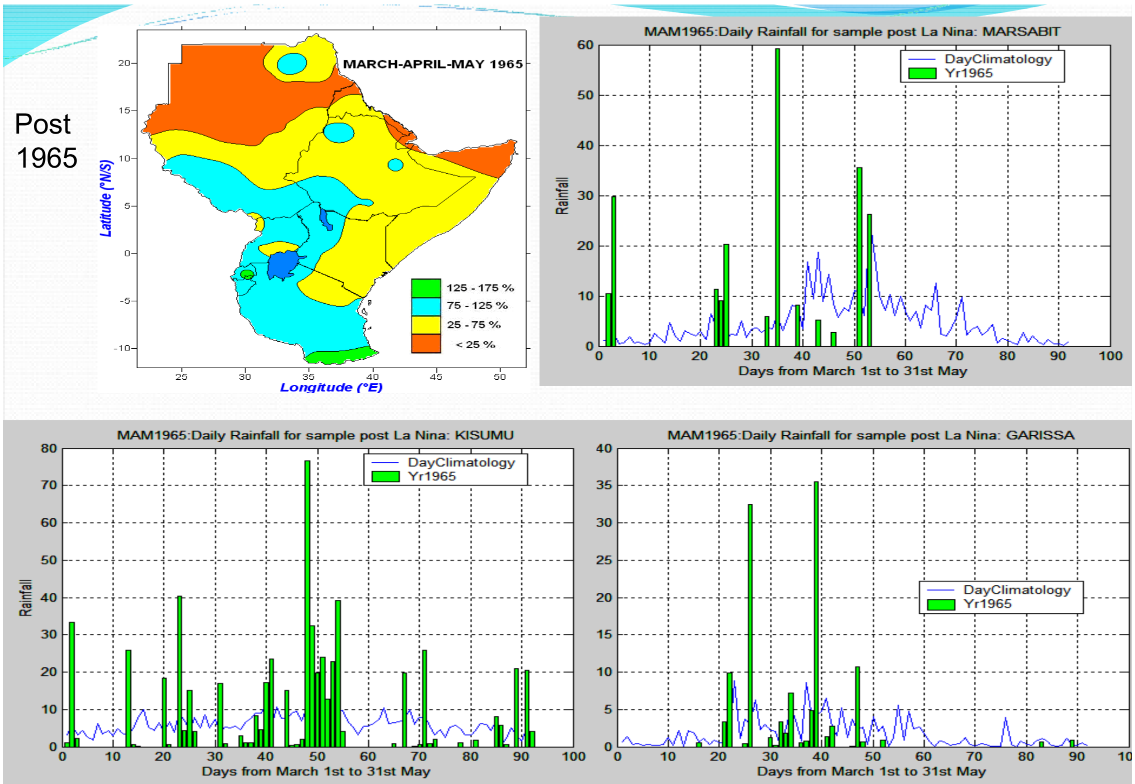

Figure 11: Post-La Niña events preceding 1965 March – May seasonal rainfall

The distribution of rainfall events, especially succession of wet and dry spells from these observations were good indicator for intra-seasonal characteristics including onset and succession of dry and wet events. Example of year 1965 was used to suggest that 2011 MAM rainfall will come and most likely cease early.

Economic vulnerability and impacts of disasters – examples from the region - *Dingel, World Bank*

There were 8,866 disaster events between 1975 and 2008 with estimated 2.28 million casualties worldwide and about US$ 1,528 billion losses in economic due to their impact. Some of the deadliest events worldwide included earthquakes and storms, while in Africa drought was the most prevalent. While high income countries incurred the highest costs from natural disasters, middle income countries suffered the greatest impacts in terms of the costs of disasters as a percentage of GNP.

Figure 12 shows example of a neighborhood in Benin caught by the rising waters during the recent floods.

Figure 12: Neighborhood in Benin caught by the rising waters during the recent floods

Africa's Disaster Profile shows that millions of people were affected by various disasters such as floods, droughts, volcano eruptions and storms during 1970 – 2009. Africa is particularly vulnerable to natural hazards, the majority of which are hydro-meteorological, due to the low resilience of its economies, the high dependence on rain-fed agriculture that is highly vulnerable to changes in seasonal rainfall and interannual variability, and the limited fiscal resources of many African countries. Droughts, in particular, have a severe impact on the economies and livelihoods.

With inadequate infrastructure, countries are not able to buffer their economies against climatic extremes (e.g., water storage capacity is limited in Africa, only 200 m3 per person/year) and to undertake rapid response and recovery. Critical infrastructure (e.g., schools, hospitals, roads) are often not constructed according to disaster resilient standards.

Few countries have institutions and policies in place that mainstreams disaster risk reduction (DRR) and thus must respond after the fact. There is only limited funding for DRM agencies (early warning, communication, and vehicles) and often a limited knowledge base too. Thus disasters can have both immediate and long term negative impacts, including damage to the stock of capital and human resources, drop in productivity due to disruption of infrastructure, and a need for increased spending on rebuilding, leading to higher fiscal deficits and/or inflation. Disasters also have greater impact on small and vulnerable economies (e.g. small island states, land-locked countries) than on large economies and those benefitting from international trade.

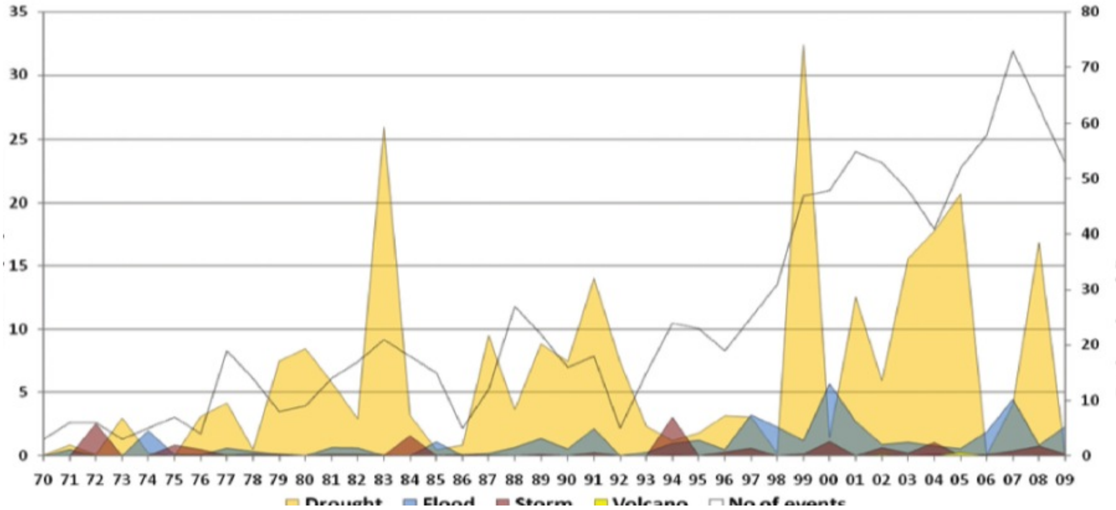

Figure 13: Africa's Disaster Profile (*World Bank 2005*)

Dr. Dingel stressed that "Prevention pays!", but that government expenditures on prevention are lower than those on relief. For example, in Bangladesh, modest sums spent on cyclone shelters, early warning systems and preparedness were more (cost) effective than embankments, while in Madagascar, construction norms for cyclone resilient houses that can withstand winds of 266 km/h were only 14 % higher construction costs.

To foster prevention, governments will need to:

- Make hazard information more accessible (e.g. open source platforms);
- Provide adequate infrastructure and services;
- Have optimal land use and markets to limit exposure to hazards;
- Have well performing and managed institutions.

Donors also need to recognize the need for prevention and provide a greater percentage of their support for prevention (only 0.7 % of humanitarian budgets are spent on prevention).

Session Four: Cooperation between climate scientists and humanitarian and develop policy makers

Strengthening two-way dialogue between climate scientists and humanitarian and development policy makers to enable more effective use of climate science: *Visman, Humanitarian Futures Programme King's College*

Ms. Visman noted the important ways in which science and technology can directly improve the prevention, preparedness and response capacities of humanitarian and development organisations. This requires direct, sustained and collaborative partnerships and dialogues between the humanitarian and development end users and the climate scientists. Only through such ongoing, two-way dialogue can the former know what questions to ask of emerging climate science, and the latter understand how climate data can better inform specific decision making processes. This dialogue should also enable both to have a greater appreciation of each others' needs and objectives, and so address the current disconnect between the outputs of climate research and practitioners' awareness and appropriate application of these outputs. For example, when applied to specific humanitarian and development decision making processes, the level and nature of uncertainty within the climate data may lie within their decision making thresholds. Many things are uncertain (military campaigns, economic forecasts), so a climate prediction may be no more uncertain than the wide range of other factors which inform specific decision making processes.

HFP works with a range of partners including ECOWAS, USAID, UN country teams in CAR, Comoros, Philippines and Ecuador, as well as head offices, and international and national governmental and non-governmental organizations and networks. HFP employs future planning tools; develops innovative approaches and adapts tools from other sectors including the corporate, military and scientific sectors.

A research study conducted in Kenya showed a clear correlation between opinions on the quality of climate information and the extent to which it was used, particularly visible amongst NGOs. Once people used climate information more and understood it better, particularly when facilitated by closer communication with the Kenya Meteorological Department, they found it to be of much better quality than previously considered, while those who still did not use it regularly tended to be a lot more critical.

In identifying funding for the dialogue, there has been a lot of money invested in climate science and a lot invested in humanitarian, disaster risk reduction and climate change adaptation work, but little resources identified to ensure that the ensuing work is appropriately informed by climate science.

The information humanitarian agencies require to promote two-way dialogue include daily climate information; start and end dates of rains, total amount and variation within the season; more specific seasonal forecasts; 5/10 day seasonal updates to fine tune decisions. Increase of flooding, pastoralists need to relocate to safer places. Blending community indicators (Indigenous Knowledge) with science increases their understanding of the scientific basis of these risks; a blended forecast also increases farmers' confidence in climate science especially if it tells farmers about longer-term change.

Making information accessible to end users requires that it be in relevant formats and go through appropriate channels if, for example, the seasonal forecast is to be understood and translated into relevant actions by humanitarian and development end users.

More effective use of climate information through two-way dialogue thus requires converting information into knowledge for wider applications. It helps humanitarian and development end users 'own' uncertainty and identify relevant and trusted channels of dialogue. It is also useful in evaluation of relevant use of climate information and assesses its economic value to support the development with no regrets options.

