Economic Commission for Africa

ACPC
African Climate Policy Centre

United Nations Economic Commission for Africa
African Climate Policy Centre

Working Paper 1

Climate Science, Information, and Services in Africa: Status, Gaps and Policy Implications

United Nations Economic Commission for Africa
African Climate Policy Centre (ACPC)

Working Paper 1

CLIMATE SCIENCE, INFORMATION, AND SERVICES IN AFRICA: STATUS, GAPS AND POLICY IMPLICATIONS

November 2011

Acknowledgment

This paper is the result of African Climate Policy Center (ACPC) of United Nations Economic Commission for Africa (UNECA) under the Climate for Development in Africa (ClimDev Africa) Programme. The paper is produced with guidance, coordination and contribution of ACPC and contributing authors from various institutions. Contributions to this paper are made by Tufa Dinku, International Research Institute for Climate and Society, the Earth Institute at Columbia University; Tatiana Arivelo, UNECA-ACPC; Seleshi B. Awulachew; UNECA-ACPC; Andre F. Kamgaf, African Center of Meteorological Applications for Development; Semu A. Moges; Addis Ababa University (AAU), Buruhani S. Nyenzi is Manager, Formerly at UN High Level Taskforce Secretariat on the World Meteorological Organization Global Framework for Climate Services; and Yilma Sileshi, AAU.

Table of contents:

List of Figures:

Common acronyms:

ACCFP	African Climate Change Fellowship Programme
ACMAD	African Centre for Meteorological Applications for Development
ACPC	Africa Climate Policy Centre
AGRHYMET	Agro-meteorology and Hydrology Regional Centre
AIACC	Adapting to Impacts of Climate Change Programme
AMCEN	African Ministerial Conference on the Environment
AMMA	African Monsoon Multidisciplinary Analysis
AU	African Union
BAP	Bali Action Plan
CCAA	Climate Change Adaptation in Africa
CCAFS	Climate Change, Agriculture and Food Security
CGIAR	Consultative Group on International Agricultural Research
ClimDev Africa	Climate for Development in Africa
COP	Conference of the Parties
DfID	UK Department for International Development
ENSO	El Niño-Southern Oscillation
GCOS	Global Observing Systems Information Center
GDP	Gross Domestic Product
GFCS	Global Framework for Climate Services
GHARCOF	Greater Horne of Africa Regional Climate Outlook Forums
ICPAC	IGAD Climate Prediction and Application Centre
IMF	International Monetary Fund
IPCC	Intergovernmental Panel on Climate Change
IRI	International Research Institute for Climate and Society
LDC	Least Developed Countries
MALOF	Malaria Outlook Forum
MDGs	Millennium Development Goals
NAPAs	National Adaptation Programmes of Action
NGOs	Non-Governmental Organizations
NMHSs	National Meteorological and Hydrological Services
ODA	Official Development Assistance;
OECD	Organization for Economic Co-operation and Development
PRESAO	Prévision Saisonnière en Afrique de l'Ouest
RCCs	Regional Climate Centers
RCOFs	Regional Climate Outlook Forums
RECs	Regional Economic Communities
SADC	South African Development Community
SADC-CSC	SADC-Climate Services Centre
SADC-DMC	SADC-Drought Monitoring Centre
SARCOF	Southern Africa Regional Climate Outlook Forum
SST	Sea Surface Temperature
UNECA	United Nations Economic Commission for Africa
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development
WCC3	World Climate Conference3
WMO	World Meteorological Organization

ABSTRACT: Climate variability and change are serious challenges to sustainable development in Africa. The current famine crisis in Somalia and the surrounding region is yet another reminder of how fluctuations in the climate can destroy lives and livelihoods. Coping with negative impacts of climate and benefiting from favorable conditions would require implementing adaptation strategies that could reduce the vulnerability to current climate variability while building resilience against risks from climate change. This is best achieved through mainstreaming climate issues into development planning and practice. Climate information is a critical input for effective climate risk management. Science-informed policy, planning, and practice will ensure that development is more resilient and less vulnerable to negative impacts of climate, thus fostering sustainable development. However, the use of climate information and science in Africa has been very weak. On one hand, the climate community in Africa has not been able to provide the appropriate decision-relevant information. On the other hand, even the available climate information is not being used properly. The major challenges for the climate community have been critical lack of trained manpower, inadequate station network, and very weak communication and computational capacity. From the user side, the main obstacles include lack of appropriate climate information and services, lack of awareness about the existence of specific climate information, lack of understanding and capacity to use climate information, reluctance to incorporate climate issues in management practices, and poor understanding on how to deal with scientific uncertainties. Lack of communication between the users and providers of climate information has also been the other serious problem. Thus, strenuous efforts should be made to improve the provision of climate information and services on one hand, and promote the integration of climate into development planning and practices on the other. This paper will assess the current state of climate science, data and information in Africa and its use in development activities. It will identify key gaps and recommend actions needed to be taken for bridging the gaps.

KEYWORDS: climate science, data, information, services, policy, Africa

1. Introduction

Climate plays a significant role in the day-to-day activities of the Africa population. Activities related to agriculture and water are the most climate-sensitive. Climate has also a significant influence on transportation, energy, and the spatial distribution and transmission of certain diseases such as malaria. Weak economic background, high dependence on natural resources, and limited capacity to manage climate variability and change has made Africa the most vulnerable region to negative impacts of climate. The whole situation has created a vicious circle whereby poverty makes the population vulnerable to negative impacts of climate, and negative impacts of climate, in turn, exposes the population to greater economic difficulties.

Building resilience against the negative impacts of climate and maximizing the benefits from favourable conditions will require designing and implementing effective climate risk management strategies that could reduce the vulnerability to current climate variability while building resilience against risks from climate change. This is best achieved through mainstreaming climate issues into development planning and practice. Climate information and services are critical inputs for effective climate risk management. Science-informed policy, planning, and practice will ensure that development is more resilient and less vulnerable to negative impacts of climate, thus fostering sustainable development. However, the use of climate information and science in Africa has been very limited. The main obstacles include lack of appropriate climate information and services, lack of awareness about the existence of specific climate information, lack of understanding and capacity to use climate information, reluctance to incorporate climate issues in management practices, and poor understanding of scientific uncertainties. Thus, strenuous efforts should be made to improve the provision of climate information and services on one hand, and integrate climate issues in development practices on the other.

The African Climate Policy Center (ACPC), as the secretariat of the Climate for Development in Africa (ClimDev Africa) programme, has as one of its objectives the development of a solid foundation of applied climate science and its use for sustainable development in Africa. As the first step towards this goal, ACPC organized a consultation workshop in Addis Ababa, Ethiopia, 13-15 April 2011. One of the objectives of the workshop was identifying key issues concerning climate data and information and ACPC's role. This paper is a follow up to that workshop. The main objective of this paper is thus assessing the current state of climate science, data and information in Africa, assessing the use of climate science and information in sustainable development, identifying key gaps, and recommending actions needed to bridge the gaps.

The paper is divided into five sections. Section-1 presents and discusses the current status of climate data, information and services in Africa. Section-2 deals with different aspects of climate science in Africa. Section-3 and Section-4 explore the role of climate science and information in supporting sustainable development and policy, respectively. Section-5 elaborates the role ACPC is expected to play in improving climate science and information and its applications in development practices. Each section is further divided into three sub-sections. The first subsection presents the current status, while sub-sections two and three discuss the majors challenges and identify key actions needed to move forward.

2. Climate data, information and services in Africa

Climate is typically defined as the average weather over a period of time. The quantities are most often surface variables such as temperature, precipitation, and wind. Climate in a wider sense is the state of the climate system, including its statistical description (WMO, 2011). Climate data refers to raw observations, while climate information is usually the processed outcome of data. The two

words are usually used interchangeably. Climate service may be defined as climate information prepared and delivered to meet a user's needs (WMO, 2011). It encompasses a range of activities that deal with generating and providing information based on past, present and future climate and its impacts on natural and human systems. Climate services include the use of simple information like historical climate data sets as well as more complex products such as predictions of weather elements on monthly, seasonal or decadal timescales, also making use of climate projections according to different greenhouse gas emission scenarios. Climate data may be divided into three categories:

- Historical data refers to observations taken over the years. These kinds of data are used in many applications including assessing climate-related baseline or static risks, putting observed and anticipated climate into context, understanding and modeling impact of climate on different socio-economic activities, improving predictions at different time scales, and downscaling climate projections.
- Current observations are useful for monitoring the climate on real-time or near real-time basis. These are useful in short-term predictions of the consequences of specific weather events – for example, heavy rainfall leading to flooding or disease outbreak.
- Climate forecasts and predictions ranging from short- and long-term weather forecasts, through seasonal prediction, to medium- (10–30 year) and long-term climate change projections. These provide information about the future state of the climate, and are useful for early warning and planning at different time scales.

Climate information and services can play a crucial role in national development planning, managing climate opportunities and risks and for mitigation and adaptation. Agricultural practitioners may use information on onset and cessation of rains, distribution and intensity of rainfall within the season, frequency of dry and wet spells, number of rainy days and length of the rainy season. Water professional would be interested in information such as frequency of heavy precipitation and flooding, late/early onset and cessation trends, exceedence probabilities, and return periods. Other examples of the uses of climate information include (WMO, 2011):

- Climate predictions can be used by farmers to help them decide, for example, which crops to plant or whether to reduce livestock numbers if a drought is forecast to occur. Farmers making such decisions are likely to use climate outlooks of rainfall and temperature and take into account the uncertainty estimates provided with these products;
- Statistical assessments of the future frequency of extreme weather and climate events can be used by engineers to help them make decisions, including where to invest in disaster mitigation measures such as dams, where to locate buildings, which construction methods to use and how much heating and cooling is needed for critical infrastructure;
- Seasonal climate forecasts and monitoring of actual temperature and rainfall can be used to provide forecasts of when and where disease outbreaks are likely to occur. The impacts of predicted outbreaks can then be minimized by public awareness campaigns, stocking and shipping medical supplies and vector control programmes such as spraying;
- Climate change projections, which can indicate precipitation patterns in the 30-to-50-year timeframe, can be used to guide major investment decisions relating to long-term water management such as whether and where to build new reservoirs.

