African Climate Report

A report commissioned by the UK Government to review African climate science, policy and options for action

December 2004

Contacts:

Dougie Brew, DFID, London

Richard Washington, University of Oxford

<u>Report Authors:</u>

Richard Washington, Climatology Research Group, Oxford University Centre for the Environment

Mike Harrison, Hadley Centre, UK Meteorological Office

Declan Conway, School of Development Studies, University of East Anglia

<u>Contributing Report Authors:</u>

Emily Black, Centre for Global Atmospheric Modelling, University of Reading

Andrew Challinor, Centre for Global Atmospheric Modelling, University of Reading

David Grimes, Department of Meteorology, University of Reading

Richard Jones, Hadley Centre, UK Meteorological Office

Andy Morse, Department of Geography, University of Liverpool

Martin Todd, Department of Geography, University College London

Disclaimer

This report was jointly funded by the UK Department for Environment Food and Rural Affairs and the Department for International Development. The views expressed in this report represent those of the authors and do not represent official policy of these Departments or the UK Government.

Acknowledgements

We gratefully acknowledge generous contributions of material, ideas and comments from:

Simon Mason, IRI, New York, USA
Brad Garanganga, DMC Harare
Neil Ward, IRI, New York, USA
Wassila Thiaw, Africa Desk, CPC, NCEP, USA
Dan Olago, University of Nairobi, Kenya
Mark New, Climatology Research Group, Oxford University Centre for the Environment
Gillian Kay, Climatology Research Group, Oxford University Centre for the Environment
Richard Graham and Andrew Colman, UK Meteorological Office
Tim Palmer and Francisco Doblas-Reyes, European Centre for Medium Range Forecasting, Reading, U.K.
Arona Diedhiou, IRD-NIGER, Niamey, Niger
Andre Kamga Foamouhoue, ACMAD, Niamey, Niger
Buruhani Nyenzi, Chief, CLIPS Office, WMO, Geneva
Laban Ogallo, ICPAC, Nairobi, Kenya
Jean-Pierre Ceron, Meteo France, Toulouse
Fred Semazzi, University of Carolina, USA.
Mark Jury, University of Zululand, South Africa
Mark Tadross, University of Cape Town, South Africa
Kelly Sponberg, RANET, NOAA

And personnel from the following National Met Services in Africa:

Bernard Gomez, The Gambia
Demlew Aweke, Ethiopia
Maurice Muchinda, Zambia
Abdelmalek Kirouane, Algeria
Tony Anuforom, Nigeria
Amos Makarau, Zimbabwe
Willem Landman, South Africa
Jerry Lengoasa, CEO, SAWS, South Africa

ACRONYMS

ACMAD	African Centre of Meteorological Applications for Development
ADCP	Acoustic Doppler Current Profiler
AGRHYMET	CILSS Regional Centre, Niamey
AIACC	Assessments of Impacts and Adaptations to Climate Change
AMMA	African Monsoon Multidisciplinary Analysis
AOC-HYCOS	Système d'Observation du Cycle Hydrologique de l'Afrique de l'Ouest et Centrale (West and Central Africa Hydrological Cycle Observing System)
CFAR	Climate Forecasting for Agricultural Resources
CILSS	Comité Inter-Etat pour la lutte contre la Secheresse dans le Sahel (Interstate Committee to Combat Drought in the Sahel)
CIMMS	Cooperative Institute for Mesoscale Meteorological Studies
CLICOM	Climate Computing Project (WMO)
CLIMAG	Climate Prediction and Agriculture
CLIPS	WMO Climate Information and Prediction Services
CLIVAR	Climate Variability and Predictability: World Climate Research Programme
CPC	Climate Prediction Center
DARE	Data Rescue (WMO)
DEFRA	Department for Environment, Food and Rural Affairs
DFID	Department for International Development
DIVERSITAS	International Programme of Biodiversity Science
DJF	December, January, February
DMC	Drought Monitoring Centre
ECA	Economic Commission for Africa
ECMWF	European Centre for Medium-Range Weather Forecasts
ENDA	Environmental Development Action in the Third World
ENSO	El Niño Southern Oscillation
EU	European Union
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
EWS	Early Warning System
FAO	Food and Agriculture Organisation of the UN
FEWS NET	Famine Early Warning System Network
FIVIMS	Food Insecurity and Vulnerability Information and Mapping Systems
FORSGC	Frontier Observational Research System for Global Change
G8	Group of Eight
GARP	Global Atmospheric Research Programme
GATE	GARP Atlantic Tropical Experiment
GCM	General Circulation Model
GCOS	Global Climate Observing System
GDP	Gross Domestic Product
GEF	Global Environment Facility
GHACOF	Greater Horn of Africa Climate Outlook Forum
GHG	Greenhouse Gas
GIEWS	Global Information and Early Warning System
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit (German Agency for Technical Co-operation)
HadAM3	UKMO Hadley Centre Atmosphere GCM
HadCM3	UKMO Hadley Centre Coupled GCM
ICPAC	IGAD Climate Prediction and Applications Centre
ICSU	International Council for Science
IDF	World Bank Institutional Development Fund