Session Five: Integration of climate information into decision making and familiarization with decision tools

Roles of WMO lead climate centers – *Yun, KMA*

In 2006, WMO began a process to designate centres making global seasonal forecasts as WMO Global Producing Centres (GPCs) for Long Range Forecasts, as an integral part of its Global Data-Processing and Forecasting System (GDPFS). Through this designation process, GPCs adhere to certain well-defined standards – aiding consistency and usability of output:

- a fixed forecast production cycle
- a standard set of forecast products
- WMO-defined verification standards (for retrospective forecasts)

A comprehensive set of standard verification measures, with which to communicate the skill of forecasts, has also been defined (the WMO Standard Verification System for Long-Range Forecasts – SVSLRF). The following are GPC products provided as minimum requirement:

- Predictions for averages, accumulations, or frequencies over 1-month periods or longer; typically, anomalies in 3-month-averaged quantities is the standard format for seasonal forecasts. Forecasts are usually expressed probabilistically
- Lead time: between 0 and 4 months
- Issue frequency: monthly or at least quarterly
- Delivery: graphical images on GPC website and/or digital data for download
- Variables: 2m temperature, precipitation, sea-surface temperature (SST), MSLP, 500hPa height, 850hPa temperature
- Long-term forecast skill assessments, using measures defined by the SVSLRF

Table 1: Designated WMO Global Producing Centres

GPC name	Centre	System Configuration (ensemble size of forecast)	Resolution (atmosphere)	Hindcast period used
Beijing	Beijing Climate Centre	Coupled (48)	T63/L16	1983-2004
CPTEC	Centre for Weather Forecasts and Climate Studies	2-tier (15)	T62/L28	1979-2001
ECMWF	European Centre for Medium Range Weather Forecasts	Coupled (41)	T159/L62	1981-2005
Exeter	Met Office Hadley Centre	Coupled (42)	1.25°x1.85°/L38	1989-2002
Melbourne	Australian Bureau of Meteorology	Coupled (30)	T47/L17	1980-2006

Montreal	Meteorological Service of Canada	2-tier (40)	T32/T63/T95/2.0°x2.0° (4- model combination)	1969-2004
Seoul	Korean Meteorological Agency	2-tier (20)	T106/L21	1979-2007
Tokyo	Japan Meteorological Agency	Coupled (51)	T95/L40	1979-2008
Toulouse	Météo-France	Coupled (41)	T63/L91	1979-2007
Washington	National Centres for Environmental Prediction	Coupled (40)	T62/L64	1981-2004
Moscow	Hydromet Centre of Russia	2-tier (10)	1.1°x1.4°/L28	1979-2003
Pretoria	South African Weather Service	2-tier (6)	T42/L19	1983-2001

The goal of the Lead Centre is to provide a conduit for sharing model data for long-term climate predictions and to develop a well-calibrated Multi Model Ensemble (MME) system for mitigating the adverse impact of unfavorable, or to maximize the benefit from favorable climate conditions.

Functions of the WMO Lead Centre for Long Range Multi-Model Ensemble (LC-LRFMME):-

i. Maintains a repository of documentation for the system configuration of all Global Producing Centre Long Range Forecast (GPC LRF) systems
ii. Collects an agreed set of forecast data from GPCs
iii. Displays Global Producing Centre (GPCs) forecasts in a standard format
iv. Promotes research and experience in MME Techniques and provides guidance and support on MME techniques to GPCs, RCCs and NMHSs
v. Generates an agreed set of Lead Centre products
vi. Redistributes digital forecast data for those GPC's that allow it
vii. Handles requests for the website password and data distribution
viii. Provides probabilistic LRF for WMO Global Seasonal Climate Updates (GSCUs)

The 12 GPSs designated by WMO are shown in table 1 and their global position in Figure 14.

Figure 14: Designated WMO Global Producing Centres

Operational Activities for LRF, both dynamical and statistical, within the range of 1 month to 2 year timescale, based on regional needs include interpretation and assessment relevant LRF products from Global Producing Centres (GPCs), distribute relevant information to RCC Users and provide feedback to GPCs.

RCOFs bring together national, regional and international climate experts, on a regular basis, to produce regional climate outlooks based on input from global and regional producers of climate information as well as from NMHSs of the region concerned. The RCOF mechanism addresses regions of common climate characteristics; ensures consistency in access to, and interpretation of, climate information. It also facilitates close user interaction to jointly assess the likely implications of the outlooks. It further provides training on long-range forecasting, communication etc.

As part of Africa Assistance projects, the Korea Meteorological Administration (KMA) signed memorandum of understanding (MoU) on meteorological cooperation with the Intergovernmental Authority on Development (IGAD) Climate Prediction and Application Centre (ICPAC). Education Program for African Countries will involve improvement of Meteorological Disaster Responsiveness for African Countries. Other areas of cooperation will include Capacity Building in Seasonal Forecast and Climate Prediction, Climate Data Control and Rescue, High-Impact Weather Forecasting and Climate Adaptation Policy.

Integration of Climate Information into Decision Making: Consensus Approaches – *Kolli, WMO CASP*

Climate information is of little value unless it influences decision making. Recently climate scientists have rediscovered risk management as a key concept. While *Uncertainty* has been equated to randomness with unknowable probabilities, *Risk* on the other hand has been likened to randomness with knowable probabilities.

Adaptation is defined as "the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities" (IPCC 2007). People try to adapt within the bounds of a known climate. Historic climate records are as important as climate predictions/projections to guide adaptation.

Challenges of Climate Adaptation in Africa include insufficient monitoring and observation systems; lack of basic information; settlements in vulnerable areas; lack of appropriate political, technological and institutional framework; lack of capacity due to low income among others. Climate adaptation therefore require inputs from Climate Information (Historical Data on Variability and Change, Climate Predictions, Climate Scenarios etc); Sectoral Information (Technological options Supply demand situations); Physical Information (Geophysical information Social development scenarios); and Economic Information. This is schematically represented as Climate Information Value Chain shown in Figure 15.

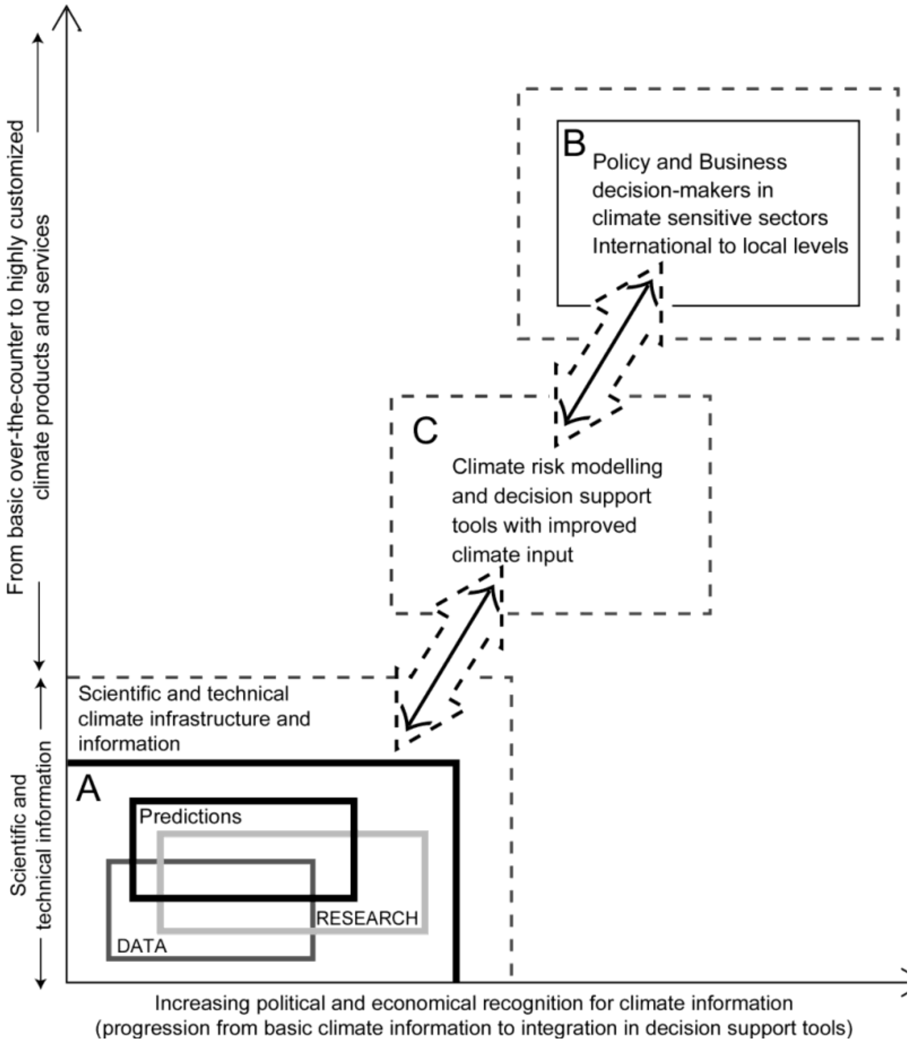

Figure 15: Schematic diagram on Climate Information Value Chain

Climate-related Risk Management works best if it is driven by the needs and requirements expressed by relevant decision sectors developed within real-world decision contexts. It is effective if enabled through facilitating institutions and policies based on environmental, sectoral and socioeconomic data. When based on tailored climate information supported by local capacity the decision can easily be included in planning strategies that incorporate incentives supported by sector-specific services from National Meteorological and Hydrological Services and related institutions.

WMO Initiative to Support Climate Change Adaptation was endorsed by WMO Executive Council in June 2008. The goal was to facilitate provision of user-oriented climate information, products, advisories and services to support national and regional climate risk assessment, climate adaptation planning and implementation practices for sustainable development. The objectives were to facilitate use of climate information for mainstreaming climate risks in decision making; to make available data and information for developing adaptation strategies and integrating them in national development agendas; enhance the national capacities in provision of user-oriented climate information; help develop regional capacities and support the scientific foundation for climate adaptation strategies.

RCOFs worldwide have been set up so far with the main focus on seasonal prediction. However, the same RCOF mechanisms can be effectively expanded to cater to the needs of developing and disseminating regional climate change information products. Such initiatives are already being taken up by some RCOFs. Regional assessments of observed and projected climate change, including the development of downscaled climate change scenario products for impact assessments, can be included in the RCOF's product portfolio. RCOFs have been recognized for their potential contributions to the UNFCCC/SBSTA Nairobi Work Programme (NWP) on Adaptation to Climate Change. CLIPS/RCOFs have been included in the UNFCCC Compendium of Methods and Tools in support of climate adaptation. RCOFs therefore form a core component of WMO Action Pledge to the NWP on climate information, products and services for adaptation.

Besides RCOFs, Climate Watch System can also be seen as an addition to an NMHS's climate prediction system. The aim of climate watches is to enable an end user to take action to minimize the effects of an expected adverse climate-related impact, rather than simply reacting to an observed climate anomaly. A Climate Watch could use climate outlooks generated by RCOF, but must be a proactive alert of impending unfavourable climate anomalies specifically focused on the end user. NMHSs participating in RCOF may consider how the results of the RCOF in their region can be integrated into the Climate Watches issued by the NMHSs and/or associated regional climate institutions.

RCOF Processes for Regional Climate Change entails a framework to use the RCOF platform to generate regional climate change information products. It also provides a platform for capacity building of climate providers and users besides developing common understanding and consistency in regional climate change assessments. Others include development of incubation projects, sharing of experiences and cascading into regional approaches and strategies. User liaison and integrating user feedback are integral parts of the process. User perspective on the value of climate change products in decision making for adaptation planning and buy-in is a significant input during the RCOF process.

Areas addressed during RCOFs include adequacy of existing information on regional climate change; Gaps in current knowledge and ways to address them; Needs for infrastructure development, role of sub-regional entities and NMHSs in contributing to coordinated development of regional climate change products.

It is important to find ways for all countries to cope with climate variability through improved access to climate information and prediction products and the use of risk management techniques. Location-specific information is crucial; downscaling sector-relevant climate products and ownership of the process is important. Better informed regional and national vulnerability assessments as well as development and validation of modelling tools to support decision making are key.

Climate services will require a clearly articulated demand by users for 'specific products' such as more targeted, rather than general, indices. It is essential to provide probabilistic rather than single value forecasts. Sectors need to have their 'champions' who can systematically identify and analyze existing leverage points for climate information and communicate/discuss this with climate experts. There is dire need for mutual recognition that climate is only one of the many risk factors that decision makers need to consider. The challenge is to integrate these risk factors for effective decision-making.

In conclusion, it is important to consider establishing a regular process that enables timely updates including the ability to take corrective action as new information emerges. RCOFs should thus be used as a means to design and manage the process and particularly the communication between multiple producers and users in light of the different needs for practitioners and policy clients.