Effective climate services need to exploit the full potential of existing knowledge and new research developments. However, though the understanding of the climate system is advancing quickly, it is not being used effectively in development planning and practice in Africa. Improving climate services will only be successful if capacity is systematically built both in the climate and user community. Current capacity building activities need to be strengthened and scaled up. This chapter

will present the current status of climate information and services delivery and use, identify the major gaps, and offer some ideas on how to move forward.

2.1. Current status

2.1.1. Provision of climate information and services. National Meteorological and Hydrological Services (NMHSs) in Africa provide ranges of information and services. There are also regional and sub-regional providers of climate information and services. The information and services provided by NMHSs include:

- Current and historical data of different climate variables (rainfall, temperatures, humidity, wind speed and direction, sun shine hours, … etc.);
- Analyzed information (minimum, maximum and mean of climate variables, dry/wet spells, frequency of extreme events, …etc, in tabular and map formats);
- Forecasts at different time scales (daily, ten-daily, monthly and seasonal);
- Products targeting specific users (10-day and monthly climate reports and outlooks, agrometeorlogical, hydrometeorological, and health bulletins, … etc.); and
- Other specific/specialized information and products in response to specific demands (such as drought early warning, flood monitoring, desert locust monitoring, …etc).

The quantity and quality of information and services offered by the NMHSs vary significantly across Africa depending on the capacities of the NMHS. One service that all NMHS offer is daily weather forecast. This is mainly a legacy of the fact that many NMHSs in Africa were first established to serve aviation.

One of the most popular and widely used climate information in Africa is seasonal climate outlook. Most NMHSs in Africa either produce their own seasonal forecasts or are involved in the regional consensus forecasts. The creation of the Regional Climate Outlook Forums (RCOFs) has facilitated the generation and use of seasonal climate forecasts. Since 1997 meteorologists from African sub-regions (West, Central, East and Southern) meet once or twice a year with experts from other international and regional organizations and institutions, NGOs and businesses to discuss and agree on seasonal climate forecasts providing indications on the expected performance of rainfall three or more months in advance. This information is then communicated to government and other agencies and the general public using different means.

2.1.2. Use of climate information and services. The use of climate information and services in Africa is mainly dependent on accessibility and familiarity to the users, rather than suitability to the specific problem or research question being addressed (Ziervogel et al., 2008b). Even though its full potential is not yet taped by different socio-economic sectors, there are documented success stories existing on the use of seasonal forecasts for water and disaster management, health, agriculture and food security. Climate bulletins, reports and assessments are source of information and knowledge for the general public and sector specific users in Africa. Experts involved in research and development in agricultural institutions use current climate data and trends to develop and update agriculture calendars to improve their assistance to the farming community. Historical data are used to downscale regional seasonal forecasts and climate projections. Some examples of the good use of seasonal outlooks include the following:

- In 2002 seasonal forecasts for a high likelihood of drought in Ethiopia prompted meetings of emergency management team to identify specific actions and donors for food relief before the

situation became critical.

- In Mali since 1998, seasonal forecasts were used by agricultural extension officers leading to income gains of more than 10% for farmers.
- From 2000 to 2005 in Zimbabwe, post season interviews of subsistence farmers revealed that farming decisions based on seasonal forecasts led to gains in yields of about 9% (Patt et al., 2007).
- In West Africa since 2008, the International Federation of Red and Red Crescent societies is using seasonal forecast to make decisions related to logistics (e.g. prepositioning relief and rehabilitation supplies).
- Malaria Outlook forums initiated in southern Africa and RCOFs focused on disaster risk reduction in East, West and Central Africa are becoming instrumental in facilitating mutual understanding of the forecasts, tailoring climate information and incorporating in disaster risk reduction policies, plans and practices.

2.2. Major gaps

2.2.1. Provision of climate information and services. Gaps associated with service provision in Africa are mainly a result of limited capacities of the NMHSs. Only a minor investment is made in the NMHSs in Africa. Analyses of surveys conducted over West and East Africa under CGIAR/CCAFS (Kadi et al., 2011a; Kadi et al., 2011b) shows that there is so much need for climate products and services, but there are severe limitations in terms of technical capacity, availability of professional staff and applications software. For many African NMHSs recruiting and maintaining staff is a major challenge. In many countries the pool of atmospheric scientists is not large and the salary NMHSs offer is not very attractive for young graduates. It all boils down to the low level of funding for NMHSs. A survey of 13 NMHSs in Africa (Jones,2010) shows that the average annual budget is $5.26 million, which is .017% of $399.692 billion total GDP (2008 nominal numbers from IMF). For comparison, the US National Weather Service has an annual budget of $959 million, which is .067% of GDP. Thus Africa is investing about 25% of what the US is investing in their NMHS. It should be noted that the National Weather Service is not the only climate information provider in the US, while the NMHSs in Africa are the sole information providers most of the time. Thus, this low level of investment in NMHSs is unacceptable considering the high dependence of the African population on climate and its vulnerability to climate variability and change. It is also true that there is a problem of capacity utilization. Whatever the reasons, here are some of the major gaps (IRI et al., 2006; Ziervogel et al., 2008b):

- The current monitoring system is not sufficient for supporting growth and sustainable development. It is oriented more towards meteorology than climate, and more towards global interests and the presumed needs of government sectoral managers than the needs of local communities.
- In too many countries, the NMHSs are not sufficiently engaged with the national development agenda and services for rural poor populations are very limited.
- There is a gap between what is currently provided (daily weather forecasts) and what is needed for achievement of the Millennium Development Goals (MDGs).
- There is lack of knowledge and understanding of user needs and how development decisions are made, so there is little capacity to tailor information appropriately.
- Available climate projections come from different sources, are produced differently and cover different time periods, making it difficult to compare them so as to develop a harmonized view

of the future.

- Little has been done to create or update country climate atlases and agriculture calendars. This limits the abilities of extension services to deliver the best advices to farmers. Atlases and crop calendars being used most often were prepared with past climate data, which does not represent the current situation (Kadi et al., 2011).
- Areas susceptible to flooding have changed and floods maps developed with past climate data lack enough precision to be useful for disaster management under current climate.
- Services based on climate scenarios are not yet well developed in NMHSs. Capacity to develop and provide climate information at decadal to multidecadal timescales is not yet available in most Meteorological Services. Locally downscaled climate projections are not easily available or accessible because extensive research and development is required to deliver such advanced services. Many African NMHSs neither have research and development departments nor the necessary institutional arrangements to benefit from available skilled labor in climate research institutes and university laboratories.

2.2.2. Use of climate information and services. Lack of climate information and services is not the only problem. Another serious impediment is that the available capacities of NMHSs are severely underutilized. This is attributed mainly to lack of awareness about the existence of specific climate information, lack of understanding and capacity to use climate information, reluctance to incorporate climate issues in management practices, and poor understanding on how to deal with scientific uncertainties (IRI et al., 2006; Kok et al., 2006). Some of the gaps in the use of climate information and services for sustainable development in Africa are listed below (some more are also given in Section 4).

- The generation of possible future impacts of climate in various sectors requires technical capacity (both human and infrastructure) that may not be readily available.
- Users are unable to use the information to affect the outcomes that they are trying to achieve.
- There are currently very few "proofs of concept" – that is examples of agricultural decision makers that have successfully drawn on climate change projection data to take decisions that have improved agricultural productivity or human well-being (Ziervogel et al., 2008b).
- There are gaps in understanding, trusting seasonal forecast and incorporating it in decision or policymaking. Ethiopian food stock was depleted by war in the late 1990. The forecasts for likely dry conditions in 1999 led to fear that drought conditions could trigger famine. Humanitarian organizations did not trust the forecasts and were unwilling to commit resources on the basis of probabilistic predictions and very costly relief operations began after the rains failed. In summer 2010 over West Africa, heavy rains and flooding hit many countries with unanticipated costly consequences because some countries climate sensitive sectors lacked trust, understanding and/or capacity to derive possible impacts and make relevant contingency plans.
- The Intergovernmental Panel on Climate Change (IPCC) and its network of scientists produce climate reports and assessments on climate change. But their findings are valid from global to sub-continental scales and may be incomplete to make policy and decisions at regional, sub-regional and national levels.

2.3. Way forward

2.3.1. Provision of climate information and services. The first step to improve climate services in Africa would be strengthening the NMHSs in human resources, telecommunications, observation

infrastructure, access to the Internet and other advanced communication and computing technologies, and increased interaction with their users. No technical modernization of a NMHS will be successful unless there are qualified and motivated meteorologists to use the tools to generate timely warnings and improved forecasts. Not only should the proper number of professional staff be recruited and maintained, but they must also be periodically trained so they can continue to utilize the latest techniques (Jones, 2010). Some other issues that need to be addressed for better delivery of climate information and services in Africa are the following (IRI et al., 2006; Ziervogel et al., 2008b; Ziervogel et al., 2008c):

- Rescuing, collecting and analyzing climate and socio-economic data, generating better climate analyses and reanalysis for detection, understanding and monitoring regional to local climate change are key priorities to upgrade current knowledge and satisfy all policy makers, planners and practitioners.
- Focus on national development objectives that serve the poor.
- Climate data should be considered a public good; increasing access increases value at little additional cost. Climate data should be considered as a resource that is used for advancing a country's collective development objectives. This way climate information delivers more to the economy than the "cost recovery" collected by NMHSs.
- Improve access to historical climate data is needed for the quality of local level projections and enhancing closer examination of past climate trends.
- Climate scientists need to be better trained to apply climate change models, particularly at the local scale.
- Regional climate centers should be established that have the necessary technology and institutional capacity to support climate modeling, prediction, downscaling and other activities.
- Institutional reforms should be made to facilitate expansion of NMHSs services in more climate sensitive sectors of countries economies. Some NMHSs have become agencies with significant involvement of sectoral users in their governance structures. Such reforms are providing new impetus for development of national climate services and should be promoted.
- For a forecast to be useful, it must: provide user specific information beyond probabilities for each category, giving for example expected range of precipitation, crop yields by combining rainfall forecasts to soil moisture and river discharge or water level in reservoir and dams. Estimates of expected damages and population affected if a given climate outlook expectations materializes have also been requested by disaster management community.
- Climate experts and users need to work in partnerships to better develop, interpret and exchange on the forecasts, options for measures and actions.