IGAD	Intergovernmental Authority on Development
IGBP	International Geosphere-Biosphere Programme
IHDP	International Human Dimensions Programme on Global Environmental Change
IISD	International Institute for Sustainable Development
IOP	Indian Ocean Panel
IPCC	Intergovernmental Panel on Climate Change
IPCC AR4	IPCC Assessment Report 4
IPCC TAR	IPCC Third Assessment Report
IRI	International Research Institute for Climate Prediction
IUCN	The World Conservation Union
JAMSTEC	Japan Marine Science and Technology Center
JJA	June, July, August
LDCs	Least Developed Countries
MDD	Meteorological Data Distribution
MDG	Millennium Development Goal
NAPAs	National Adaptation Plans of Action
NCEP	National Centers for Environmental Prediction
NGO	Non-Governmental Organisation
NMHS	National Meteorological and Hydrological Services
NMS	National Meteorological Services
NOAA	National Oceanic and Atmospheric Administration
NOAA/OGP	NOAA Office of Global Programmes
OASIS	Observational Activities for the Study of the Indian Ocean Climate System
OECD	Organisation for Economic Co-operation and Development
PRECIS	Providing Regional Climates for Impacts Studies
PRESANOR	Prévision Saisonnière en Afrique du Nord (Seasonal Climate Prediction Forum for North Africa)
PRESAO	Prévision Saisonnière en Afrique de l'Ouest (Seasonal Climate Prediction Forum for West Africa)
RANET	Radio and Internet for the Communication of Hydro-Meteorological and Climate Related Information
RCC	Regional Climate Centre
RCM	Regional Climate Model
RCOF	Regional Climate Outlook Forum
SADC	Southern African Development Community
SADC-HYCOS	SADC Hydrological Cycle Observing System
SAFARI	Southern African Regional Science Initiative
SARCOF	Southern Africa Regional Climate Outlook Forum
SATCC	Southern African Transport and Communications Commission
SBSTA	UNFCCC Subsidiary Body for Scientific and Technological Advice
SCOM	Sub Committee on Meteorology of SATCC
SODEFITEX	Société pour le Développement des Fibres Textiles (Society for the Development of Textile Fibres)
SRES	IPCC Special Report on Emissions Scenarios
START	System for Analysis, Research and Training
TAMSAT	Tropical Applications of Meteorology using SATellite and other data
TRITON	Triangle Trans-Ocean Buoy Network
UKMO	UK Meteorological Office
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
USAID	US Agency for International Development

VACS	CLIVAR Variability of the African Climate System
VAMOS	CLIVAR Variability of American Monsoon Systems
WCRP	World Climate Research Programme
WHYCOS	World Hydrological Cycle Observing System
WMO	World Meteorological Organisation
WWW	World Weather Watch

Contents

Summary

Future economic development across the African continent has a high level of dependency upon water availability. In turn, water availability is reliant on rainfall over a continent subject to marked inter-annual variations in rainfall and predicted, for much of its surface, to become drier as the atmosphere warms.

Yet there is a sense that climate is only marginally entering into development planning, and that societal resilience is not improving.