Overview of Regional climate change scenarios past and future (IPCC methodologies) – *Odingo, University of Nairobi*

In 1992, the IPCC released six "emission scenarios" providing those working on climate change with alternative emission trajectories for the period 1990-2100 for greenhouse related gases, namely CO2, CO, CH4, N2O, NOx, and SO2. These scenarios to be used by scientists for the preparation of future scenarios of atmospheric composition became known as IS92 Scenarios. IS92 Scenarios were path-breaking in being the first global scenarios to provide estimates of the full suite of greenhouse gases. They were also the first to provide emission trajectories for Sulphur emissions which are important for radiative forcing, and are associated with atmospheric cooling rather than warming.

Beyond IS92 there was need for better scenarios with broader uses and regional based that was capable of driving climate models. There was a demand for scenarios which were not only broader, but also open to the research community. For post IS92 future scenarios II to be more relevant to the research community, key input assumptions were reviewed and provided to modelers. The modelers constructed emissions scenarios based on the input assumptions provided and results to be used to develop scenarios from a representative model.

A scenario is a coherent, internally consistent, and plausible description of a possible future state of the world. Scenarios are commonly required in climate change impact, adaptation and vulnerability assessments to provide alternative views of future conditions considered likely to influence a given system or activity. Scenarios are images of the future, or alternative futures. They are neither predictions nor forecasts. Rather each scenario is one alternative image of how the future might unfold.

Key input assumptions are Population projections, Technological change, Geographical reporting regions and years together with units of measurement. Data sources for Scenario Building include population; economic development; energy production and consumption; mitigation of climate change; concentrations levels of greenhouse gases in the atmosphere; temperature increase levels arising from the socio economic assumptions.

Scenario baselines consist of a projected level of future emissions against which reductions by project activities could be determined. Base Year- is a common year for calculating emission inventories, or to begin model simulations for future scenarios. The basic scenario question is "how will the world climate change in this century (i.e., up to 2100). IPCC (2007) Working Group III Report comments about drivers of emissions captured in baseline scenarios as dynamic processes influenced by demographic and socio-economic development, as well as technological and institutional change. Of special relevance are energy intensity, and carbon intensity of energy consumption which are non-intervention scenarios.

Scenario building examples are socioeconomic, land use and environmental scenarios, sea level rise scenarios, climate scenarios and scenarios of the 21st century. Users of the new scenarios are climate change impact modelers, impact assessment analysts and other users. Once the modeling teams have completed their work, a set of scenarios will then be chosen as a representative model in terms of inputs or an average model for the creation of derivative scenarios.

SRES Scenarios were employed for AR3 and AR4 of the IPCC, and whereas they served their purpose, it was concluded that for broader uses than simple emission trajectories to drive climate models, new scenarios are required. It was agreed that IPCC would no longer issue its own scenarios after SRES.

Figure 16 shows comparison of population assumptions in post-SRES emissions scenarios with those used in previous scenarios Blue shaded areas span the range of 84 population scenarios used in SRES or pre-SRES emissions scenarios; individual curves show population assumptions in 117 emissions scenarios in the literature since 2000. The two vertical bars on the right extend from the minimum to maximum of the distribution of scenarios by 2100. The horizontal bars indicate the 5th, 25th, 50th, 75th, and the 90th percentiles of the distributions.

In 2006 the IPCC decided that rather than directly coordinating and approving new scenarios itself, the process of scenario development should now be coordinated by the research community. Using a series of benchmark emission scenarios (also known as "Representative Concentration Pathways [RCPs]"), the research community would give leadership in producing scenarios some of which would be available for the fifth assessment report (AR5).

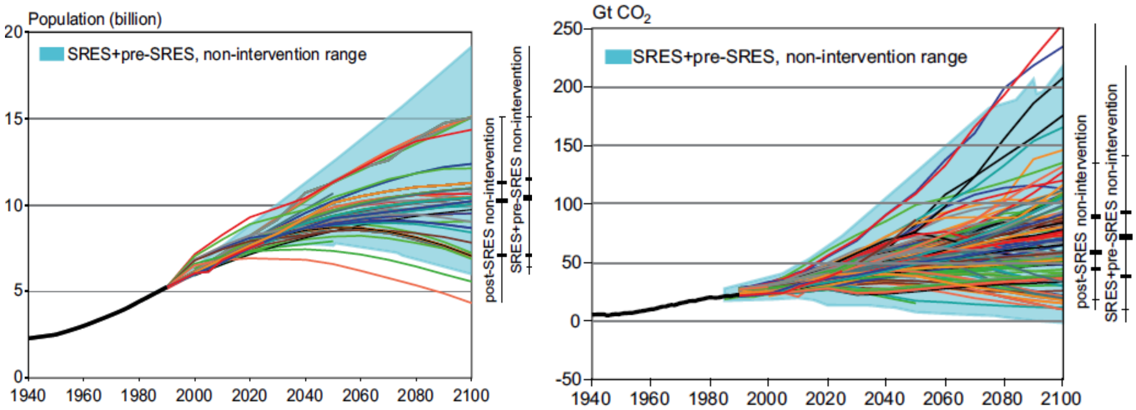

Figure 16: Comparison of population assumptions in post-SRES emissions scenarios with those used in previous scenarios (*Data source: After Nakicenovic et al., 2006*).

The RCPs will be used to initiate climate model simulations for developing climate scenarios for use in a broad range of climate-change related research, and assessment. They were to be compatible with the full range of stabilization, mitigation, and baseline emission scenarios available in the current scientific literature. A decision was made to include developing countries and CETs in the new scenario effort. End users targeted were policy, decision makers and other intermediate users.

There was a choice between the sequential approach, and the parallel approaches to scenario development. The sequential approach would start from emissions and socio-economic scenarios, and end with IAV. In contrast, the parallel approach would start with RCPs and levels of radiative forcing, move on to IAMs and CMs, and end up with impacts, adaptation and vulnerability and mitigation (Figure 17).

IPCC suggested ways to reduce the computational requirements in scenario development by proposing a limited number of scenarios for climate modeling. It is not clear if the results of scaling different AOGCM will be comparable to full AOGCMs designed to achieve similar outcomes. Improved analysis of IAV at regional and sub-regional scales will be required for improved analysis. Regional narrative story lines will be necessary in future for a more satisfactory understanding of climate at the regional and local scales.

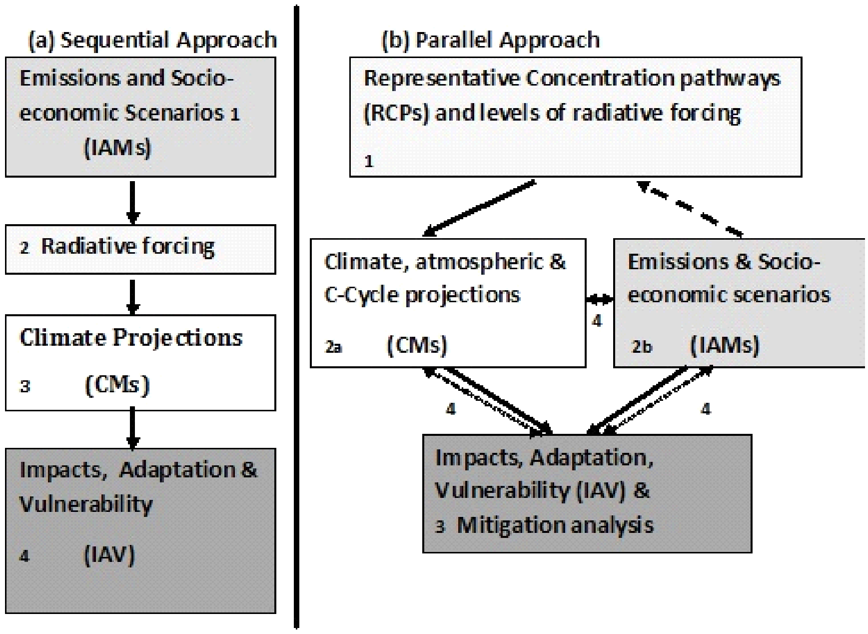

Figure 17: Approaches to the Development of New Global Scenarios

Use of climate change projection scenarios in the development of regional adaptation strategies – A Case Study for the Hydrology of Lake Victoria– *Semazzi, NCSU*

Lake Victoria is the source of White Nile. It directly supports over 30 million people with average economic productivity of between $3-4 billion per year. It also provides water and hydroelectric power; supports agriculture, trade, tourism, wildlife and fisheries among many others. It has undergone dramatic drop in level of approximately 10.69 meters lowest level since 1951 (Figure 18).

Nalubaale Dam (originally Owen Falls Dam) was the first major hydroelectric plant in Uganda, opened in 1959. Kiira Dam came online in 2000 while Bujagali dam (250 MW) is expected to be commissioned in October 2011. Muchison Falls and several other hydroelectric dams are in the planning phase. The flow of the White Nile and hydroelectric productivity of dams are primarily determined by Lake Victoria levels.

Climate change adaptation for the hydroelectric power industry over the Nile Basin in Uganda can be assessed by comparing the lake levels with the derived Lake Level Climate Index for 1961-1990. The model is validated based on differences between the Lake Level Climate Index (1961-1990) and model projections of the Lake Level Climate Index (2071-2100). Based on the results obtained, the hydroelectric power industry can developed adaptation strategies for projected climate change.

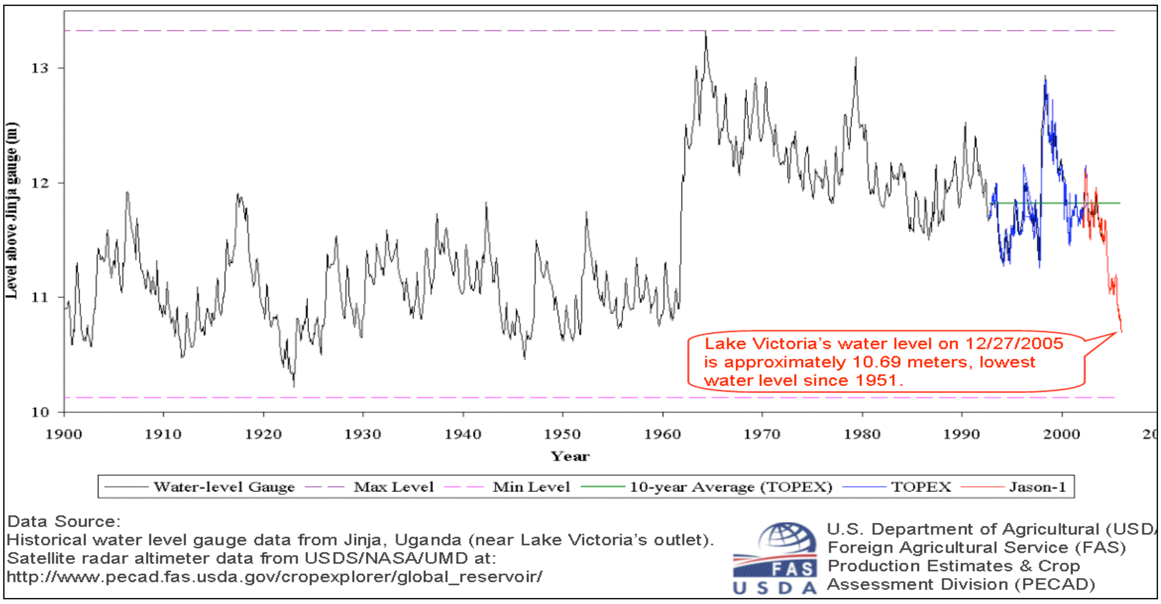

Figure 18: Historical water level of Lake Victoria since 1900

A suitable framework for assessing future performance of the hydroelectric energy industry in Uganda has been tested. The proposed step 'High Level' and 'Low Level" water release operation rule that assumes that the upper water outflow threshold based on the early 60s will result in flooding and will have to be revised. There is need to develop another operation rule (revised user defined thresholds) for more optimal adaptation to climate change. This will require close collaboration with sectoral expert's hydroelectric energy industry in Uganda.