2.3.2. Use of climate information and services. The key to improving the use of climate information and services would be building the capacity the user community to understand, demand and use climate information and services. Users must be equipped to appropriately interpret and apply climate information while also clearly understanding the possibilities and limitations of the information. On the other hand, climate scientists must develop a better understanding of the information needs of different user groups so that outputs can be effectively targeted. Those working as intermediaries between users and producers must be able to translate the scientific concepts into language that users can understand and apply. Some others ideas include the following (Ziervogel et al., 2008a; Ziervogel et al., 2008b; Ziervogel et al., 2008c):

- User organized workshops, dialogue and regular exchanges with climate communities on forecast reliability, accuracy, consistency and value, incorporation of climate forecasts into

development policies, plan and practices, and climate change adaptation would be very important. Multisectoral climate outlook forums would be a priority endeavor in this respect.

- A better climate service for decision making must ensure that NMHSs and other local climate services be able to respond to local users, often by providing locally relevant information and those services.
- A culture change is required to build a chain of communication that realises the benefits of advances in climate predictions to society. The chain must target decision makers responsible for national infrastructures and welfare, and should include also climate intermediaries and NMHSs, sectoral scientists, government, business sectors, media, and others.
- Involving sectoral scientists and decision makers as collaborating partners very early in the process is critical to ensure relevance, trust, and ownership of climate-related decision systems.
- Document and disseminate the pitfalls, benefits and success stories of climate products.

2.3.3. Some new initiatives. There are number initiatives underway to improve the generation, delivery and use of climate information at global, regional and national levels. The Global Framework for Climate Services (GFCS) is a significant global initiative. One of the priorities of the GFCS is capacity building for developing countries. The Task Force created for formulating the GFCS "has found that about 70 countries do not have the necessary basic capabilities to provide sustainable access to climate services. It therefore recommends that a high profile programme of fast-track projects be established to build the necessary capacity of the countries, in accordance with their needs and priorities," WMO (2011).

At regional level ClimDev-Africa programme (UNECA, 2008) has been established to support Africa's response to climate variability and change by building regional, sub-regional and national policy capacity. ClimDev also aims at improving the quality and availability of information and analysis to decision-makers. The ACPC is a component of the ClimDev programme, covering the whole of Africa and focusing on knowledge generation, sharing and dissemination; advocacy and consensus building; and technology transfer and service delivery. The first component of the ClimDev has targeted enhancing the capacity of African climate centers to generate and make widely available relevant climate-related information to end-users. These centers are: the African Centre for Meteorological Applications for Development (ACMAD), the Agro-meteorology and Hydrology Regional Centre (AGRHYMET), IGAD Climate Prediction and Application Centre (ICPAC) and the former SADC Drought Monitoring Centre (DMC) at Gaborone, Botswana but currently called the SADC-Climate Services Centre (CSC). This phase of ClimDev is already underway.

At sub-regional level WMO is promoting the creation of Regional Climate Centers (RCCs). The RCCs are regional institutions with capacity and mandate to develop high quality regional scale climate products using global products and incorporating regional information. The RCCs will, with the new knowledge and tools developed through applied climate research, generate regional and sub regional scale tailored products. RCCs will provide online access to their products/services to national climate centers and to other regional users. Typically RCCs will (GFCS, 2009, p.11):

- Downscale, interpret and assess relevant prediction products from global centers;
- Monitor regional climate variability and extremes;
- Implement and conduct Climate Watches;
- Develop quality controlled regional climate datasets for temperatures (minimum, maximum and mean) and for total precipitation, rainfall and snowfall; and

- Share regional and sub regional products and information.

3. Climate Science in Africa: status, gaps, and way forward

Climate science is the systematic study of the climate at a specified location and time period as governed by natural laws. Climate science deals with (1) developments in the scientific understanding of past and present climate, climate variability, climate predictability, climate change including feedbacks from climate impacts; (2) progress in the modelling and projection of global and regional climate and sea level change; (3) observations of climate, including past climates, and assessment of trends and anomalies; and (4) gaps and uncertainties in current knowledge (IPCC, 1996). Africa's climate is very diverse and highly variable with the Sahara deserts at one extreme and the very humid Congo rainforest at the other. There are several processes that drive the African climate, which are interrelated in complex and still not yet fully understood ways. These processes include tropical convection, the monsoons, the El Niño-Southern Oscillation (ENSO) in the equatorial Pacific ocean as well as sea surface temperatures of the surrounding Mediterranean sea, tropical Atlantic and Indian oceans.

Scientific understand of the climate system is vital to improve our ability to predict climate and help users incorporate its inherent uncertainty into their decision-making. However, scientific understanding of the African climate system is very low, and the level of understanding varies significantly from region to region. Though it is improving, our understanding of the drivers of the African climate and their complex interactions is still very poor. This lack of knowledge limits our ability to analyze and understand African climate variability, detect and attribute climate change, and predict the climate with an appreciable degree of accuracy. This in turn limits our ability to manage climate variability and adapt to climate change. The current drought and famine in East Africa is part of a recent trend for that region (Williams and Funk, 2011). However, climate model projections suggest the climate of the region will become wetter by the end of this century. Projections for the current and few coming decades are still uncertain. What are the different physical processes? How well are the drivers of African climate represented in climate models including the delivery of remote signals? Answering such questions underscores a critical need for enhanced scientific understanding of the climate of Africa. We need to address the fundamental gaps in our understanding of the drivers of the recent climate extremes across Africa and how anthropogenic climate change may alter the physical characteristics of the climate.

The lack of sufficient knowledge about Africa's climate system has resulted from chronic lack of research. There are only few centers that are capable of running global and regional climate models. The level of engagement of African scientists in different international scientific activities, such the Intergovernmental Panel on Climate Change (IPCC), has been very limited. As a result, adaptation research and availability of evidence have been dominated by the industrialized north. This has implication with respect to the applicability these research results in the Africa contest. Low capacity in climate research has been widely noted and identified as a barrier to progress in the understanding and use of climate information by the African society (Conway, 2011). Thus, there is an urgent need for building research capacity to understand the dynamics of the global drivers on the one hand, and detailed consequences at local levels on the other. This chapter will provide a summary of current status, major gaps and what needs to be done going forward.

3.1. Current status

The main players in national climate science in Africa are NMHSs, universities, research institutions (mainly agriculture, water and environment), and regional climate centers. However,

scientific research is very weak at all levels. Most NMHSs do not have the capacity to conduct research as they use their limited resources on operational activities. The regional climate centers are not different. There are very few universities involved in climate research in Africa, and their capacities are very limited. Job opportunities for climate professionals are very limited. As a result, there are few universities that offer post-graduate programmes in climate science and related fields. A related problem is that Africa has been losing climate scientists to US, Europe, and other developed countries. Few of the many of African students who are educated abroad return home. They are contributing significantly to research in the developed world with less benefit to the countries of birth. Very few centers are capable of running global and regional climate models and even fewer of experimenting with model components. Downscaling activities are limited as well. Most climate modelers tend to rely on only one model output for their analysis, be it a GCM or a downscaled model (Ziervogel et al., 2008c). The low-level climate research capacity and activity is manifested by few publications by African scientist in international journals. Figure 1 compares affiliation of lead author of papers in two climate journals during 2002–2004.

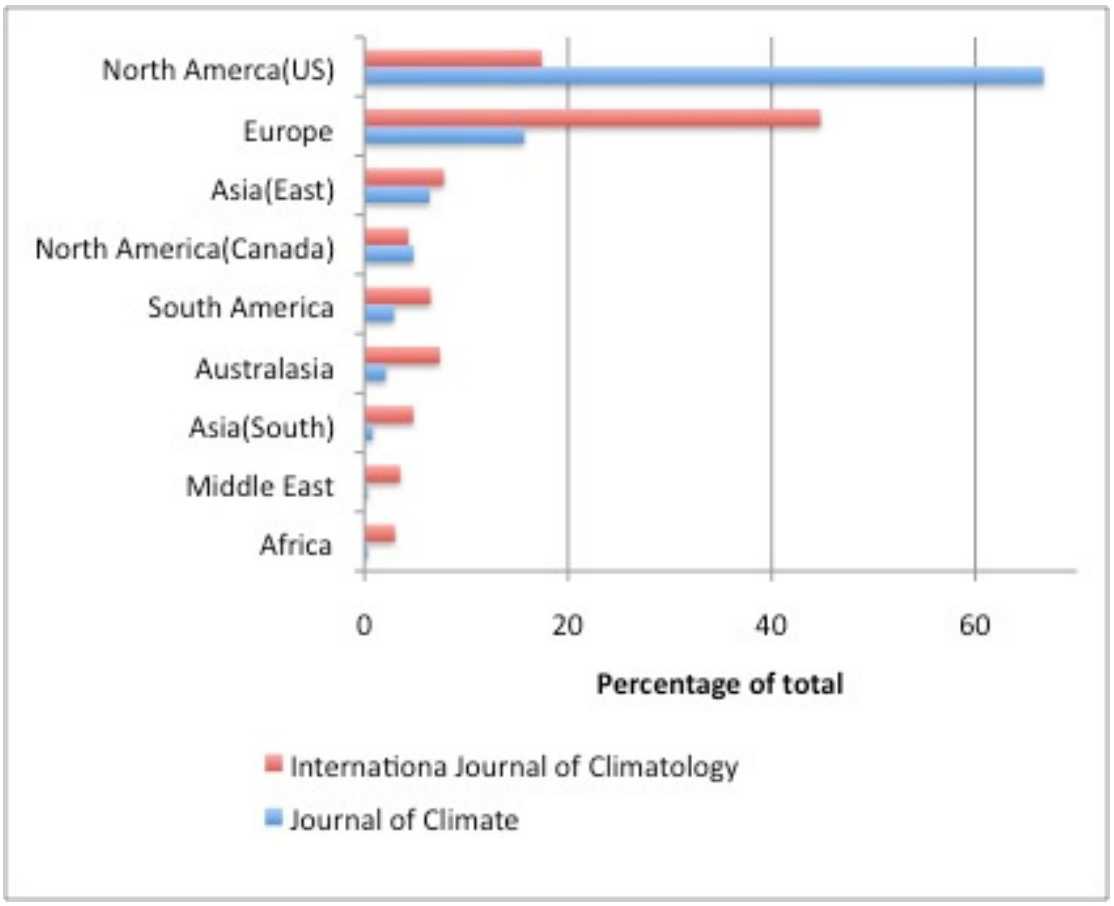

Figure 1: Affiliation of lead author of papers in the International Journal of Climatology, and Journal of Climate during 2002–2004; data from Washington et al. (2006).