The net economic benefit of climate services to Africa and its development cannot be assessed. That climate knowledge is beneficial to the planning process cannot, nevertheless, be disputed. The thesis presented in this report, that substantial gains may be made within Africa through improvement of its climate services, is a based on four pillars:

- Climate observations are fundamental to all direct services, and further to all efforts to assess the role of future climate in development activities
- Research provides the underpinning of all services and advice, be it based on analysis of observations or the use of advanced models
- Prediction, either independently or in combination with observational knowledge, is the foundation of numerous planning activities
- But even if all the basic components were functioning fully, there is still the necessity for prompt delivery of services and information in appropriate formats to those who make decisions.

With this backdrop, the report identifies key issues in African climate for the international community to consider in order to support African development and bring African concerns into international climate change negotiations and assessments. The report evaluates a number of key questions: What is the state of the climate observing system in Africa? What issues surround climate prediction on all time scales? How good are the prediction tools? Is African climate science in a satisfactory state? How well does climate information and policy connect? What level of international support exists for African climate? What short and medium term actions could be taken to improve concerns and what are the associated costs and benefits?

It is shown that the African climate observing system is in a worse state than that on any continent and is deteriorating. The observing system underpins climate science, including satellite calibration, monitoring of change and variability, model evaluation, understanding of the climate system and climate prediction.

Relative to many parts of the world, the scientific understanding of the African climate system as a whole is low. For certain regions in Africa, the level of understanding is reasonable, for other parts, such as the Congo basin (a key for the global climate system), very little is known. Climate models are a crucial tool in climate prediction. Evaluation of global climate model products and the use of regional climate models (RCMs) is critical to the climate prediction process. But the level of technical expertise needed to support modelling in Africa and hence the level of activity, is very low, although some recent projects such as the application of the UK Met Office RCM, PRECIS, have been successful. International collaboration which is vital to support African climate science is certainly hampered by existing funding structures.

Traditionally the provision of climate services and information in many African National Meteorological Services (NMSs) has developed around transport demands, climate being a minor player. However, with the UNFCCC and, more recently, the events surrounding the 1997/98 El Niño together with the development of seasonal forecasting, NMSs have become far more aware of climate issues and their need to encompass these, but also of their resource limitations. Much remains to be done before climate information, especially on seasonal time scales, is used effectively in planning.

Encouragingly, seasonal forecasting, the provision of probabilistic climate information on time scales from months to a year, has been met with great engagement and enthusiasm in Africa. Within a global context, seasonal forecasting in Africa thus far is a success story. Given the intimate link between climate and sustainable development, the limited technical understanding of climate in Africa, and the restricted resource and expertise in handling climate issues within Africa, it is argued that raising the capacity of Africa to handle climate variability out to a few years will is an appropriate means to increase the resilience and reduce the vulnerability of the continent to climate variability and change on all time scales. This will provide one prime route towards sustenance of African society and its environment, as well as achievement of certain MDGs. Developing an adaptive capacity for climate change and climate variability can therefore be achieved through much the same mechanisms.

A number of options are identified to address African resource and capacity gaps in the areas of observations, research and model development, prediction activities, and of the delivery of climate services. All are parts of a continuous chain that provides benefits to sustainable development only insofar as the strength of the weakest link, and only after appropriate integration with other pertinent non-climate factors. The prime focus is on activities that may provide policy benefits over a few years. As stressed earlier, whether these proposals directly address climate variability or climate change is immaterial – they address both.

Options for action are provided within the context of gearing existing activities for both short-term and medium-term scales, but all have been filtered within the perspective of providing long-term legacy to African science, society and environment; all potentially provide substantive input towards the goal of sustainable development. It is envisaged that the activities suggested will build legacies appropriate to Africa and ensure ownership of all processes associated with climate science and society. Suitably managed, these legacies should feed back into the international arena, thus helping raise the profile of the continent.