Progress in climate change negotiations and roles of the NMHSs and regional centres, including brief on Cancun outcomes relevant to the region – *Nkalubo, PR of Uganda with WMO*

PR Nkalubo discussed the UNFCCC issues and negotiations since 2005.

During the tenth Conference of Parties (COP10), it was recognized that although adaptation and mitigation are mutual strategies, adaptation had not received adequate attention and therefore required a special focus. At COP 11 in Buenos Aires a five-year Programme of work on adaptation was initiated and then strengthened at COP11. This led at COP 12 to the Nairobi Work Programme (NWP) on impacts, vulnerability and adaptation to climate change (NWP) to improve the techniques for assessing the vulnerabilities to and adaptation strategies for the impacts of climate change on developing countries.

The discussions were informed and guided by the IPCC-AR4 and the Stern Review on the economics of climate change among others. The AR4 called for urgent actions and deeper GHG emission cuts to avert catastrophic impacts of climate change. The Stern's review concluded that climate change is manageable within the resources of the international community but added that "delay to take action now will significantly increase the costs of combating climate change".

Leading up to COP13, there was general consensus on the need for deeper greenhouse gas emission cuts and urgent actions to tackle climate change. The negotiations focused on the status of the climate change regime, the economic case for action, sustainable development, adaptation, technology transfer and financing. Parties observed that technology and financing play pivotal roles in mitigation of greenhouse gases as well as tackling adaptation in developing countries. These negotiations however did not lead to a formal agreement but resulted in Bali Action Plan (BAP), adopted at COP13 (2007), to establish a comprehensive process (Bali Roadmap) for enhanced future action on implementing the Convention and seeking further commitments by Parties after the expiration of the Kyoto Protocol. The BAP includes:

- Ad Hoc working group on long term cooperative action (AWG-LCA) to focus on key elements of long term cooperation, including mitigation, adaptation, technology transfer and financing. Its outputs were to be presented at COP15
- Ad Hoc Working Group on Further Commitments for Annex I Parties under the Kyoto Protocol (AWG-KP)

However, COP15 in Copenhagen did not yield the much desired and anticipated concrete legally binding outcome, but instead a political outcome, the Copenhagen Accord, was reached wit a majority of countries associating with it. The Copenhagen Accords extended the work of the AWGs (AWG-KP & AWG-LCA) in hope of reaching concrete outcomes at COP16 in Cancun. The toughest challenge was for the Annex 1 (developed) countries as the biggest emitters to agree to concrete GHG emission reduction targets during the Second Commitment and subsequent periods in line with the IPCC recommendations. Annex I Parties are now proposing a pledge-based approach but these pledges fall below the scientifically recommended targets. Some Annex 1 Parties are strongly opposed to continuity of the Kyoto Protocol, i.e. they want to "kill" it. Instead such developed countries favour the GHG emission pledge based approach under the Copenhagen Accord. USA is one such country that is not a Party to the KP but is in favour of the provisions of the Accord.

Within the negotiations the key shared issues include:

Vision: Integrated shared vision covering all elements of Bali Action Plan with a set of science-based global goals and limits use of unilateral measures.

Adaptation: Institutional framework on adaptation including executive body; Adaptation fund, Adaptation programme, mechanism to address loss and damage together with compliance mechanism.

Mitigation: Annex I emission reductions of 45% by 2020 from 1990 levels under Kyoto Protocol and comparable efforts by non-Kyoto Annex I Parties under the Convention, and reductions of 95% by 2050 from 1990 levels. Non-Annex I countries was required to take NAMAs enabled by technology, finance and capacity; voluntary with no-offsetting; mechanism to register and ensure MRV.

Finance: At least 1.5% Annex I GNP, $400 billion in fast-track ($150 as SDRs), multilateral climate fund and compliance mechanism.

Technology: Technology mechanism, compliance and cooperation on joint development of technologies (addressing IPRs).

Capacity: Capacity building mechanism.

Reducing Emissions from Deforestation and Degradation (REDD+): including forest conservation and sustainable management as well as enhancement of carbon stocks.

On the status of the negotiations, Parties agreed to implement the Convention and its Kyoto Protocol through the two-tracks of the Bali Roadmap, i.e., through AWG-KP and AWG-LCA. The REDD+ discussions have made some reasonable progress on mitigation, while the AWG-LCA has achieved some progress on response measures and on some elements of the Shared Vision, Adaptation, Technology Transfer, Finance and Capacity Building.

According to analysis of the pledges, Annex I emissions could increase by up to 6% by 2020 from 1990 levels with a 50% chance that warming will exceed 3 degrees Centigrade. Pledged levels for financing ($30 billion to 2012, and $100 billion by 2050) are inadequate. There are Risks of major “taking” of Earth’s remaining carbon budget without adequate financing and technology for developing countries, and for catastrophic impacts to Africa. These are so far some of the major developments in the negotiations.

The 2010 meeting of the United Nations Framework Convention on Climate Change (UNFCCC) was held in Cancún, Mexico from 29 November to 10 December 2010, officially referred to as the 16th session of the Conference of the Parties (COP 16) to the UNFCCC and the 6th session of the Conference of the Parties serving as the meeting of the Parties (CMP 6) to the Kyoto Protocol. In addition, the two permanent subsidiary bodies of the UNFCCC – the Subsidiary Body for Scientific and Technological Advice (SBSTA) and the Subsidiary Body for Implementation (SBI) held their 33rd sessions. The 2009 UNFCCC extended the mandates of the two temporary subsidiary bodies, the Ad Hoc Working Group on Further Commitments for Annex I Parties under the Kyoto Protocol (AWG-KP) and the Ad Hoc Working Group on Long-term Cooperative Action under the Convention (AWG-LCA). They met at COP16 as well.

Following the non-binding 2009 Copenhagen Accord, international expectations for the COP16 conference were reduced. Four preparatory rounds of negotiations (i.e. sessions of the AWG-KP and the AWG-LCA) were held during 2010. In August 2010, Ban Ki-Moon stated that he doubted whether member states would reach a new global agreement to address global warming but after the Tianjin talks in October, Christiana Figures, the UNFCCC executive secretary and other commentators spoke of a positive spirit of negotiation and of paving the way for agreement in Cancun.

The outcome of the summit was an agreement, though not a binding one, that climate change represents an urgent and potentially irreversible threat to human societies and the planet and thus requires to be urgently addressed by all Parties. It also affirmed that climate change is one of the greatest challenges of our time and that all Parties share a vision for long-term cooperative action in order to achieve the objective of the Convention, including through achievement of a global goal. It recognized that warming of the climate system is unequivocal and that most of the observed increase in global average temperatures since the mid twentieth century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations, as assessed by the IPCC in its Fourth Assessment Report. It further recognized that deep cuts in global greenhouse gas emissions are required, so as to hold the increase in global average temperature below 2°C above pre-industrial levels. The meeting called on rich countries to reduce their greenhouse gas emissions as pledged in the Copenhagen Accord and for developing countries to plan to reduce their emissions too.

The agreement included a "Green Climate Fund," proposed to be worth $100 billion a year by 2020, to assist poorer countries in financing emission reductions and adaptation. Cancun Adaptation Framework and the Adaptation Committee be established with mandate to invite Parties to strengthen and, where necessary, establish regional adaptation centres and networks. It also noted that an international centre to enhance adaptation, research and coordination be established in a developing country.

On mitigation, developed countries should submit annual greenhouse gas inventories and inventory reports and biennial reports on their progress. It was agreed that developing country Parties will take nationally appropriate mitigation actions in the context of sustainable development, supported and enabled by technology, financing and capacity-building, aimed at achieving a deviation in emissions relative to "business as usual" emissions in 2020. The meeting decided to set up a registry to record ‘nationally appropriate mitigation’ actions seeking international support and to facilitate matching of finance, technology and capacity-building support to these actions. Once support has been provided they are called internationally supported mitigation actions (ISMAs) that will be subject to international measurement, reporting and verification.

On finance, the collective commitment by developed countries to provide new and additional resources, including forestry and investments through international institutions, approaching USD 30 billion for the period 2010-2012 was reaffirmed. It recognized that developed country Parties commit, in the context of meaningful mitigation actions and transparency on implementation, to a goal of mobilizing jointly USD 100 billion per year by 2020 to address the needs of developing countries. It decided to establish a Green Climate Fund, to be designated as an operating entity of the financial mechanism of the Convention.

On technology development and transfer, it decided to establish a Technology Mechanism, which will consist of a Technology Executive Committee and a Climate Technology Centre and Network. The Climate Technology Centre and Network and the Technology Executive Committee shall relate so as to promote coherence and synergy. Executive Committee shall further implement the framework of the Convention (technology transfer framework) and Committee shall comprise 20 expert members. The Climate Technology Centre shall facilitate a Network of national, regional, sectoral and international technology networks, organizations and initiatives.

It reaffirmed that capacity-building is essential to enable developing country Parties to participate fully in addressing the climate change challenges, and to implement effectively their commitments under the Convention.

The Outcome of the work of the Ad Hoc Working Group on Further Commitments for Annex I Parties under the Kyoto Protocol at its fifteenth session recognizes that the contribution of Working Group III to the Fourth Assessment Report of the IPCC, to achieving the lowest levels would require Annex I Parties as a group to reduce emissions in a range of 25-40 per cent below 1990 levels by 2020 (close to the 51% reduction in a low-carbon society). It urged Annex I Parties to raise the level of ambition of the emission reductions to be achieved. In the second commitment period, the base year shall be 1990 while the global warming potentials shall be those provided by the IPCC.

The Cancun Agreements recognize the need to strengthen international cooperation and expertise to understand and reduce loss and damage associated with the adverse effects of climate change, including impacts related to extreme weather events and slow onset events. They also call for a possible development of a climate risk insurance facility to address impacts associated with severe weather events. Under the Cancun Adaptation Framework (CAF), Parties are invited to enhance climate change related disaster risk reduction strategies, taking into consideration the Hyogo Framework for Action2 where appropriate; early warning systems; risk assessment and management; and sharing and transfer mechanisms such as insurance, at local, national, sub-regional and regional levels, as appropriate.

Under the CAF, there is also emphasis for strengthening data, information and knowledge systems, education and public awareness; and improving climate-related research and systematic observation for climate data collection, archiving, analysis and modelling in order to provide decision makers at national and regional levels with improved climate-related data and information.

The roles of NMHs in climate change science include monitoring the melting ice/glaciers and their impacts, levels of rivers and streams, sea level rises, frequency of El Niño/ La Niña, and studies on trends in meteorological parameters. Other roles include monitoring, detection, attribution and prediction of climate change using Scenario Models. The outcomes in monitoring help in adaptation, in strengthening Early Warning Systems at NMHSs, in the timely forecasting of severe weather and extreme climate events. NMHSs have to collaborate with Global and Regional centres to keep abreast with technology development and in use of products from super computers and satellites. NMHSs should support the NAPAs by providing necessary information useful for adaptation. This will require the strengthening of the NMHSs to meet these national needs.

The roles of NMHSs in meteorological infrastructures are:-

- Data Observational systems and network;
- Data telecommunication systems and network;
- Data procession, analysis and forecasting systems;
- Product and information dissemination systems;
- Human resource capital

Climate change mitigation and adaptation is a development issue, and Members of Parliament (MPs) are involved with development issues at constituency levels. NMHSs have the responsibility of sensitizing the Members of Parliament on matters of climate change. They are also involved in policy formulation that is also linked to planning and sustainable development and at the same time may participate in decision making at international meetings like COP.

They have to collaborate with Universities in research and take into account existing coping strategies at the grassroots level, and build upon them to come up with local technology.