But all is not so bleak. Climate research in Africa is receiving more and more attention. There have been some promising efforts that may contribute to bridging the research gaps in climate research in Africa. Some of these efforts include the following (Conway, 2011):

- The Adapting to Impacts of Climate Change Programme (AIACC) supported Research- Driven Capacity Building in Developing Countries in a three year Programme through 11 projects across Africa.
- The African Monsoon Multidisciplinary Analysis (AMMA) is an international project to improve knowledge and understanding of the West African monsoon through collaboration

between Europe, USA, and West Africa.

- The Africa Climate Policy Centre (ACPC) is a new center created under the auspices of UN Economic Commission for Africa; it has a good potential for fostering climate research in Africa.
- The African Climate Change Fellowship Programme (ACCFP) offers experiential learning, education, research and training opportunities to African professionals, researchers and graduate students that will build their capabilities for advancing and applying knowledge for climate change adaptation in Africa. ACCFP follows on from a long-running successful programme through START.
- The Climate Change Adaptation in Africa (CCAA) programme aims to: strengthen capacity of African scientists, organizations and decision makers to contribute to adaptation; support adaptation by rural and urban people through action research; better share understanding of the findings of scientists and research institutes on climate variability and change; and inform policy processes with good quality science-based knowledge.

3.2. Major gaps

Some of the major gaps in climate science in Africa include the following (Runci, 2007; Conway, 2011; Ziervogel et al., 2008c):

- Chronic lack of investment in postgraduate education and research infrastructure for climate science. Climate science is not the priority for most African countries as they allocate their limited resources on addressing near-term pressing challenges.
- Lack of availability/accessibility of reliable historical climate data.
- Lack of human resources and computational capacity to expand the available databases. In particular, running dynamical downscaling models requires considerable computational capacity and there are currently few computers available on the continent, which are powerful enough to run these models.
- There has been no coordinated programme of research on climate and climate change supported by governments or any other bodies. As a result, the current situation for research is rather *ad hoc*; research findings and other activities tend to appear through largely disconnected projects often with different approaches or scenarios.
- There has not been much work linking impacts of climate change with the practical implications of climate change for near-term planning and management.
- Most studies have focused on long-term changes, generally beyond the 2050s and rarely set impacts in the context of future socio-economic conditions, which may significantly outweigh the effects of climate factors (e.g., population growth).
- While the models used to generate scenarios of future emissions, climate change, impacts, and mitigation possibilities all include modules that simulate the key regions of the developing world, these characterizations often aggregate countries in ways that make little sense to indigenous experts and that bear far less resemblance to reality than those modules representing industrialized regions. The lower resolution and higher levels of aggregation of developing regions' modeling representation stems in part from a lack of sufficient and reliable data with which to populate the models and in part from limitations on indigenous modeling experience.
- Very little has been done to assessing the performance climate projections over African.

3.3. Way Forward

Some of the issues that need to be addressed in order to improve climate science and its role in sustainable development in Africa include the following:

- Create a center or network of centers of excellence for climate science and applications in Africa. This center would serve as continental resources center, help in building capacities of individual countries and NMHSs, and cater specifically to the needs of Africa. Existing climate institutions, such as ACMAD, could be transformed into such a center.
- Enhance substantive participation of developing country scientists in the process of generating new modeling scenarios of climate change. This will contribute both to capacity development in Africa also help improve the visibility of African concerns in the international climate change policy discourse.
- Conduct research to understand the nature and impacts of climate variability and change at local/community level.
- Undertake comprehensive assessment of the performance of global climate models and downscaling tools in the African contest.
- Given the prominence of ENSO role on interannual African rainfall variability, at least in some regions, determining future changes in interannual rainfall variability in Africa can only be properly considered in the context of changes in ENSO behavior. There is still ambiguity, about how ENSO, SST as dipoles modes and anomalies in oceans surrounding Africa may respond to global warming. Therefore the relative importance of Pacific, Atlantic, Indian oceans and Mediterranean Sea in modulating precipitation variability in Africa should be investigated.
- Research is needed to better isolate aspects of African climate variability that are natural from those that are anthropogenic.
- Increased climate variability would be a feature of climate change; thus, the ability to handle current climate variability is a vital requirement for coping with climate change. This would be a crucial step in building capacity to deal with climate change over the next decades and century. Thus, emphasis should also be placed on increasing capacity to manage climate variability.
- Given the limited number of African climate scientists, international collaboration on PhD programmes on priority scientific and application oriented questions would be crucial. The next generation of African climate scientists should effectively develop and produce climate information and knowledge based on African needs.
- National and regional datasets should be prepared for studies and operations. Ideally, a data library including methods and tools to facilitate access, processing and analysis to generate products and results for African countries is necessary. Given the experience of the IRI at Columbia University, the institute could facilitate development and operation of an African climate data integration and analysis system.
- Climate science training opportunities (e.g. seminars, workshops, summer schools and conferences) targeting African scientists should be promoted.
- Experts from global climate centers and university laboratories of developed countries could collaborate with and help improve research capacity at African regional climate centers (ACMAD, ICPAC, SADC-CSC, AGRHYMET) and lead universities.
- African scientists working on climate change adaptation should be encouraged to use outputs

of models and observations and interact with agriculture, disaster management and water resources groups.

- Expand developing countries' scientific capacity and level of participation in the international scientific discourse on climate change.
- Advanced web-based training materials, knowledge, methodologies and tools should be developed and made available. Scientists, operational climate service providers, policy makers, resource managers should be considered as main beneficiaries of capacity building initiatives.
- Ways should be explored to involve the African Diaspora in improving climate science in Africa.

4. Climate Science in Support of Sustainable Development

Climate variability and change have been recognized as major challenges to sustainable growth and development in Africa. Coping with negative impacts of climate would require implementing adaptation strategies that could reduce the vulnerability to current climate variability while building resilience against risks from climate change. This would involve effective management of climate risks through implementation of risk-reduction strategies within development activities. This is best achieved through mainstreaming climate issues into development planning and practice (Huq et al., 2006; Kok et al., 2006; APF, 2007; Klein et al., 2007). Mainstreaming involves the integration of policies and measures that address climate issues into development planning and decision-making. The United States Agency for International Development (USAID) recommends six steps in incorporation climate issues in project planning and implementation (Fig.2).

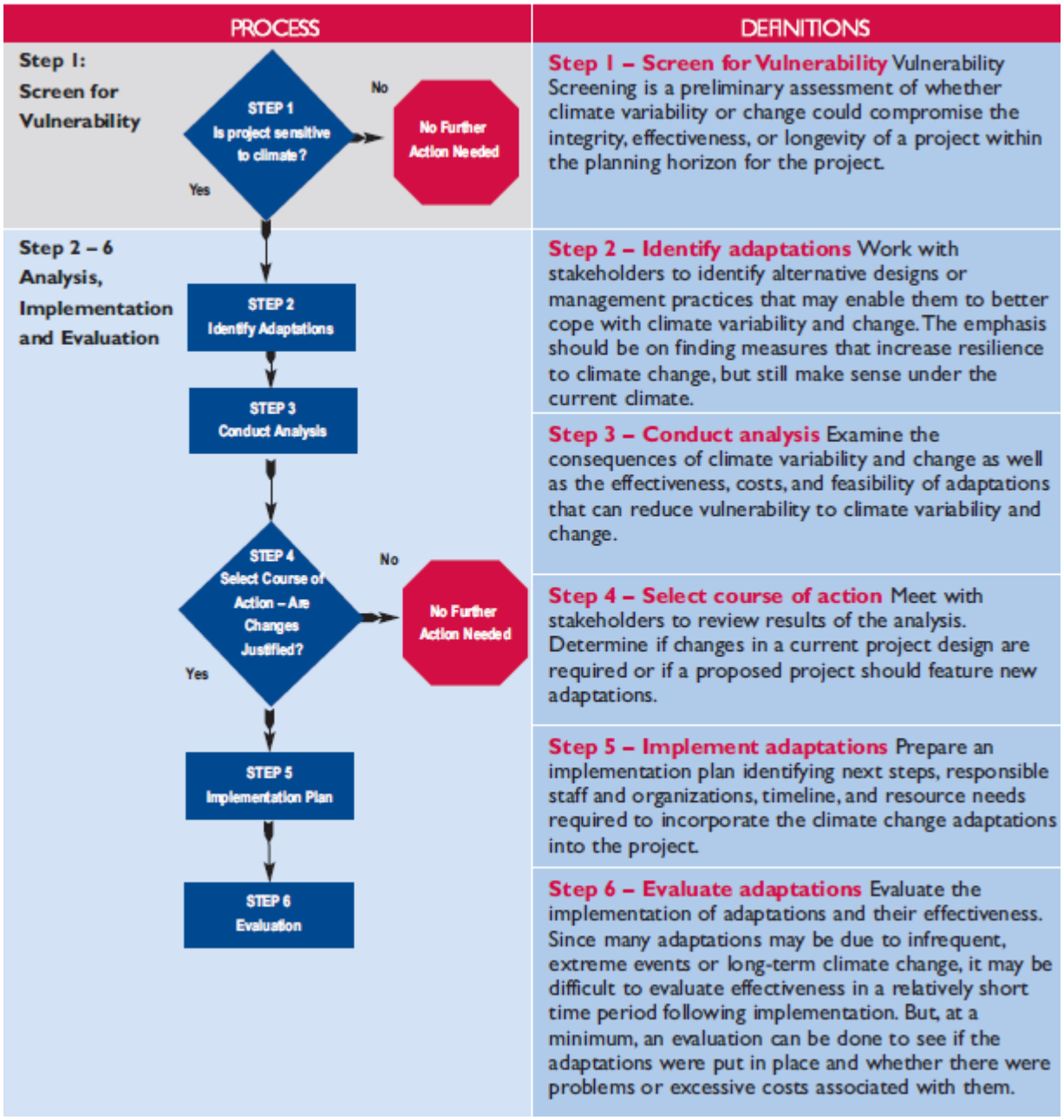

Figure 2: Steps to incorporate climate change into project planning (USAID, 2007)

The need for mainstreaming stems from the understanding that integrating climate issues into development activities would ensure the long-term sustainability of investments as well as to reduce the vulnerability of development activities to both today's and tomorrow's climate. The mainstreaming of climate issues into national development policies, planning and practice will also help to ensure consistency between the needs of adaptation and poverty eradication. This "holistic" or "development-first" approach of addressing climate risks should be part of an ongoing development policy-making, planning and activities across all sectors. Strategic level mainstreaming involves addressing the organizational environment in which policies and programmers are planned and implemented (Oates et al., 2011).