All proposed options have been considered critically regarding the delivery of African needs, in terms of vulnerability reduction, creation of capabilities within Africa that fill essential gaps regarding development, building partnerships within and external to Africa, and raising the national, regional and international profiles of Africa within the climate, development and decision making communities. Options are reviewed in funding terms, legacy for Africa, the benefits and urgency of each option, and the magnitude and sourcing of initial and on-going costs (see Summary Table 1). Known impediments in terms of bottlenecks, policy issues and other external influences are considered in Summary Table 2.

Africa and climate: report background

The economies of Africa are predominantly agricultural, an agriculture-based society existing upon one of the driest landmasses of the globe. Future economic development across the continent, development in all terms including agriculture and industry, and with it reduction in levels of poverty, has a high level of dependency upon water availability. In turn, water availability is reliant on rainfall over a continent subject to marked inter-annual variations in rainfall and predicted, for much of its surface, to become drier as the atmosphere warms.

Africa is a major target of the Millennium Development Goals; rainfall, and climate more generally, is implicated in many of these goals.

Development planning often takes limited, if any, account of climate, despite frequent significant vulnerability to climate variations. The World Bank planning process, for example, at present makes no specific consideration for climate issues in development projects, although consultation is in progress to develop this. Yet the brake imposed by climate variability on development is uncontested and Africa remains vulnerable, recent events demonstrating the limited resilience of African societies. The devastating floods from tropical cyclones in 2000 reduced Mozambique's annual growth rate from 8% to 2%. East African drought, also in 2000, drastically reduced Kenyan hydroelectric power output, precipitating a US$72 million emergency loan from the World Bank. Droughts in southern Africa during the 1990's resulted in billions of dollars of cereal crop losses. The human cost of the long-lived Sahelian drought is well documented, even if no dollar value can be placed upon this. There are numerous other examples. Perhaps African resilience has reduced as international borders, globalisation, adjustments in political structures, and so on, have been introduced. If so, then the future presents additional challenges as predictions indicate that pressures of climate variability on development may become more severe over the coming century.

Climate is a factor, amongst many, that limits development and that requires full consideration in planning, a fact recognised, of course, many years ago. Climate services have been implemented in many African countries: extension services for agriculture, observation networks for the planning and management of water resources, prediction facilities for forward planning of many economic activities. Regional centres to provide climate services to all or parts of Africa have been created through international agreement – ACMAD and AGRHYMET based in Niamey, the SADC Drought Monitoring Centre in Harare and its companion the IGAD Climate Prediction and Applications Centre in Nairobi. Early Warning Systems have been established, and the continent is home to national centres providing expert information and forecasts. To these capabilities have been added new prediction opportunities, longer-term predictions covering coming seasons and the long-term future.

Yet Africa remains vulnerable to climate variability. There is a sense that climate is only marginally entering into development planning, and that societal resilience is not improving. It is certainly true that climate structures are degrading – observation networks are in retreat, facilities are below international standards, expertise is leaking from the continent – and with it, it is likely that climate services are failing to provide their potential contribution to planning for many activities.

The net economic benefit of climate services to Africa and its development cannot be assessed. That climate knowledge is beneficial to the planning process cannot, nevertheless, be disputed. The thesis presented in this report that substantial gains may be made within Africa through improvement of its climate services cannot be proven, but it is a thesis entirely consistent with all the facts. It is a thesis established on four pillars:

- Climate observations are fundamental to all direct services, and further to all efforts to assess the role of future climate in development activities
- Research provides the underpinning of all services and advice, be it based on analysis of observations or the use of advanced models
- Prediction, either independently or in combination with observational knowledge, is the foundation of numerous planning activities
- But even if all the basic components were functioning fully, there is still the necessity for prompt delivery of services and information in appropriate formats to those who make decisions.

A review, prepared by nine UK-based African climate specialists and using crucial input from 30 others, including many from Africa, is provided in this report of the status of climate services across the continent, and of the critical gaps. From this, options are proposed for addressing needs within the vision of delivering improved services to the benefit of development. The report is presented in five sections:

- An appraisal of the current facilities within Africa, provided in Section One, reveals numerous gaps not only in the ability of Africa to satisfy international agreements but also to provide quality national climate services
- A review of climate policy within Africa, provided in Section Two, and including issues relevant to the UNFCCC, identifies important limitations in the use of climate within policy planning
- International support for African climate activities is summarised in Section three, support that is concluded to be "diffuse and largely discontinuous".
- Based on the background established in the earlier Sections, a view is presented in Section Four on immediate issues for consideration in addressing the gaps, a view that includes a recommendation for priority on actions with time scales of a few years
- In the final Section Five, a list of options for actions is offered within a framework that covers the legacy of each action for Africa, the benefits and the costs; possible impediments are also identified.