The Regional centres on the other hand bring together scientists from member countries with varying ideas to come out with a single negotiated regional position. They provide capacity building development for both climate scientists and users on climate risk screening and development of tools and methods for coping with climate variability and adapting to climate change including the role of indigenous knowledge. Others are pioneering the Regional Climate Outlooks which are attended by climate scientists, policy makers, users and the media where outcomes from international meetings like the COP can be discussed and actions formulated.

Session Six: Development of adaptation strategies for the agriculture and water sectors

Adaptation strategies in water resources – *Kizzy, TANESCO*

Tanzania is endowed with many economically important river and lake basins with the major river basins being Rufiji, Pangani, Ruvu, Malagarasi, Kagera, Mara, and Ruvuma, and the major lakes being Victoria, Tanganyika, Nyasa, Rukwa, Eyasi and Natron. In addition to being economically significant, these river basins are also important in sustaining the daily livelihood of the local communities through fishing and traditional farming irrigation systems.

Climate change is projected to have both positive and negative consequences for Tanzania water resources. The Ruvu-Wami Basin is the major water supply Dar es Salaam, Tanzania's major population centre. The Pangani Basin supplies water to the Tanga, Kilimanjaro, and Arusha regions besides supporting a number of economically important activities (irrigation schemes and hydropower stations). The Rufiji Basin, the largest catchment in Tanzania, is economically important to the nation for the hydropower it generates at Mtera, Kidatu and Kihansi hydropower stations (greater than 80% of total HEP) and has the largest hydropower potential site (greater than 3000 MW). It also supports a number of irrigation projects, supplies water and has a delta.

Figure 19: Tanzania Water Resources Map

The Kagera and Malagarasi Basins host a number of hydropower potential sites and support a number of economic activities including water supply and irrigation projects. The Lakes supports the livelihoods of a large population by providing fishing, water supply and transport. Stream flows are projected to decline in the Ruvu, Wami, Pangani and Rufiji rivers, but are projected to increase in the Kagera and Malagarasi rivers. Thus in adaptation planning should consider not only the adverse impacts but also seek to harness positive opportunities.

The National Action Plan on Climate Change for Tanzania was developed in 1997 and has different objectives for various timeframes:-

Short term program (Year 1 - 2) – would undertaken efforts to raise awareness of possible impacts stemming from climate change on various social and economic activities.

Medium term program (Year 2 - 5) – would develop and support projects that internalize climate change aspects, especially those reducing GHG emissions and in addition, would include climate change aspects in the educational curriculum, preferably starting at secondary school level.

Long term program (Year 10 - 20) – would undertake large projects in the energy and transport sector and in addition, implement adaptation measures to cope with a rising sea level and its adverse effects on coastal infrastructure.

The NAPA identifies climate change related vulnerabilities of key economic sectors, which form the basis of the livelihood of the rural community and the backbone of national development and prosperity. Project activities initiated include:-

- Water efficiency in crop irrigation to boost production and conserve water in all areas.
- Farming systems and water harvesting
- Development of alternative water storage programs and technology for communities
- Community based conservation and management programs for catchments
- Explore and invest in alternative clean energy sources e.g. wind, solar, biodiesel, etc. to compensate for lost hydropower potential
- Promotion of application of cogeneration in the industry sector for lost hydropower potential.
- Development community forest fire prevention plans and programmes
- Establishing and Strengthening community awareness programmes on preventable major health hazards
- Implementation of sustainable tourism activities in the coastal areas and relocation of vulnerable communities from low-lying areas.
- Enhancement of wildlife extension services and assistance to rural communities in managing wildlife resources
- Water harvesting and recycling
- Construction of artificial structures, e.g., sea walls, artificially placing sand on the beaches and coastal drain beach management system
- Establishment of a good land tenure system and facilitate sustainable human settlements
- Aforestation programmes in degraded lands using more adaptive and fast growing tree species

Various coping strategies are employed in each sector depending on vulnerability. Based on sectoral consultations, the proposed NAPA project activities concerning water and energy sector (hydropower) are outlined in table 2a and 2b.

Table 2a: Adaptation Strategies and Prioritization in Water sector

Vulnerability	Existing Adaptation Activities	Potential Adaptation Activities
1. Decreased/ increased runoff in river basins. 2. Encroachment into stream Ecosystems. 3. Water pollution. 4. Water logging due to increased water flow	1. Integrated water resource management. 2. New Infrastructure. 3. Efficient water Use. 4. Inter-basin transfers. 5. Protection of water Catchment. 6. Rainwater Harvesting. 7. New dam sites.	1. Develop alternative water storage programs and water harvesting technologies for communities. 2. Strengthen integrated water resources management. 3. Development of both surface and subsurface water reservoirs. 4. Promotion of Community based catchments conservation and management programs. 5. Promote new water serving technologies in Irrigation. 6. Development of recycle and reuse facility.

Table 2b: Adaptation Strategies and Prioritization in Energy sector

Vulnerability	Existing Adaptation Activities	Potential Adaptation Activities
Biomass and Hydropower are vulnerable due to reduced rainfall and high temperatures.	• Improving and increasing clean thermal power generation. • Protection of hydropower water catchments. • Increasing availability of biomass resources. • Improvement of biomass to energy conversion efficiency. • Increased use of modern biomass to energy technologies. • Energy switching. • End-use energy efficiency programmes.	• Explore and invest in alternative energy sources. • Develop community based mini-hydropower. • Harness the proven coal reserves. • Support programmes to develop alternative source of energy which is feasible and less polluting. • Increase use of geo-thermal power generation. • Appropriate and efficient use of biomass resources. • Enhance natural gas utilization • Promotion of application of cogeneration in the industry sector.

Adapting to Climate Change: Increasing Community Resilience to Drought in Sakai, Makueni project in southeastern Kenya- Ouma, University of Nairobi

Coupled with multiple stresses and low adaptive capacities exacerbated by widespread poverty, weak institutions and complex disasters in Kenya, like many other African countries, are particularly vulnerable to climate change. The potential impact of climate change is threatening to undo decades of poverty reduction and development achievements. The 1999/2000 La Nina-related drought resulted in a loss of approximately USD 3.2 billion, and every five or so years when Kenya experiences drought it costs about 8% of GDP equivalent or about USD 0.8 billion (World Bank, 2008). Therefore there is an urgent need to mainstream climate information into development programmes by accelerating and prioritizing adaptation to climate change into development policy.

As part of efforts to mainstream climate change adaptation into sustainable policy, the Global Environment Facility (GEF) initiated a regional project on "Integrating Vulnerability and Adaptation to Climate Change into Sustainable Development Policy Planning and Implementation in Eastern and Southern Africa (ACCESA)"

Through pilot projects in Kenya, Rwanda and Mozambique, ACCESA has worked with communities to promote the integration of vulnerability and adaptation to climate change into sustainable development plans and planning processes. Increasing community resilience to drought in Sakai in Kenya is one of the three pilot projects of ACCESA.

The overall goal of the project is to provide practical examples of how a community can cope with climate change-induced drought together with practical examples of how national policy may be modified based on inputs from local communities.

The aims of the project are to increase food security by enhancing drought resilience of local agricultural practices; reduce poverty through diversification of livelihoods; and facilitate integration of adaptation to climate change into Kenya's sustainable development plans and policies.

Linking meteorological and agricultural information more effectively entails downscaling climate forecasts to guide choice of crops planted and the timing of agricultural activities. It also involves provision of downscaled weather forecasts in readily understandable language(s). By developing skills in communicating and interpreting weather information such as onset and cessation of rain events through training, farmers are encouraged to enhance their resilience to unexpected weather events by cultivating a portion of their farm with crops suitable for the projected rainfall and planting varieties that would grow even if the rains were greater or less than expected.

In an effort to improve agronomic practices, the project, in conjunction with Kenya Agricultural Research Institute (KARI), Ministry of Agriculture (MoA) and community members, re-introduced seeds from traditional crops (gadam sorghum, pearl and finger millet) and drought-tolerant, open-pollinated varieties of maize and also provided for training on crop husbandry; pest control; seed bulking and storage; and post-harvest management. Beginning with 40 farmers (65% of whom were women), household demonstration sites were established through farmer-to-farmer learning. More than 80% of the households in Sakai had adopted the methods promoted by the project in the second planting season in 2007.

The project has also enhanced access to water during dry seasons by building sand dams and small boreholes fitted with a hand/foot pumps. These have been linked to drip irrigation systems providing farms with water necessary for increased agricultural activity (Figure 20).

Figure 20: Building sand dams, shallow boreholes and drip irrigation systems to improve access to water for use in crop production

The project is also increasing local self-help groups to diversify income sources, such as "merry-go-round" micro-credit scheme in conjunction with the District Social Services Dept. Five women's self-help groups trained in accounting and climate proof business plan development. Upon completion of these plans, each group was provided with funds to carry out new income generating activities (such as production of tree seedlings and high value vegetables).

The project has also facilitated the formation of a biogas cooperative society and the construction of a biogas plant and bakery (Figure 21). Under the direction of the cooperative, the biogas digester is used to fuel the bakery – further helping to diversify incomes. These groups are increasingly becoming self-empowered and are paying back their initial loans and this will help other self-help groups to participate in the micro-credit scheme.

Figure 21: Biogas Digester Project

Participatory "bottom-up" approach responsive to institutional structures helping local people determine their own development has been encouraged and practiced. Arid Lands Resource Management Project (ALRMP) in Kenya agreed to work together and complement one another in areas of mutual interest. Makueni District Steering Group has endorsed the project while local community engagement in problem identification and prioritization is now part and parcel of the project.

The project's continual engagement with district- and national-level policy makers also facilitated the integration of adaptation to climate change into sustainable development policies. The Centre for Science and Technology Innovations (CSTI) and ALRMP implementation teams worked to influence the content of Kenya's draft National Disaster Management Policy and its revised policy on the sustainable development of arid and semi-arid lands.

Lessons learned from the project are encouraging. The recent drought experienced in the country has tested the measures introduced by the project and their potential usefulness in adapting to long term climatic changes. It highlighted the need for the government to promote an integrated drought management system that links together:

- The distribution of a diversified mix of locally appropriate, traditional seeds at the community level
- Improved access to water resources (sand dams) and water conservation practices (drip irrigation systems)
- The diversification of livelihoods through promoting and using drought-tolerant crops, training in small-scale business management and providing micro-credit

From its inception, the project brought together national and district government officials, academia and enthusiastic community members, creating an environment for mutual learning and knowledge sharing. Also the direct involvement of district and national government officials in the project led to continual opportunity to identify and promote policy changes, creating the potential for significant up-scaling of benefits. By bringing together meteorologists, agricultural extension officers, seed and livestock specialists and farmers, the project demonstrated a process for generating and delivering the information that farmers need to make informed planting decisions while taking into consideration the uncertainty associated with rainfall projections.

Improving access to meteorological information at the local level and communicating this knowledge to farmers in a manner that is understandable to them helps farmers cope with increasingly unpredictable weather patterns.

Critical to the success of the Sakai project was the involvement of ALRMP and district level officers demonstrating the critical role of agricultural extension services in preparing farmers for the impacts of climate change. There is need to improve agricultural extension capacity and to raise the capacity of district officers to access sufficient information about climate change, its potential implications and actions they can take to reduce vulnerability in the agricultural sector.