Effective use of the best available climate science is key for successful mainstreaming of climate issues into national development practices. It is critical that planners and decision makers are presented with data, analyses, and policy options. "*Successful anticipatory adaptation requires the*

best available information concerning the nature of future climate risks: therefore it is vital that climate science is used more effectively in adaptation decision-making,"(Ziervogel et al., 2008a). Science-informed policy, planning, and practice will ensure that development is more resilient and less vulnerable to negative impacts of climate, thus fostering sustainable development. Figure 3 summarizes the views of over 600 survey responses from researchers, policy-makers and intermediary organizations from the developed and developing countries on what information types are most useful to policy-makers in development policy decision-making (Jones et al., 2008). This section summarizes the current status of the use of climate science in development, the major gaps, and actions to be taken the bridge the gaps.

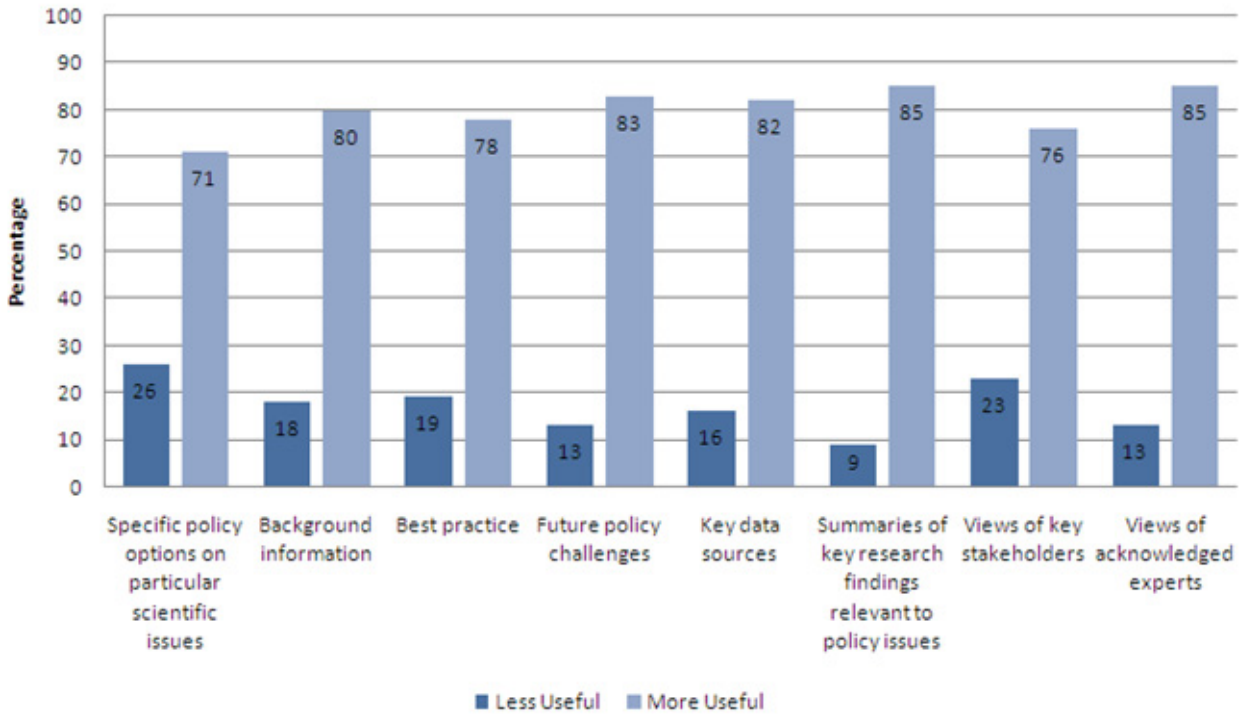

Figure 3: Information types found useful by policy-makers in development policy decision-making (Jones et al., 2008)

4.1. Current Status

Africa is a region most affected by climate variability and expected to suffer more from climate change. Thus, one would have expected better integration of climate issues in the planning and implementation of development programmes in this region. However, development planning and practice in Africa rarely takes into account risks associated with climate variability and change (Sperling, 2003; Fischer et al., 2005; Huq et al., 2006; Washington et al., 2006; APF, 2007). "*In spite of its pervasive importance, and powerful new advances in climate related science, opportunities have been largely under-exploited in decision-making in Africa. Lip service is paid to climate and its variability, but in practice, study after study has shown that climate information is rarely, if ever, incorporated into planning and management decision as effectively as it could be*" (IRI, 2005, p. 24).

This is also true for projects implemented by international development organizations in Africa. For instance, a review of 136 German-funded development projects in Africa (Klein et al., 2007) has shown that none of the project documents take climate issues into account explicitly. An in-depth study of five of these projects showed that climate change was not accounted for even in areas where there were obvious climate risks. Similar studies for the World Bank, Norwegian Agency for Development Cooperation, the UK Department for International Development (DfID), and OECD

(Organization for Economic Co-operation and Development) projects have shown that climate considerations were either totally absent or were very weak (Klein et al., 2007).

This does not mean climate science and information have not been used in Africa at all. There have been some efforts to use climate information in development activities. Planners and decision-makers in agriculture and food security, water and disaster management sectors have done relatively better in this respect (Huq et al., 2006). These efforts are visible both at national and regional levels. The International Research Institute for Climate and Society (IRI) has published a case study (Hellmuth et al., 2007) presenting some "good practices" in climate risk management in Africa. The six case studies in this document come from different parts of Africa and deal with different applications of climate information. Mozambique has put an early warning system for floods in place, which brings together meteorologists, hydrologists and disaster managers to forecast and monitor flood risks and issue warnings whenever necessary. The early warning system in Ethiopia, established some 30 years ago, has been effective in managing the different droughts the country has endured. This was accomplished by constantly monitoring the rain and related agricultural conditions, and mobilizing local and international resources on time. The approach in Mali, put in place 25 years ago, provides agrometeorological information and related advices directly to farmers. Malawi's pilot project provides index-based weather insurance to farmers in order to protect them against the impacts of severe droughts. Other examples of efforts to integrate climate issues into development include Senegal and Tanzania's attention to climate issues (Kok et al., 2006). Senegal is making efforts to adapt to long-term climate change through managing short-term climate variability using early warning systems and agricultural process. Tanzania has undertaken steps to protect its climate-sensitive economy from negative impacts of climate by featuring environmental issues in the different national and sectoral policies and strategies.

There have also been some efforts at regional and sub-regional levels. A good example for regional efforts in linking climate and development could be the Regional Climate Outlook Forums (RCOF). The first, Southern Africa Regional Climate Outlook Forum (SARCOF), was started in 1997 in Harare, Zimbabwe. This was then followed by the Greater Horne of Africa Regional Climate Outlook Forums (GHARCOF) and Prévision Saisonnière en Afrique de l'Ouest (PRESAO) for western Africa. These forums bring together climate forecasters and the major users of climate forecasts from countries in each region in order to produce consensus seasonal forecasts and discuss the implications and use of these forecasts (Basher et al., 2001). A related effort is that of the Malaria Outlook Forum (MALOF). In these forums malaria control experts meet to review the climate forecasts given by RCOF's, assess vulnerabilities, and devise action plans for dealing with malaria epidemics during coming seasons (Hellmuth et al., 2007). The success of these regional efforts is mixed. However, these initiatives could serve as springboards for the next level of climate-development integration. Most of the above examples deal with the use of climate information for disaster monitoring and prevention. It is still a long way from integrating climate into the overall economic activities. However, there is a potential for these disaster reduction and prevention policies to develop, albeit slowly, into climate-development integration in Africa.

4.2. Major Challenges

There are a number of challenges to integrating climate science into and development practices globally. Figure 4 is another result from the survey by Jones et al. (2008). It summarizes the issues the respondents' identified as major obstacles to the use of scientific information in development practices.