1. Climate monitoring, climate science, models and climate prediction

A sound platform of climate science is imperative if climate is to contribute effectively to the development process. This section begins by reviewing the state of climate monitoring in Africa. Without climate data, the behaviour of the climate system cannot be quantified or understood. The existence, extent, longevity and frequency of droughts, for example, would remain unknown in the absence of data. Issues relating to climate models and Africa are discussed next before the status of African science both internationally and in the continent is assessed. The remainder of the section deals with weather and climate prediction.

Climate monitoring

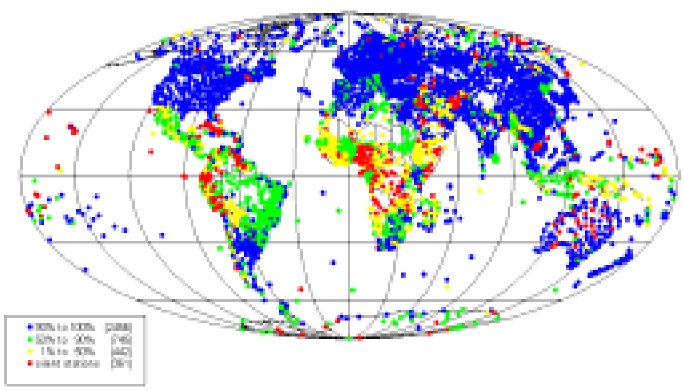
The climate observing system in Africa is in a far worse state than that of any other continent and it is deteriorating. This creates key gaps in our understanding of and ability to predict the global climate system.

Monitoring of climate parameters is crucial for three main reasons:

- to monitor and understand climate variability and change,
- to provide information on which climate-related activities can be based,
- to initialise and evaluate climate and weather computer models

The network of WMO World Weather Watch (WWW) stations provides real time weather data which are a vital input to weather and climate forecasts worldwide as well as forming the basis of international climate archives. There are 1152 WWW stations in Africa giving a station density of one per 26,000 km^2, 8 times lower than the WMO minimum recommended level. This shortage of data is exacerbated by an uneven distribution, leaving vast areas of central Africa unmonitored, and the lowest reporting rate of any region in the world (Figure 1). The reporting of upper air data is even worse but could be improved with modest resources.

Figure 1. The global network of WWW stations colour coded to show reporting rates. Data sparse areas and low reporting rates for Africa are clearly visible. :Source, WMO (2003) Twenty-First Status Report on Implementation of the World Weather Watch: Forty years of World Weather Watch, WMO No. 957, p49.



Many counties in Africa have useful networks of secondary stations which do not report internationally. The issue of data availability to the international community is a sensitive one and needs to be approached with the needs of the African climate community in mind.

Satellite-based datasets provide spatially complete coverage and are particularly useful for rainfall monitoring. However this does not obviate the need for conventional observations as the satellite methods need ground based data for calibration and validation. There remains a pressing need for evaluation of satellite products over Africa.

Understanding the evolution of the state of the oceans is vital to climate prediction on time scales of seasons to decades. Africa's climate is influenced by the Atlantic, Indian and Pacific oceans, but monitoring of the Indian and Atlantic Oceans in areas proven to be crucial for African climate variability does not yet exist.

Understanding of the African climate system

Based on several decades of research, there is now a reasonable scientific understanding of several parts of the African climate system, including southern Africa, the Sahel and to a lesser extent East Africa. This work has highlighted the highly variable and unpredictable nature of African climate. For other regions, including the central African convective region (at certain times of the year, the largest on the planet), adjoining Angola and much of the Sahara, we have little to no understanding and without new research initiatives, this is unlikely to change. Interaction between different regions and the mechanisms behind the delivery of remote influences on African climate (e.g. from the Pacific via the ENSO mechanism), which are crucial to controlling variability from weeks to decades, requires ongoing work.