Some of the recommendations include the need for:

- Improved access to meteorological information at the local level in Kenya in order to help farmers cope with increasingly unpredictable weather conditions.
- Greater priority in promoting the use of indigenous crops suitable for marginal areas and encouraging local community-based production.
- Increasing the availability of drought-tolerant seeds in other semi-arid districts and expand the emerging network in order to provide drought-tolerant seeds to more farmers
- Full involvement of extension workers in adapting to climate variability and change
- Field officers who are knowledgeable about climate variability and change
- Syllabus for extension officers that includes climate variability and change
- Continuous training
- Research on climate change and climate variability.
- Improved agricultural extension capacity in Kenya by increasing the capacity of district level officers to access sufficient information about climate change and its potential implications and by making them aware of actions that they can promote to reduce vulnerability in the agricultural sector

In conclusion, the success of the project demonstrated the need for a significant up-scaling of construction of additional and more diversified water sources. Through its policy engagement activities, the project also helped to spread its benefits to a much wider population. For instance, based on the project's experiences the Ministry of State for Development of Northern Kenya and other Arid Lands now requires all the Kenya's Arid and Semi-Arid Lands (ASAL) districts to receive downscaled weather forecasts as part of its drought early warning activities. Such changes are helping to increase the capacity of smallholders across the ASALs in Kenya to adapt to drought now and in the future.

Adaptation Strategies in Agriculture: Adaptation through Climate Smart Agriculture – Kinyangi, CCAFS

Adapting future agricultural development to changing climate conditions faces significant challenges due to population growth, a high degree of vulnerability of current agriculture to natural climate variability (UNECA); slow rate of growth in agricultural production and growing food insecurity (AU Commission); and declining public investments in development (NEPAD, CAADP). A NEPAD study has projected growth and development to further decline due to inadequate capacity to deal with negative impacts from present and future climate change and variability.

This presentation covered five (5) main points.

1. There is a need for a good assessment of local and regional impacts (including opportunities) to design climate smart agriculture for enhanced food security. The region has known hotspots of vulnerability to climate change. There is a need to make full use of current technologies to close the yield gap between GHA and the global yields.
2. Elements of climate smart agriculture that already exist. Remaining requirements are for commitment from all stakeholders, for innovation in pricing and packaging, for a commitment in implementing and extending these elements. This project can be undertaken with rural communities to provide science driven actions addressing overall goals of development. Simple agronomic options can increase adaptation and meet food demands in the short-term (Figure 22).

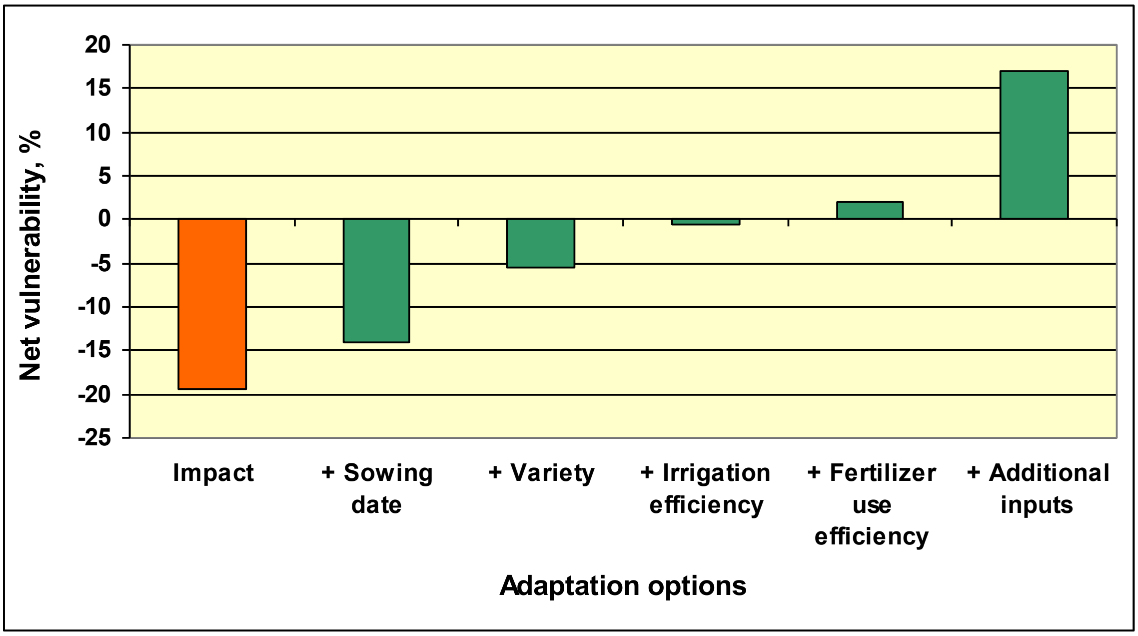

Figure 22: Some of the agronomic options to increase adaptation

3. Breeding has been successful in managing spatial climatic patterns. but not in addressing temporal/inter-annual variability. Breeding success stories exist for more robust crops including potato, tomato, grapes, cabbage, spring wheat, and corn.

4. A systems approach to continuous evolution and innovation is needed to address multiple future opportunities and risks;
5. Problems related to poverty, governance, institutions, and human capital limit agriculture growth today and can potentially do so in the future as well.

Adaptation Strategies in Agriculture – Almaz, Food Security Sector, Ethiopia

The extent and nature of negative impacts imposed by climate change on agriculture can be managed by effective adaptation. In the context of climate change, adaptation refers to adjustments in human and natural systems to respond to actual or expected climate impacts. Climate change adaptation is a process of socio-institutional co-learning that recognizes often-competing goals and processes and uses information at various levels and in many ways to reduce vulnerability to climate risks.

Adapting to climate change will depend on adjustments and changes at every level i.e. from community-based to national and international. However, the capacity to adapt will vary significantly from country to country, community to community depending in particular to the level of development. The adaptation process has the potential to reduce adverse effects of climate change and enhance beneficial developmental activities which can be the driving force for sustainable development.

The capacity of human nature to adapt to and cope with climate change depends on such factors as wealth, technology, education, information skill, infrastructure, access to resources, and management capabilities. There are gender differences in climate change impacts and in adaptive capacities. As a great portion of women in developing countries are involved in agricultural activities any adaptation measures related to agriculture are directly linked to women's day to day life. Such differences in vulnerability and also in adaptive opportunities should be recognized in the adaptation process to avoid further increases in gender inequality and to ensure the success adaptation policies and measures.

Adaptation measures should be supported by investigation and research findings in order to design appropriate strategies. In general, the preferred adaptation strategies are actions with multiple economic and environmental benefits for current and future conditions with needs to be based on sound scientific assessments.

Some of the possible adaptation measures in agriculture include applying improved knowledge to develop better techniques and to resist the effect of climate change in a given locality. Attention should be given to culturing practices that mitigate the effect of stress factors from changed climate conditions, such as changes in land use by changing farm area or changes in crop location or using different techniques such as crops with higher thermal requirements and drought-tolerance or crops with lower moisture requirements.

Changes may be required in the use of irrigation and fertilizer, in the control of pests, in soil drainage, or in farm infrastructure. It is critical to create awareness among people about the causes of climate changes so that farmers can change their current management practices such as deforestation, over grazing, etc. which are the main causes for desertification and exacerbate other climate change factors at large.

In conclusion, to design and implement a sound adaptation strategy, appropriate scientific assessment and research findings have paramount importance, since any adaptation strategies are actions with multiple economic and environmental benefits, including for current and future conditions. The range of practices that can be used to adapt to climate change is diverse, and includes behavioral changes, structural changes, policy based responses, technological responses and managerial responses.

Role of Indigenous Knowledge (IK) in adaptation: A case of Nganyi community in western Kenya- Maria, Bondo University

Indigenous Knowledge (IK) may be defined as an ancient, communal, holistic and spiritual knowledge that encompasses every aspect of human existence. Community based adaptation to climate change relies heavily on IK. Local communities depend on accumulated IK gained from generation to generation which they use to interpret weather patterns; predict local natural disasters and their recurrence; and base early warnings through keen observations of nature changes to cope with extreme impacts.

Some of the lessons based on Nganyi Community Project (Western Kenya) include special talents for predicting climatic changes and providing reliable early-warning for rainfall-patterns, "Rain-making". Over the years, the Nganyi community of Western Kenya has provided climatic early warning information to neighboring communities using IK based predictions of impending changing weather conditions with high level of credibility. The Nganyi community predictions are based on keen observations of extremely scientific proxies including flora and fauna, solar systems and stars among others. The techniques are comparable with those of modern scientists although they require no laboratory.

The project design and its relevance and satisfaction is consistent with the common vision of the funders and has the goal of enhancing the community resilience, through participatory action research activities. Harmonization of the needs of Nganyi community and the other stakeholders ensured project ownership by all in planning and implementation.

The project team with complementary competencies efficiently addressed the skills and information gaps through capacity building activities. Enterprise training addressed the socio-economic needs of the women and the youth within the Nganyi community, who were found to be culturally vulnerable. The Nganyi community was able to collaborate with project team without compromising the secrets of their art through KIPI's role in the project. Modern science uses scientific equipment while IK depends on natural flora and fauna. Some other key differences between the two methods are highlighted in Table 3.

Table 3: Comparison of Indigenous Knowledge and Modern Science compared

Factor	Modern Science	Indigenous Knowledge
How approached	Compartmental	Holistic
How communicated	Written	Oral
How taught	Lectures, theories	Observations, experience
How explained	Theory, "value free"	Spiritual, social values

ICPAC played a critical coordination role in the demystification of myths associated with IK rainfall prediction with local communities. Documentation of methodology facilitates opportunity to replicate similar projects elsewhere in other countries. Dissemination of a quarterly consensus forecast has created a working bond between the Kenya Meteorological Department (KMD) and the Nganyi community and has resulted in construction of Nganyi community resource centre to be fitted with automatic MET Station. The value of the Nganyi community project to disaster risk reduction (DRR) and climate change adaptation (CCA) was demonstrated through the massive interest it attracted locally and from international communities. Sustainability of the project was built into the selection of strategic partners whose core functions are generating and disseminating climate forecast information to end users. Women were able to develop alternative income earnings and saving while the former apathy of the youth was reduced through capacity building in forestation and nursery technologies and the opportunity to earn an income.

The benefits to the community from this project initiative include early warning information which is disseminated in a language understandable by end user and a rewarding change in the status and conditions of the vulnerable women and youth. This was a win-win situation of capacity enhancement for both climate scientists and the indigenous communities which motivates collaborative learning. The Nganyi community image has improved and is appreciated as a rainfall control group.

Lessons learned from the project include value in applying integrated and participatory approaches complemented with IK in capacity building for enhancing community resilience and influencing positively CCA and DRR. Although Nganyi predictions and the scientific predictions use different predicting techniques, they concur that environmental conservation enhances rainfall and community adaptive capacity and resilience. Using special skill groups within community structures as an entry point was challenging in that it can breed mistrust and competition which could mar project outcome. Gender complementarity is essential in addressing vulnerability and enhances resilience as CCA and DRR affecting all. Both men and women have distinct roles to play in IK prediction but there is bias against women in key roles.

It is not clear if communities are fully aware of disaster risks and climate change impacts. Therefore, there is need for capacity building to go beyond economic needs to safety and security measures. The lead institutions of learning in this region should make themselves visible enough in addressing community vulnerability to climate change and risk reduction through collaboration with climate scientists and local communities. CCA and DRR have no tribe or clan boundaries and should be addressed by collaborative research which should encourage documentation and information sharing. Similar projects in the future should forge a regional focus in addressing conservation of the environment to reduce risks and vulnerabilities. More capacity building and policy lobbying is still required to underscore CCA and DRR as developmental issues in their own right and have allocated budgets lines.

In conclusion, scientific prediction is a reality and readily accepted because it is based on meteorological modeling. IK prediction is also readily accepted by the local communities because it is based on systematic observation of nature. The two approaches are very scientific in their own rights; therefore integrated predictions between these two groups can further in ownership by both. There has been increased awareness and usage of the integrated product for community climate risk reduction. There is need for consistent documentation of IK, including time-series analysis to conserve knowledge for future generations and for increasing the knowledge base on the integration of IK and western disaster risk reduction strategies. Policy take-up to support capacity of modern scientists and the IK communities for symbiotic understanding has greatly been enhanced.