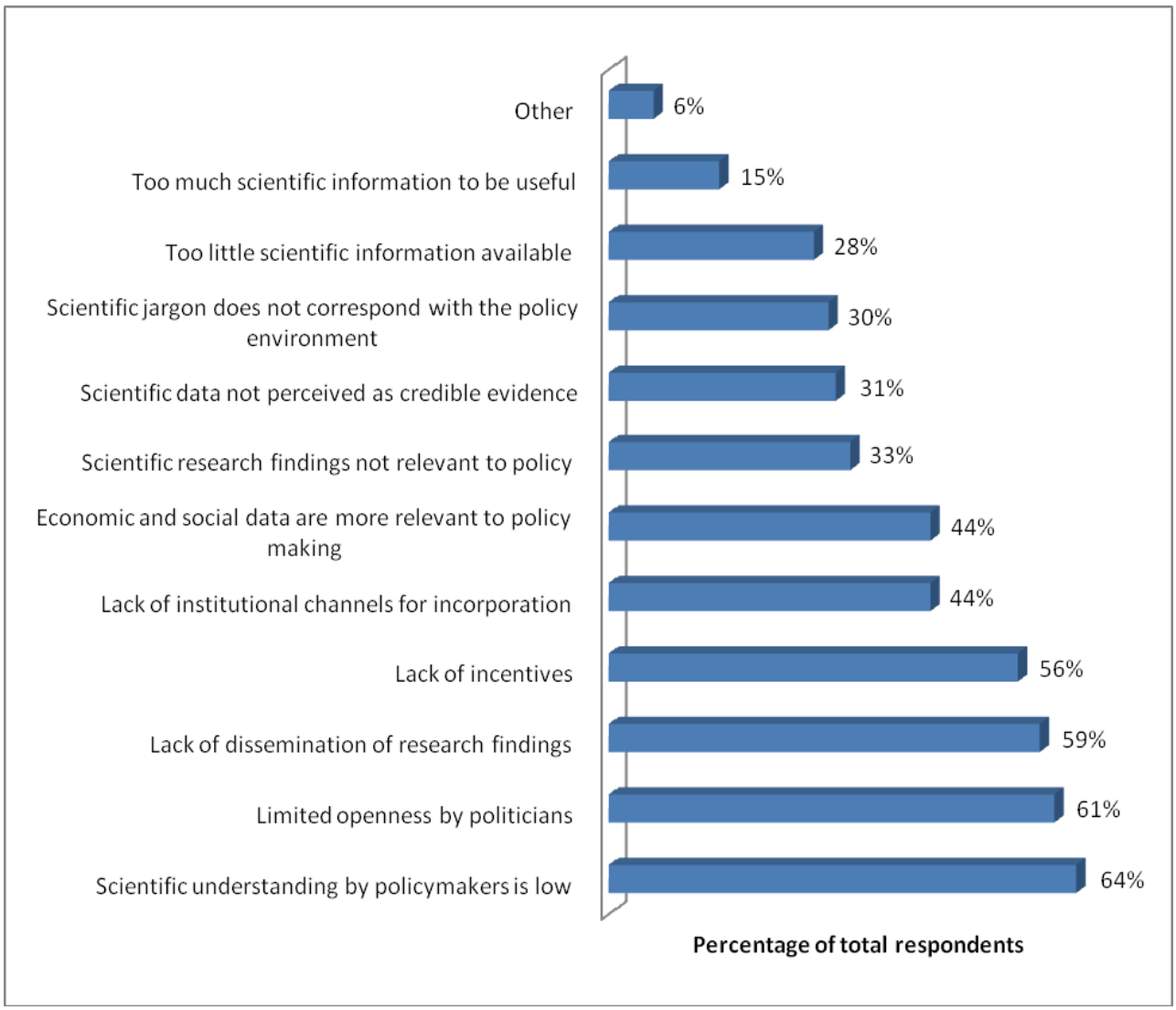

Figure 4: Obstacles to the uptake of scientific information in development policy-making (Jones et al., 2008)

The main obstacles to integrating climate science in development activities in Africa include the following (IRI et al., 2006; Washington et al., 2006; Corbera et al.2006; Ziervogel et al., 2008c).

- Lack of capacity for integrating climate issues into development planning and implementation. This may include the lack of capacity to respond to climate information, reluctance to incorporate climate variability in management practices, inability to use relevant national agricultural research reports and lack of appropriate institutions.
- Lack of effective institutional arrangements to facilitate the generation, analysis and systematic integration of relevant climate information with other pertinent information in a form that planning and operational agencies can use.
- Lack of relevant and reliable climate and socio-economic data. The quantity and quality of climate information provided by African meteorological services has been deteriorating.
- Lack of qualified climate scientists, which is responsible for lack of capacity to present evidences as to the usefulness of integrating climate information into development.
- Lack of clear guidance on best practice for mainstreaming climate issues into development activities.
- Less priority is given to climate issues relative to other pressing issues such as poverty alleviation, food security, health, natural resource management, economic development and

energy needs.

- Lack effective coordination among different actors.
- Lack of access to the right information: In spite of the fact that many climate change projections are freely available, decision makers do not know where to access this information and are not yet accustomed to searching for this information.
- Communication gaps between scientists and development practitioners. Development practitioners often complain about not receiving the appropriate information while scientists may get frustrated because their information is not being used.
- Differences between the time scale at which most African policy makers and planers function, and that of available climate information. For many African planners the time it takes for climate change effects to take place, which is about 30 to 100 years, is beyond their horizon of concerns.
- Skepticism about the reliability of climate information.

4.3. Way forward

Although climate issues, particularly climate change, has been marginalized compared to the other more pressing development problems, there now seems to be some consensus that development plans need to take climate issues into account. As a result, more and more attention is being given to climate issues in the scientific, policy and development circles (Davidson et al., 2003; Sperling, 2003; Huq et al., 2006; Kok et al., 2006; APF, 2007; Klein et al, 2007). Donor organizations have begun incorporating climate issues into their development programmes (Huq et al., 2006, and references there in). There are some concrete steps taken by international development organizations towards mainstreaming climates issues in Official Development Assistance (ODA; Davidson et al., 2003; Sperling, 2003; Klein et al., 2007).

There are also some steps being taken at continental level to address the issue of climate and development. The Climate Information for Development Needs: an Action Plan for Africa (ClimDev Africa) programme (GCOS, 2006), and the consequent creation of the African Climate Policy Center (ACPC), is a good example of the new initiatives. The African Union (AU) has also recognized the need for adaptation to climate change and has issued a declaration on climate change and development in Africa (AU, 2007). This declaration includes the following:

- Avail funds to promote and strengthen the application of science and technology to climate data collection, analysis, generation of early warning information and timely communication;
- Integrate climate change and climate change adaptation strategies into national and sub-regional development policies, programmes and activities;
- Undertake targeted awareness raising amongst policy, decision makers and civil society with the view to ensuring that climate change considerations are taken into account in all sustainable development initiatives;
- Foster and strengthen cooperation between National Meteorological and Hydrological Services, Regional Climate Centers, Regional Economic Communities and institutions on matters of climate variability and climate change;
- Strengthen current African Regional and Sub-regional climate centers of excellence to address climate change and variability prediction as well as in the development of climate applications decision tools; and

- Develop and/or strengthen research and development in climate change in Africa, particularly in renewable energy, forestry and agriculture, to increase the continent's resilience and adaptation to climate change.

Though these initiatives are promising, successful use of climate science and information for sustainable development would require addressing the challenges mentioned above. Following are some recommendations for addressing these challenges (Corbera et al., 2006; IRI et al., 2006; Vogel et al., 2007; Ziervogel et al., 2008b; Ziervogel et al., 2008c)

- Strengthen funding for existing research institutions and networks in Africa.
- Improve collaboration among scientists and governments to share climatic information.
- Identify institutional mechanisms through which the natural disaster and climate change communities can be closely linked in terms of research effort and funding strategies.
- Capacity building should not be just a provision of short workshops; it should be a sustained process involving both African researchers and policy-makers, and conducting activities within African countries.
- Promote equal partnerships between Northern-based and African institutions, as well as African leadership, in networks and research programmers.
- Produce and disseminate comprehensive risk management guidelines focused on multiple climate-related risk (water, health, agriculture etc.) This should also provide practical demonstrations of climate risk management in different climate-sensitive sectors.
- Build the capacity of decision makers at all levels to incorporate climate risk management into the development process.
- Train sectoral and crosscutting specialists such as economists and statisticians involved in assessment of development outcomes, in the use of climate science and information for decision-making.
- Develop curriculum at all levels of education to ensure the broad uses of climate science and information.
- Improve collaboration between climate scientists and users and target scientific outputs to the needs of resource managers.
- Strengthen collaboration with local, regional and national governments in order to identify policy interventions, which reduce vulnerability and enhance adaptation.
- Recognize that the link between science and practice is not a simple linear process but a complex labyrinth of communication and engagement requiring patience and persistence.
- Practitioners and policy-makers should become more than mere recipients of scientific knowledge but should help to focus research on vulnerability, adaptation and resilience.
- Communication pathways should establish between users and information providers to facilitate feedbacks.
- Support translators who understand the challenges on both sides and can act as information conduits.
- Provide refined study of climate change modeling and scenarios on shorter timescales (5-20 years) in order to be consistent with development priorities and investments.
- Identify climate information and services required to improve climate risk management for the range of stakeholders, specifically targeting poor and vulnerable communities.

- Developing demand-led climate science, methods, tools and products.
- Assess quality of climate information products relative to user requirements.
- Assess the value of climate information for particular development outcomes.

5. Climate Science in Support of Policy

It has been realized that many African governments lack knowledge of climate change and the capacity to cope with the impacts. Climate change can be seen as a low priority when compared to pressing and clearly definable issues such as health, employment, housing and education. Communities in these countries may have few savings, few alternative livelihood opportunities and no insurance, and already be close to or even below the poverty line. So when a climate-related disaster strikes these countries are badly impacted. Many communities in these countries also live in particularly vulnerable areas. In cities, informal illegal settlements commonly occupy land on floodplains or at the foot of unstable hillsides.

At the UNFCCC's international climate talks, African countries, which comprise of many poorer countries, also suffer serious capacity constraints. Few can send more than a handful of delegates to these negotiations; and without financial and technical resources, negotiating against large well-prepared and paid teams from wealthier nations, who often see taking action on climate change as a threat to their economic development. This poses a huge challenge and an imbalance. However the world at large and particularly the developing countries including African countries have realized this problem in the process of these complex negotiations that they lack the necessary capacity to fully participate in these discussions. As a result some effort has been made to help these countries understand the underpinning problems of climate change and the need for their full involvement in these discussions and taking some response measures.

From the international level perspective some effort has been made by some of the United Nations agencies and programmes to help Africa understand the impacts of climate change and the need to take some precautionary policy measures in their planning process. There has also been some effort to equip the African negotiators with the necessary scientific background that can help them to engage effectively in the process of the negotiations and making decisions both at international and national level. IPCC (2007) through its authoritative scientific report informed the world the dangers the world is facing if we continue emitting greenhouse gases without taking the necessary precautionary measures. Following this report there have been several conferences, workshops, meetings and seminars where elaboration on these scientific results on climate change and its associated impacts have been elaborated. Our African leaders and experts have participated in many of these events as part of making them scientifically informed of the impacts of climate change.