On the other hand, African climate poses some intriguing questions which are important in terms of fundamental climate science and human relevance. For example, Africa is one of the few parts of the world to be influenced strongly by all three ocean basins. The ENSO signal which dominates year to year variability in the climate of the continent, originates half way round the world from Africa so delivery of this signal is as crucial to seasonal forecasting as it is a fine test of climate theory. Similarly, the nature of the land surface in Africa presents a remarkable laboratory for studying this science and may be responsible for amplifying droughts in some areas.

The level of published activity of climate science in Africa is amongst the lowest anywhere in the world (Table 1). While excellent, locally reported science is a feature of several climate centres in Africa, lack of international engagement further isolates African climate science. The UK has a critical mass of climate scientists interested in Africa, but funding for collaborative projects is scarce.

Table 1: Affiliation of lead author of papers in two leading climate journals (2002-2004).

	J Climate		Int J Climatology	
	number	%	number	%
N. America (USA)	416	66.7	40	17.4
N. America (Canada)	30	4.8	10	4.3
S. America	18	2.9	15	6.5
Europe (excl. UK)	62	9.9	78	33.9
UK	36	5.8	25	10.9
Africa	**2**	**0.3**	**7**	**3.0**
Middle East	2	0.3	8	3.5
Asia (East)	40	6.4	18	7.8
Asia (South)	5	0.8	11	4.8
Australasia	13	2.1	17	7.4

Climate models

Global circulation models (GCMs) are the only means to predict climate of future decades. They also form the basis of modelling systems to predict weather and one means to predict seasonal to interannual climate variability. They, and the linked regional climate models (RCMs), are the only means to experiment on the climate system in order to better understand its workings. In short they are the key to gaining insights into future climates and understanding current climate. Model development is a critical issue for climate prediction in Africa.
Climate models are typically developed and run in major climate research centres in Europe, USA, Japan, Canada and Australia. From the African climate perspective there are nevertheless a number of crucial issues. These are divided into model performance and capacity building.

How well do climate models represent the climate of the African region?
Global Climate Models capture the following reasonably well:

- simulation of mean large scale patterns of contemporary climate (e.g. temperatures, wind, precipitation),
- broad response to Pacific ocean forcing (ENSO) and to ocean temperatures patterns in surrounding basins (Indian, Atlantic and Mediterranean).

Examples of areas where progress still needs to be made include:

- precise positioning, timing and intensity of specific features, such as the onset of the Sahel precipitation which happens several months early in some models,
- the precipitation gradient across southern Africa, and the orientation of tropical convection over East Africa.
- in coupled models, the cross-Atlantic Ocean temperature gradient is in the wrong direction
- Interaction of Saharan dust with climate is not included in most models
- Coupled land-surface atmosphere feedbacks.

How well are the drivers of African climate represented in climate models including the delivery of remote signals? ENSO is the primary source of skill in seasonal to interannual climate prediction. It follows that climate models need to simulate the delivery of this signal to Africa well if climate information on these time scales is to be useful. Although models simulate ENSO in the Pacific well, as with the simulation of the large-scale circulation surrounding southern Africa, there are important errors compared with observations e.g. the simulated ENSO signal in southern Africa is too weak and there are errors in the simulation of upper level dynamics during ENSO events in some models.

How best can African institutions develop capacity in working with climate models?
A key question for discussion is the tension between scientists in Africa running climate models themselves against the simple delivery of data from experiments for analysis at African climate centres. In the former case, scientists develop a stake in model data and are motivated to analyse it. There is also a much greater chance that the workings of models will be understood. Recent progress with the UK Met Office RCM PRECIS in Africa serves as a good example. However, an important consequence of such work is its potential to divert limited available capacity. In this case the latter approach may be more appropriate but may lead to African scientists feeling they have less of a stake in the data and the analysis of the data may be neglected in favour of more pressing operational needs.