Weather and climate change impacts are occurring and will continue to occur. Indigenous communities have co-existed with these two vagaries and recognize that better integration between them is worthwhile. Modern scientists should expand their research into past events and learn lessons trom what worked in the past and modify them for greater acceptance by the current generation. The negative impacts of weather and climate variability are psychosocial problems which compel us as scientists and researchers to communicate with IK custodians. The challenge is for us to break the barriers and make the local community predictors feel that they are opinion leaders and their information combined with the scientifically validated approaches will surely enhance early warning and mitigation efforts. It is desirable that the policy framework embraces the complementarity of scientific and IK prediction.

Knowledge sharing for climate change adaptation in Africa – Tadege, AfricaAdapt

Human induced climate change is happening now and more change is on the way. Africa is identified as the most vulnerable continent to current and future climate change. Sharing of knowledge has a key role in climate change adaptation in the UNFCCC negotiations (Decision 2/CP.11)

AfricaAdapt is an independent bilingual network (French/English) focusing exclusively on Africa. The Network's aim is to facilitate the flow of knowledge on climate change adaptation for sustainable livelihoods between researchers, policy makers, civil society organizations and communities who are vulnerable to climate variability and change across the continent. AfricaAdapt's mission is to promote and facilitate knowledge sharing on climate change adaptation in Africa. One objective is to facilitate flows of information through web, guides, newsletters, publications and broker relationships, while another objective is to demonstrate the added values of a culture of knowledge sharing to increase the visibility and inclusion of African adaptation knowledge.

The activities and services of AfricaAdapt involve interactive platform hosting a community of practice; dissemination of summarized research and thematic overviews available; briefings for policy-makers; multimedia repository of community-based adaptation initiatives; news and updates via email among others. Other services carried out offline include face-to-face meetings; dissemination of paper-based policy briefs and CDs; newsletter; community radio-based programmes and innovation fund.

Some of the main achievements realized by the network are:-

- ✓ A network with more than 1000 registered members established since its launch in May 2009 from all stakeholder groups and all corners of Africa
- ✓ AfricaAdapt website operationalized (http://www.africa-adapt.net) with more than 120 projects and 500 documents directly related to Africa.
- ✓ A twitter feed and YouTube channel where AfricaAdapt can be followed and videos can be downloaded
- ✓ 15 innovation fund winners awarded
- ✓ Strong relationship established with Climate Change Adaptation in Africa (CCAA) programmes.
- ✓ Five “Joto Africa” policy briefing series produced and disseminated
- ✓ 5 Newsletters published and disseminated

Session Seven: Linking disaster risk reduction and climate change

Strengthening regional cooperation for disaster risk reduction in sub-Saharan Africa – *Wielinga, Regional DRM Coordinator Africa, World Bank*

Climate change, population growth and more intensified land use are increasing the hazard frequency and vulnerability. Disasters cause severe hardships and economic loss and so emergency action is important. But reducing the risk of disasters is far more economical than relief and reconstruction. Using knowledge-based response, clients depend on the Bank’s ability to package global expertise and knowledge for effective response for recovery and reconstruction. Disaster operations account for 12-15% of annual WB portfolio source.

Disasters related to meteorological, hydrological and climate extremes are increasing across the region, exacerbated by unplanned and unregulated land use, lack of environmental controls, poor enforcement of building standards, urbanization, and other factors that increase the vulnerability of people, property, and infrastructure., African urban population growth rates of 3.3 to 3.7 percent annually have been and will continue to be the highest in the world. African city-based populations are growing faster than their counterparts in all other regions of the world and are estimated to continue to do so in the next two decades and very likely beyond. There are strong linkages between high-urbanization rates/high concentration of assets and increased vulnerability to hazards.

In response to growing risks, notable efforts have been made at the regional, sub-regional, and national levels to reduce vulnerability. At the regional level, the African Union, together with the New Partnership for Africa’s Development Secretariat, has developed the African Regional

Strategy for Disaster Risk Reduction and a Programme of Action for the Implementation of the Africa Strategy (2005-2010). Implementation of the Strategy rests at the sub-regional and national levels. The First Africa Ministerial Conference on Disaster Risk Reduction (DRR) adopted the Programme of Action in 2005. In 2006, the African Ministerial Conference on Environment (AMCEN) mainstreamed the Africa DRR strategy into its five year programme.

At the sub-regional level, the Inter-Governmental Authority on Development (IGAD) has developed a sub-regional strategy for disaster reduction. The Economic Community of West African States (ECOWAS) in early 2007 approved a sub-regional Common Policy and mechanisms for DRR. The Southern Africa Development Community (SADC) has revised its sub-regional strategy, factoring in DRR and the Economic Community of Central Africa States (ECCAS) has established a sub-regional centre for DRR in the Republic of the Congo and is developing a sub-regional strategy.

The following specific priority needs were identified:

Improvement in the Identification, Assessment, and Awareness of Disaster Risks: There is a need to strengthen knowledge of the variety, geographical coverage, type and extent of disaster risks across the region.

Capacity Development & Coordination: The lack of technically oriented human resources at national levels has hampered the effective implementation of policies and projects. Cross-sectoral training for all professionals involved in disaster management is vital for the success of the regional strategy as well as for the implementation of national policies. In addition, there is a need for reflection on coordination between DRR institutions in the region.

Enhancement of Knowledge Management for Disaster Risk Reduction: The transformation of disaster management practices towards a disaster risk reduction approach will occur when knowledge of disaster risks and reduction options is disseminated effectively to all partners. It is therefore necessary for the strengthening of national and regional mechanisms and forums for knowledge transfer.

Increase in Public Awareness of Disaster Risk Reduction: Increasing public awareness of disaster risks and reduction options is pivotal to the empowerment of people to protect their livelihoods against disaster risks. Risk reduction information needs to be provided regularly through all means of communications, interaction between risk reduction authorities and the public at all levels.

Improvement in Governance of Disaster Risk Reduction Institutions: Disaster management institutions need to be strengthened if disaster risk reduction is to be integrated into development. This requires that the governance of these institutions be improved and that they develop the requisite capacity with adequate and secure resources.

Integration of Disaster Risk Reduction into Emergency Response Management: Disaster risk reduction needs to be integrated into emergency response and post-disaster rehabilitation and reconstruction activities in the region. A long history of disasters in the region has shown that timely and comprehensive recovery comprised of relief, rehabilitation, and reconstruction interventions can reduce vulnerability and promote development if local coping capacities contribute to sustainable recovery.

Increased Financial Support for Disaster Risk Reduction Initiatives: Regular development support must factor in disaster reduction to achieve sustainable outcomes in a region that faces current climate shocks, and pervasive social and economic vulnerability.

Mainstreaming Disaster Risk Reduction into Development Planning: The region has many development projects being undertaken, there is need to proactively factor in disaster risk into these development plans. Together with this is the need for increased political support to build more holistic assessments of disaster impact into development planning.

UNISDR regional activities: Linking DRR and climate change, Pedro, UNISDR

The second World Conference on Disaster Reduction was held in Hyogo, Japan, 18-22 January 2005. The outcome of the conference was the Hyogo Framework for Action (HFA) 2005-2015 on building the resilience of nations and communities to disasters articulated through three strategic goals and five priorities for action. 168 Governments, 78 regional and international organizations, and 161 NGOs attended.

The commitment of nations on implementation and follow-up were to integrate disaster risk reduction into policies, plans and programmes of sustainable development and poverty reduction. It was to recognize risk reduction as both a humanitarian and development issue – in the context of sustainable development. It was to further focus on national and local implementation, with bilateral, multilateral, regional and international cooperation.

The three HFA strategic goals to be achieved by 2005-2015 were:

i. The integration of disaster risk reduction into sustainable development policies and planning
ii. The development and strengthening of institutions, mechanisms and capacities to build resilience to hazards
iii. The systematic incorporation of risk reduction approaches into the implementation of emergency preparedness, response and recovery programmes

The expected outcome was substantial reduction of disaster losses, in lives and in the social, economic and environmental assets of communities and countries.

The Hyogo Framework for Action (HFA) Priorities for Action:

HFA 1: Ensure that disaster risk reduction (DRR) is a national and local priority with a strong institutional basis for implementation

HFA 2: Identify, assess and monitor disaster risks and enhance early warning

HFA 3: Use knowledge, innovation and education to build a culture of safety and resilience at all levels

HFA 4: Reduce the underlying risk factors

HFA 5: Strengthen disaster preparedness for effective response at all levels

The United Nations Strategy for Disaster Risk Reduction (UNISDR) support for the priorities action include global assessment report on disaster risks; monitoring and implementation of HFA; regional capacity building in DRR; national platforms in DRR; Inter-Agency coordination in DRR and response. Others are global campaigns on DRR for safer schools, safer cities and hospitals. The major campaign targeting local authorities and communities to increase cities resilience to disasters popularly known as *"Resilient Cities; My city is Getting Ready"*

Collaboration and cooperation are crucial to disaster risk reduction: states, regional organizations and institutions, and international organizations all have a role to play. Civil society, including volunteers and community-based organizations, the scientific community, the media, and the private sector are all vital stakeholders. Following is an indication of the variety and diversity of actors and their core responsibilities.

Regional organizations are responsible for:

- Promoting regional programmes for disaster risk reduction;
- Undertaking and publishing regional and sub-regional baseline assessments;
- Coordinating reviews on progress toward implementing the Hyogo Framework in the region;
- Establishing regional collaborative centres; and
- Supporting the development of regional early warning mechanisms.

Regional Africa Strategy, Programme of Action 2005-2015 and Guidelines were negotiated and approved by 53 African countries in 2004 and these were to be fronted by African Union Commission (AUC), New Partnership for Africa's Development (NEPAD), African Development Bank (AfDB), and ISDR.

The African Programme of Action 2006-2015 has an overall goal to reduce the social, economic and environmental impacts of disasters on African people and economics, thereby facilitating the achievement of the MDGs and other development aims in Africa.

The Strategic Areas of Intervention include:-

i. Increase political commitment to disaster risk reduction.
ii. Improve identification and assessment of disaster risks.
iii. Increase public awareness of disaster risk reduction.
iv. Improve governance of disaster risk reduction institutions.
v. Integration of disaster risk reduction in preparedness plans and emergency response management.
vi. Overall coordination and monitoring of the implementation of the Strategy.

Expected results from Africa Programme of Action 2006-2015 are:

i. DRR becomes a regional, sub-regional and national priority.
ii. Vulnerabilities, hazards and disaster risks are identified, assessed and monitored.
iii. People-centered, user-friendly early warning systems are in place.
iv. Knowledge, innovation and education are applied to build a culture of safety and resilience.
v. DRR institutions have the requisite authority and capacity to coordinate across sectors and from national to local levels.
vi. Underlying risk factors and DRR measures are integrated into policies, plans and programmes.

vii. DRR measures are integrated into post-disaster recovery and rehabilitation processes

viii. Comprehensive preparedness and contingency plans and processes are established, and activated in a timely manner from national to local levels

The comparison between the Africa Programme of Action and the HFA is shown in Table 4

Table 4: Comparison between the Africa Programme of Action and the HFA

Africa Program of Action for DRR, 2006-2015		HFA 2005-2015
1. Increase political commitment to disaster risk reduction (DRR);		1. Ensure that DRR is a national priority with strong basis for implementation;
2. Improve identification and assessment of disaster risks;		2. Identify, assess and monitor disaster risks and enhance early warning;
3. Increase public awareness of DRR and enhance knowledge management;		3. Use knowledge, innovation and education to build a culture of safety and resilience at all levels;
4. Improve governance of DRR institutions and reduce the underlying risk factors (linkage with CC);		4. Reduce the underlying risk factors (including linkage with CC);
5. Integrate DRR in emergency response management;		5. Strengthen disaster preparedness for effective response at all levels;
6. Overall coordination and monitoring of the implementation of the Strategy.		Chapter IV: Implementation and follow-up

Other activities on Hyogo Framework for Action monitoring and review process 2009-2011 include Global Assessment Report on Disaster Risk Reduction; Africa DRR Status Report; Drought Risk Reduction Framework and Practices- Africa drought adaptation forum and ISDR Africa Informs.