The United Nations Environment Programme (UNEP) through the African Ministerial Conference on the Environment (AMCEN) process has help to create awareness to the African Ministers of Environment on matters related to climate change and bring them to a common stand at the international level on these matters. A good example of such effort is the Nairobi Declaration on the African process for Combating Climate Change (2009). The Declaration, among other issues, called upon Governments of Africa to promote further the common African position on the comprehensive international climate change regime beyond 2012 and participate actively in the continuing international negotiations, knowing that failure to reach a fair and equitable outcome will have direct consequences for Africa. They also agreed that the African common position forms the basis for negotiations by the African group during the negotiations for a new climate change regime and should take into account the priorities for Africa on sustainable development, poverty

reduction and attainment of the Millennium Development Goals. They further agreed to urge all Parties and the international community that increased support to Africa under the future climate regime should be based on the priorities determined by Africa: adaptation, capacity-building, research, financing and technology development and transfer, including support for South-South transfer of knowledge, in particular indigenous knowledge. This was strongly supported by the African Union Commission and the UNEP Executive Council. UNEP has also supported countries to carry out studies that help to identify policies that address climate change issues at national, sub-regional and regional levels.

The Bali Action Plan, adopted at COP 13 in Bali, December 2007, identified adaptation as one of the key building blocks required for a strengthened future response to climate change to enable the full, effective and sustained implementation of the Convention through long-term cooperative action, now, up to and beyond 2012. Adaptation to the adverse effects of climate change is vital in order to reduce the impacts of climate change that are happening now and increase resilience to future impacts. The UNFCCC webpages on adaptation highlight the range of issues that are being addressed by Parties under the various Convention bodies, including Cancun Adaptation Framework, Nairobi Work Programme and issues related to implementing the National Adaptation Programmes of Action (NAPAs) and supporting adaptation through finance, technology and capacity building. Considering the importance of addressing issues related to adaptation to climate change, the above AMCEN Nairobi Declaration puts adaptation as one of their priority areas to be addressed. The National Adaptation Programmes of Action (NAPAs) provide an important way to prioritize urgent and immediate adaptation needs for Least Developed Countries (Article 4.9 of the UNFCCC). The NAPAs draw on existing information and community-level input. A database of all NAPA priority adaptation projects sorted by country and sector is available online at the UNFCCC Least Developed Countries (LDC) portal. A number of African countries have submitted NAPAs projects to the UNFCCC Secretariat. Some of these projects are already being implemented by the respective countries.

African common position in the negotiations process is very important. Therefore during the climate conferences such as the Conference of the Parties, the African Group has always been coordinated to have common position on various issues. Of course this has not been easy because of the differences on national priorities and sometimes donor influence has contributed to divide the group's positions.

Scientific UN Agencies such as WMO and UNESCO and other institutions have continued to inform the world including African negotiators the importance of scientifically informed decisions (WMO, 2010). The World Climate Conference3 (WCC3) organized by WMO with other partners confirmed the need for improved climate services to underpin, inter alia, decision making for climate change adaptation. In its Declaration the WCC3 called for the implementation of a Global Framework for Climate Services (GFCS) to meet this urgent, global need for improved climate service to serve a broad range of needs including, and beyond, those of the UNFCCC (WMO, 2009). Learning to adapt to present weather and climate variability helps develop capacity to adapt to climate change tomorrow. Comprehensive climate information and services at various levels from global to regional, national and local at various timescales is fundamental to the design of effective adaptation policies. A Global Framework for Climate Services will generate comprehensive understanding of the climate system; fill information gaps at global, national, and local scales; and enable use of such information in various socioeconomic sectors. Enhanced research, comprehensive observations, and efficient and effective service delivery and service application constitute the essential components of such a framework. The WCC-3 declaration is very strong in calling for the need to fill gaps in areas where meteorological data are sparse because these are the basis for good scientific output. These Agencies have either jointly or alone on a number of occasions held side events at the UNFCCC Conference of the Parties (COP) Session to

highlight the need for science based decision making on climate change related matters.

ACPC being an African institution responsible for addressing climate policy issues will have to work with some of these Agencies and institutions to ensure that their efforts are being coordinated in the best way for the interest of the African countries. As part of its advocacy role, it will have to coordinate capacity building activities that contribute to enhance the scientific understanding on these issues of our negotiating teams.

6. Role of ACPC

One of the major obstacles to integrating climate issues into development activities in Africa has been lack of appropriate institutions that facilitate incorporating science into policy, ensuring that scientific knowledge is effectively shared with policy-makers in a timely and relevant manner (IRI et al., 2006; Ziervogel et al., 2008c; Jones et al., 2009; Dinku, 2010). A recent study (Jones et al., 2009)) reports wide consensus on the need for intermediary organizations that serve as knowledge brokers at the science–development-policy interface and as capacity builders for both researchers and policy-makers. Figure 5 shows the most important functions of an intermediary organization according the survey. The African Climate Policy Center (ACPC) would be ideal for this role at continental level. Being responsible for the operations of ClimDev, ACPC could facilitate the science-policy and science-practice interfaces by building the capacities of both researchers and policy-makers. It is well placed to play a bridging role between research, policy and practice. It should also advocate and support the development of a solid foundation of applied climate science for assessments of climate vulnerability, risks and impacts, and analysis and formulation of policy options for better integration of climate issues into development practices.

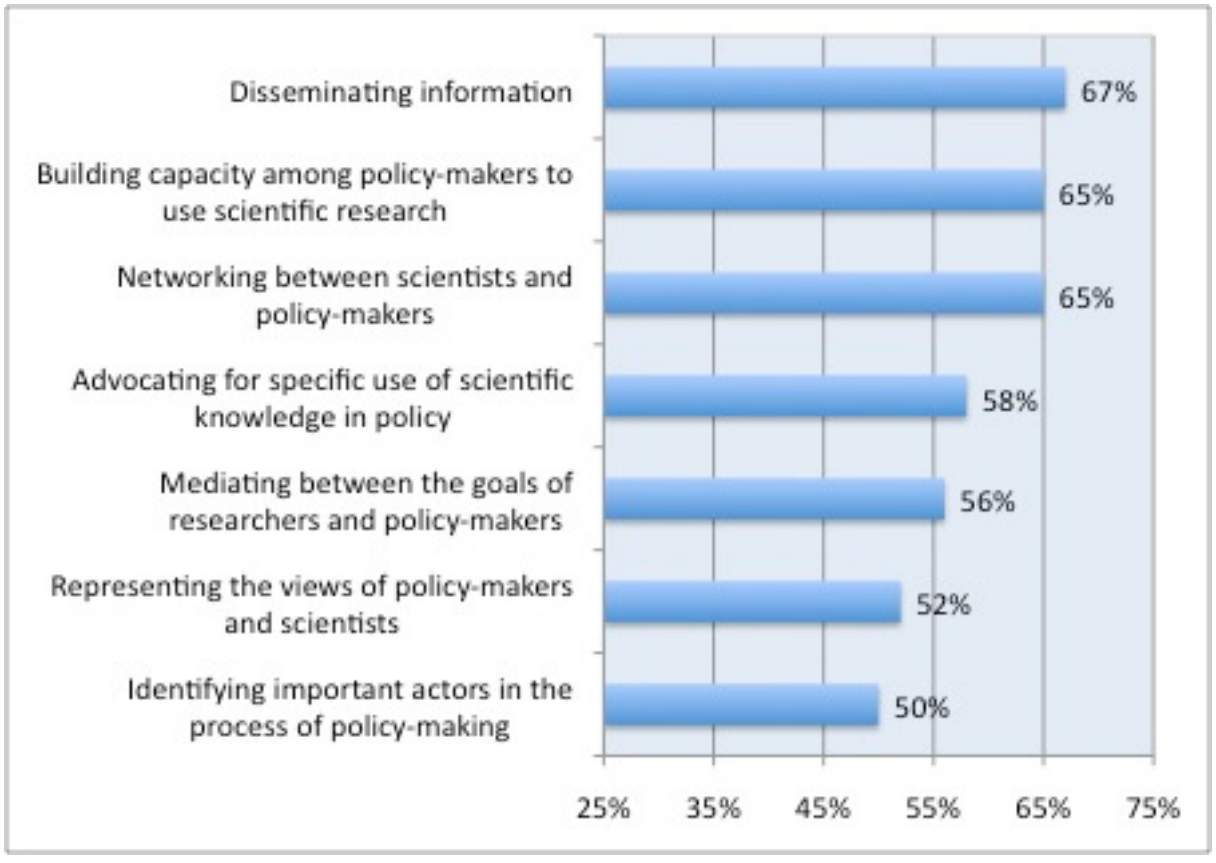

Figure 5: Most important roles for an intermediary organization; based on an international survey with more than 600 developing and developed country stakeholders, key informant interviews with 30 global experts, and

six country case studies (Jones et al., 2009)

Other more specific roles for ACPC may include the following:

- Strengthening climate services in Africa, in collaboration with regional (ACMAD, ICPAC, SADC-CSC, AGRHYMET) and international (WMO, GCOS, and other) institutions, by building the capacities climate institutions at all levels;
- Promoting and supporting the creation of regional center or network of centers of excellence for climate science and applications;
- Making sure Africa fully participates in and drives the maximum benefits from the GFCS;
- Defining requirements for decision-relevant climate information and services in consultation with the users;
- Building the capacity of the user community in to understand, demand and use climate information and services in development activities;
- Fostering collaborations among African universities and relevant international institutions from both the north and south.
- Raising awareness of decision-makers, advisors, planners and other development practitioners on the need for, and value of integrating climate issues into decision-making processes;
- Assisting governments and regional economic communities in the formulation of national climate policies and strategies and their implementations;
- Identifying, documenting, and disseminating effective climate risk management and adaptation options;
- Assist climate service providers to understand how policies and decisions are made and tailor climate services accordingly;
- Lead institutional or organizational reforms and establishment of optimal working arrangements needed to facilitate interdisciplinary work at the climate science-policy and practice interface
- Facilitating the collection, organization and use of socio-economic and other non-climate data for use in climate-development research and applications;
- Organizing training on communication of climate information for NMHSs and stakeholders; encouraging governments to invest in diverse dissemination structures;
- Facilitate the effective participation of the African Diaspora in climate science and applications in Africa.

7. Conclusions

Africa has been suffering a lot from climate fluctuations for decades. And climate change is making it worse. Comprehensive climate risk management strategies would be instrumental to manage climate variability and adapt to climate change. This is best achieved through mainstreaming climate issues into development policies and practices. Integrating climate issues into development activities would ensure the long-term sustainability of investments as well as to reduce the vulnerability of development activities to both today's and tomorrow's climate. Effective use of the best available climate science and information is a key for successful mainstreaming of climate issues into national development practices. It is critical that planners and decision makers are presented with data, analyses, and policy options.

Despite the fact that climate issues play a significant role in the economic development of most African countries, development planning and practice in Africa rarely takes into account risks associated with climate variability and change. There are serious challenges both in the provision of climate information and its use. In the supply side, the climate community in Africa has not been able to provide appropriate decision-relevant climate information. Responsible factors include lack of adequate institutional arrangements and trained manpower, inadequate station network, and very weak communication and computational capacity. The climate community has also not been able to use the available national and regional capacities, and international opportunities effectively. Thus, there are both lack and underutilization of capacity. From the demand side, even the available climate information is not being used effectively. Lack of appropriate climate information and services, lack of awareness about the existence of specific climate information, lack of understanding and capacity to use climate information, reluctance to incorporate climate issues in management practices and poor understanding on how to deal with scientific uncertainties have been among the major problems. Lack of communication and interaction between the user and climate communities has been another impediment.

Effective climate risk management in Africa would thus require strenuous efforts towards improving the provision of climate information and services on one hand, and promote the integration of climate into development policy, planning and practices on the other hand. Capacities should systematically be built both in the climate and user community. Some steps that need to be taken include the following:

- Investing in improving the capacities and competencies of NMHSs , national climate training and research institutes, regional climate centres and other climate related organizations to develop more science based reliable and useful climate information;
- Creating or updating national climate atlases, agroclimatic zones, crop calendars, climate suitability maps for climate-sensitive diseases, and other relevant maps;
- Establishing a regional center or network of centers of excellence for climate science and applications;
- Facilitating the establishment of African climate services user interface platform to facilitate interactions, build trust between providers and users across the continent, support integration of climate information in policies, plans and practices;
- Promoting and supporting mainstreaming of climate issues into development policy, planning and practice;
- Building the capacity of decision makers and sectoral scientists in the understanding and use of climate science and information for decision-making at all levels; and
- Producing and disseminating comprehensive risk management guidelines, best practices, and proofs of concepts focused on multiple climate-related risks.

Lack of appropriate institutions that translate science into policy and practice has been one other impediment to the integration of climate issues into development activities in Africa. The ACPC is an ideal institution for this role. It should serve as a bridge between research, policy and practice. It should also strive to build capacities both in the climate and user communities.

8. References

APF (Africa Partnership Forum), 2007. Climate Change and Africa. 8th Meeting of the African Partnership Forum, 22-23 May 2007.

AU (African Union), 2007: Assembly of the African Union Eighth Ordinary Session, Addis Ababa -

Ethiopia, Decl.1 – 2 (VIII)
Basher, R., Clark, C., Dilley, M., & Harrison, M., 2001. Coping with climate: A way forward. (IRI Rep.CW/01/2). New York: International Research Institute for Climate and Society.
Conway, D., 2011. Adapting climate research for development in Africa. WIREs Climate Change,2, 428-450.
Corbera et al., 2006. Climate Change in Africa: Linking Science and Policy for Adaptation. Workshop Report, The Royal Society, London, March 30th 2006, 10p.
Davidson, O. Et al., 2003. The development and climate nexus: the case of sub-Saharan Africa. Climate Policy, 3S1, S97-S113.
Dinku, T., 2010. The Need for National Centers for Climate and Development in Africa. Climate and Development, 2, 9-13.
Fischer, G., M. Shah, F.N. Tubiello, and H. van Velhuizen, 2005. Socio-economic and climate change impacts on agriculture: an integrated assessment, 1990-2080. Phil. Trans. Royal. Soc. B, 360, 2067-2073, doi:10.1098/rstb.2005.1744.
GCOS, 2006. Climate Information for Development Needs An Action Plan For Africa, Report and Implementation Strategy. Global Climate Observing System, United Nations Economic Commission for Africa, and the African Union Commission.
Global Framework for Climate Service (GFCS), 2009. Concept Note Verbal 3.4
Grey, D., & Sadoff, C. W., 2006. Water for growth and development. In Thematic documents of the World Water Forum. Mexico City: Comision National del Agua.
Hansen, J. W. et al., 2004. Climate variability and the millennium development goal hunger target. (IRI Technical Report No. 04-04). New York: International Research Institute for Climate and Society.
Hellmuth, M. E. et al. eds., 2007. Climate risk management in Africa: Learning from practice. New York: International Research Institute for Climate and Society.
Huq, S., Reid, H. & Murray, L.A., 2006. Climate and development links. (iied Gatekeeper Series 123). London: International Institute for Environment and Development.
IPCC, 2007. Fourth Assessment Report. Intergovernmental Panel on Climate Change, Geneva. Kelly C. and Khinmaung J., 2007. Prepare to Live: Strengthening the Resilience of Communities to Manage Food Insecurity in the Sahel Region. Tearfund, UK.
IPCC, 1996. Climate Change 1995: Impacts, Adaptations, and Mitigation of Climate Change: Scientific-Technical Analyses. Contribution of Working Group II to the Second Assessment Report of the Intergovernmental Panel on Climate Change [Watson, R.T., M.C. Zinyowera, and R.H. Moss, eds.]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 880 pp.
IRI, GCOS, DfID, & ECA, 2006. A Gap Analysis for the implementation of the Global Climate Observing System Programme in Africa. (IRI Technical Report No. IRI-TR/06/1). New York: International Research Institute for Climate and Society.
IRI, 2005. Sustainable development in Africa: Is the climate right? (IRI technical note No. IRI-TR/05/1). New York: International Research Institute for Climate and Society.
Jones, J., 2010. Capacity of African National Meteorological and Hydrological Services. Report Prepared at the request of for World Bank.
Jones, H., Jones, N., Walker, D., and Walsh, C., 2009. Strengthening science–policy dialogue in developing countries: a priority for climate change adaptation Background Note, ODI: London.
Jones, H., Jones, N., Walker, D., and Walsh, C., 2008. Political science? Strengthening science–policy dialogue in developing countries. ODI Working Paper 294. ODI: London.
Kadi, M., Njau, L.N., Mwikya, J., Kamga, A., 2011a. The State of Climate Information Services for Agriculture and Food Security in West African Countries. CCAFS Working Paper No. 4. Copenhagen, Denmark.
Kadi, M., Njau, L.N., Mwikya, J., Kamga, A., 2011b. The State of Climate Information Services for

Agriculture and Food Security in West African Countries. CCAFS Working Paper No. 5. Copenhagen, Denmark.

Klein, R.J.T. et al., 2007. Portfolio screening to support the mainstreaming of adaptation to climate change into development assistance. (Working Paper 102). Norwich: Tyndall Center for Climate Change Research.

Kok, M.T.J., Metz, B., Verhagen A. & van Rooijen, S.N.M., 2006. Policy Brief on Integrated Development and Policies: how to realize benefits at national and international level. Netherlands: Netherlands Environmental Assessment Agency.

Oates, N., Conway, D., and Calow, R., 2011. The 'mainstreaming' approach to climate change adaptation: insights from Ethiopia's water sector. Background Note, ODI: London.

Patt AG, Ogallo L, HellmuthM, 2007. Learning from ten years of climate outlook forums in Africa. Science 318:49–50

Sperling, F. ed., 2003. Poverty and climate change-reducing the vulnerability of the poor through adaptation. AfDB, ADB, DfID, EC DG Development, BMZ, DGIS, OECD, UNDP, UNEP & the World Bank. Washington, DC: The World Bank.

Vogela,C, Moserb, S. C., Kaspersonc, R E., and Dabelkod, G. D., 2007. Linking vulnerability, adaptation, and resilience science to practice: Pathways, players, and partnerships. Global Environmental Change, 17, 349–364

Runci, P., 2007. Expanding the Participation of Developing Country Scientists in International Climate Change Research. Environmental Practice, 9, 225-227.

Vogela, C., Moserb, S. C., Kaspersonc, R. E., and Dabelkod, G. D., 2007. Linking vulnerability, adaptation, and resilience science to practice: Pathways, players, and partnerships.

UNECA, 2008. Climate for Development in Africa Frame Work Document. Addis Ababa, Ethiopia.

Washington, R. et al., 2006. Africa climate change: Taking the short route. Bulletin of American Meteorological Society, 87, 1355-1366.

Williams, A.P., Funk, c., 2011. Westward extension of the warm pool leads to a westward extension of the Walker circulation, drying eastern Africa. Climate Dyn. DOI 10.1007/s00382-010-0984-y.

WMO, 2011. Climate Knowledge for Action: Global Framework for Climate Services – Empowering the Most Vulnerable. WMO-NO 1065, WMO, Gneeva, 248p.

WMO, 2010. WMO statement on the status of the global climate in 2010. WMO - No. 1074. World Meteorological Organization, Geneva.

WMO, 2009. WMO statement on the status of the global climate in 2009. WMO - No. 1055. World Meteorological Organization, Geneva.

Ziervogel, G., Downing, T., and Shale, M., 2008a. Effective use of climate science to improve adaptation in Africa. Policy brief, SEI, Oxford, 2p.

Ziervogel, G., Downing, T., and Shale, M., 2008b. Using Science to Improve Adaptation in Africa Policy brief, SEI, Oxford, 4p.

Ziervogel, G. et al., 2008c. Climate Change and Adaptation in African Agriculture. SEI, Oxford, 54p.