Some results and monitoring realized for Africa include establishing and strengthening NPs and legal frameworks and national plans. Others are guidance for thematic agendas, e.g. Drought risk reduction framework and practices; guidance and indicators for disaster preparedness; holistic approach, strategies and institutional frameworks; components of preparedness planning and readiness for response.

Growing awareness of the potential impact of climate change has increasing our attention and awareness on how existing climate risks can be managed as DRR and CCA are intertwined. As the impacts of climate change are being increasingly felt so too will be the scale and unpredictability of climatic hazards and related hydro-climatic disasters. Hyogo Framework for Action includes specific commitments to integrating DRR and CCA through raising greater, political attention/advocacy on benefits of DRR/CCA and consequences of not investing in it.

Enhancing links between DRR and climate change adaptation agendas together with promoting better mainstreaming of DRR/CCA and the HFA into policies and practices have greatly been enhanced.

Some of the key DRR events for Africa in 2011 include:-

- 2010-2011 World Disaster Reduction Campaign on building resilient cities – "My City is Getting Ready"
- GAR, Africa Status Report, HFA National Reporting
- The 16th AU Summit – Addis Ababa, January 2011 (Africa Programme of Action was endorsed)
- Africa Working Group on DRR – 29th March 2011
- 3rd Africa Regional Platform / Regional Consultation March 2011
- Third Session of the Global Platform for DRR 8-13 May 2011, Geneva

Lessons Learned

The concept of 3 workshops was very effective way to demonstrate what is possible and to build confidence in data and models. It will lead to more effective way for dissemination of climate information to decision makers because the meteorological and applications information providers more fully understand what they are communicating and hence will communicate more effectively.

Experience gained in the project will help in mainstreaming climate change into national policies, including DRR.

Need to identify key national project participants (contacts) prior to implementation of workshops to assist in planning, implementation and assessment of the overall project. These people should participate in all three workshops and be actively involved in all project implementation discussions.

Need for more preparatory work prior to workshops to develop background guidance and material for use in workshops.

One week workshops good to demonstrate capabilities but not sufficiently long to complete training

Need to establish commitment to data sharing for regional analyses; need more time series for consideration at the workshops.

There is need to establish the role of regional centres in producing aggregated products, downscaled projections, etc.

Implementing third workshop along side RCOF is an effective means to bring together decision makers, stakeholders and technical experts, but should include more time for group work, e.g. sector representatives from different countries and national representatives from met services, application sectors and decision makers.

Recommendations for Future Work

Workshop series is a first step – need follow up; longer term training; on line help (role for RCC)   Take advantage of AfricAdapt to post links to software, etc on their site and/or WCRP Site.

National data need to be made available for use in regional and national analyses and for prediction products regionally and globally. There is need for step in data rescue, digitization and input from reanalyses to fill many gaps in time series data.

Further explore what indices would be of particular use (current and new ones to be constructed) to the region, DRR and other application sectors e.g. length of growing period, onset and cession of seasonal rainfall

Develop national and regional story lines to develop relevant future climate scenarios - indices should to be compiled at a central point; need regional effort to develop relevant indices; time sensitive issue if will have impact on next 4th IPCC assessment

Develop examples /demonstration projects of where indices and downscaled model projections are used as input to assessing impacts in specific climate – sensitive sectors (possible "incubation projects");

Quantify uncertainties at every stage of the process (data through to media communications);

Extend what is learned with PRECIS by using multiple models and models with multiple forcings.

For future work, use CORDEX resource/ runs that are in public domain; and associated capacity building and regional analysis

WCRP and partners should sponsor a conference in two years time to showcases results from workshop series, including use of indices and downscaled climate projections for climate change impact studies with focus on use of CORDEX and involvement of CLIVAR VACS.

A regional paper on indices and regional climate modeling from the 3 workshops should target August 2012 publication deadline for the firth IPCC Report

There is strong need to continuously enhance the capacity of NMHSs to provide the necessary data and information required for science-based discussions and actions under the UNFCCC process.

In future UNFCCC climate change negotiations, climate scientists, WMO and related institutions/centres should closely follow the negotiations and most especially the sessions of the Subsidiary Body for Scientific and Technological Advise (SBSTA) in order to plan and engage appropriately in the unfolding issues.

Whereas sources of information, such as the IPCC Reports, can be referenced for macro/global policy actions, they may not be ‘accurate’ enough for specific actions at national and sub-national levels. Hence there is a need for downscaled localized information sources to analyze geographically specific adaptation actions. This can easily be attained with increased public investment in NMHSs to support research at national and regional levels.

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ANNEX I: WORKSHOP PROGRAMME

<table>
<tr><th colspan="3">Day One: Tuesday 1st March 2011</th></tr>
<tr><th>Time</th><th>Activity</th><th></th></tr>
<tr><td>08h00 – 09h00</td><td>Registration of participants</td><td rowspan="4">Chair: Rwanda</td></tr>
<tr><td>09h00 – 10h00</td><td>Session One: Workshop Perspectives ; Regional Climate needs and challenges
• Overview of the WCRP/WMO/GCOS/ICPAC/WB-GFDDR;Workshop Project Objectives and Context; and Workshop 3 Objectives – Ogallo, ICPAC
• Regional Data and Observational Needs: Way Forward from the PRs regional efforts- Kijaze, PR Tanzania with WMO</td></tr>
<tr><td>10h00 – 10h30</td><td>Health Break</td></tr>
<tr><td>11h00 – 1300</td><td>• GCOS Regional Data Needs and Gaps and - GCOS – Thomas
• Use of satellite data to monitor the environment in Africa – Njoki, AMESD
• Regional Climate Change needs and challenges for sector specific applications - Komutunga
• Global Framework for Climate Services (GFCS) – Nyenzi
• Panel discussion – sector exposure to climate change – Ouma, facilitator
➢ Climate change and Agriculture – Hakuza (Ministry of Agriculture Uganda)
➢ Climate change and water resources – Artan (USGS)
➢ Exposure of sectors to climate and Nature of sector decision making – Gallu (FEWSNET)</td></tr>
<tr><td>13h00 – 14h00</td><td>Lunch Break</td><td></td></tr>
</table>

14h00 –	<u>**Session Two: Review of workshop 1 & 2 outcomes and local climate trends and variability**</u> • Innovative approach to climate change adaptation in Africa **– Odingo** • Use of climate data, indices and regional climate models for climate risk mitigation in the region – **Anyah, UCON** • Major outputs from Workshop 1: climate indices from WS1, regional climate extremes – **Pyuzza, ICPAC** • Major outputs from Workshop 2: Regional model outputs for climate change impacts, vulnerability and adaptation studies - **Instiful , UNDP AAP** • **Discussion of Regional / local evidences of climate change -** statements from countries, institutions and communities, **Semazzi facilitator**	Chair: Djibouti :
16h00 – 16h30	**Health Break**	
16h30 – 18h00	<u>**Session Three: Impacts and vulnerability of the region to climate variability and climate extremes**</u> • Review of the ongoing La Nina and La Nina impacts atlas for the region – **Mutemi, ICPAC** • Economic vulnerability and impacts of disasters – examples from the region **- Dingel, World Bank** <u>**Session Four: Cooperation between climate scientists and humanitarian and develop policy makers**</u> Strengthening two-way dialogue between climate scientists and humanitarian and development policy makers to enable more effective use of climate science: **Visman ,Humanitarian Futures Programme King's College, London**	Chair: Ethiopia :
Day Two: Wednesday 2nd March 2011		
Time	**Activity**	
09h00 – 10h30	<u>**Session Five: Integration of climate information into decision making and familiarization with decision tools**</u> • Roles of WMO lead climate centers **– Yun, KMA**	Chair: Kenya :

	• General overview, Using RCOF approach to facilitate consensus approaches to climate change adaptation – **Kolli, WMO CASP** • Overview of Regional climate change scenarios past and future (IPCC methodologies) – **Odingo, U Nairobi**	
10h30 – 11h00	**Health Break**	
11h00 – 13h00	• Use of climate change projection scenarios in the development of regional adaptation strategies – A Case Study for the Hydrology of Lake Victoria".– **Semazzi, NCSU** • Progress in climate change negotiations and roles of the NMHSs and regional centres: including brief on Cancun outcomes relevent to the region **- PR of Uganda with WMO** • Discussions - Regional / Local scale lessons from countries, institutions and communities – Facilitator **-Nyenzi**	Chair: Eritrea
13h00 – 14h00	**Lunch Break**	
14h00 – 16h00	**Session Six: Development of adaptation strategies for the agriculture and water sectors** • Adaptation strategies in water resources **– Kizzy** • **Panel discussion – facilitator Artan** Success story: Makueni project in southeastern Kenya- **Ouma, University of Nairobi** Adaptation Strategies in Agriculture – **Kinyangi, CGIAR /Almaz** Role of Indigenous Knowledge (IK) in adaptation: A case of Nganyi community in western Kenya- **Onyango, Bondo U** Knowledge sharing for climate change adaptation in Africa – **Tadege**	Chair: Burundi

16h00 – 16h30	**Health Break**	
16h30 – 18h00	**Session Seven: Linking disaster risk reduction and climate change** • Strengthening regional cooperation for disaster risk reduction in sub-Saharan Africa **– Wielinga, World Bank** • UNISDR regional activities: Linking DRR and climate change**, Pedro** • Use of climate information for disaster preparedness – **Amadi** • Regional lessons in integrating Disaster risk reduction and climate change - **Ouma, ICPAC** • Development of regional disaster risk reduction user interface platforms in partnership with ICPAC – **Microsoft** • **Discussion** • Distribution of guidance for country reports	Chair: Uganda
Day Three: Thursday 3rd March 2011		
Time	**Activity**	
9h00 – 13h00	**Session Eight: Field visit to ascertain evidence of climate change, impacts and vulnerability** (Countries expected to compile lessons learned) • **Team 1** – Slopes of Mt Kilimanjaro • **Team 2** – Lake Manyara • **Team 3** – Visit to Ngorongoro	Chair: Tanzania
13h00 – 14h00 LUNCH		
14h00 – 17h00 Evening	**Session Nine: Country consultations on way forward – stakeholders, users and climate scientists** • Participants from each country to form working groups to develop way forward post- workshop (national reports on lessons learned, experiences, gaps, needs and priorities) • Development of the field trip reports Climate change lessons from Tanzania (Cultural evening)	Chair: Tanzania
Day Four: Friday 4th March 2011		
Time	**Activity**	

09h00 – 10h30	**<u>Session Ten : Lessons from the practical sessions</u>** • **Lessons from the field trip** (Presentation of lessons from the two sites) • **Presentations of country reports** • Discussions	Chair: Sudan
10h30 – 11h00	**Health Break**	
	<u>Session Eleven: Sustainability: Post- workshop mechanisms to implement workshop recommendations</u> • East African Community efforts towards a regional climate change strategy (**EAC**) • Challenges in communication and dissemination of climate information - **Luganda** • Reports from rapportuers – panel discussion • Conclusions and recommendations -discussion	Chair: Tanzania
13h00	**Closure of workshop**	
	<u>Visits to Arusha</u>	

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