East African example:
The strongest teleconnection with ENSO in East Africa is experienced during the short rains. Both observational and modelling studies suggest that the ENSO teleconnection to East African rainfall is mainly manifested via the Indian Ocean. In particular, the relationship between ENSO, the Indian Ocean temperatures and East African rainfall needs to be correctly reproduced, if the models are to simulate ENSO teleconnections with East African rainfall. In HadAM3, the teleconnections between ENSO and East African rainfall is apparently well reproduced. In years when El Nino was strong so, as observed, is rainfall but the relationship between the Indian Ocean surface temperatures and rainfall is poorly simulated. Idealised model studies suggest that anomalously high rainfall is induced by warming in the western Indian Ocean whereas in the observations, it is caused by circulation anomalies induced by the gradient in sea surface temperature. This implies that the good simulation of the El Nino/East African rainfall relationship is in part right for the wrong reasons.

In contrast, HadCM3 simulates the relationship between Indian Ocean surface temperatures and the short rains reasonably well. This improvement may seem surprising and again implies it results from compensation of errors, in this instance in the magnitude and horizontal gradient in Indian Ocean surface temperatures. Such systematic errors are common in coupled models. Given that they are key tool for long term climate prediction and (increasingly so) for seasonal to interannual prediction, it is clearly important that their source and impact is understood.

Weather forecasting

For most of Africa, particularly the tropics, short term (i.e. up to five day) weather forecasts are of use mainly to transport, particularly aviation. Given the nature of tropical weather and seasonality, they tend to have little impact or be of much interest to the general population. This is not true of severe weather or unusual weather, for example, a particularly lengthy break in the monsoon rains which may have a large user base in agriculture, and extreme flooding, such as the tropical cyclone induced conditions in Mozambique during 2000. Given the state of the observing system and the technical capacity in Africa, skilful weather forecasts of extremes will remain unlikely outside just a few centres.

Medium range forecasts extending up to 30 days may provide a much needed window of information. At present such forecasts are produced by just a few international centres and the forecast skill and potential predictability over Africa at these time scales is generally unknown.

Despite this background, weather forecasting is still traditionally a focus of activity at many NMSs. Together with nowcasting, particularly for aviation, this time scale of information has been the basis for privatisation of a few NMSs and has brought much needed financial resources in some cases.

Early Warning Systems (EWS) tend to be based on monitoring rather than forecasting but coupling these could potentially bring the best information on short time scales. The Regional Climate Outlook Forums (RCOFs) are beginning to investigate such possibilities.

Seasonal forecasting

Seasonal forecasting refers to the provision of climate information, often in the form of probabilities of climate outliers, several months to a year in advance. The science is based primarily on the influence of the slowly evolving oceans on the atmosphere.

Seasonal forecasting has the potential to be the most relevant time scale of climate information for Africa. This is because:

a) the amplitude of seasonal to interannual climate anomalies on the continent is large
b) the exposure of the largely subsistence based economy to climate anomalies is high
c) the political will exists to engage with these (shorter) time scales
d) the potential predictability of climate anomalies for parts of Africa is amongst the highest anywhere in the world (Table 2)
e) Institutional mechanisms to engage with seasonal forecasting are thriving compared with many parts of the world.
f) Development of a capacity to deal with climate on seasonal forecasting time scales may strengthen the institutional fabric to deal with climate change.

Table 2: Qualitative assessment of potential predictability (evaluations are relative to other parts of the world rather than absolute).

Region	Potential Predictability
West Africa July-Sept	High
East Africa Oct-Dec	High
Southern Africa Jan-Mar	Medium
East Africa Mar-May	Low to Medium
North Africa	Low
Congo/Angola/Mozambique	Unknown

Seasonal forecasting information comes from two distinct methods:

- climate models; and
- empirical/statistical methods based on historical data.

Global Climate Models are typically used and developed only at international centres. In the African context, the most important of these include ECMWF, UK Met Office, and Meteo France. The IRI, Columbia, New York, have developed a system of combining several models into one forecast, thereby maximising skill. In Africa, South Africa is probably the only country to be developing and running global climate models for operational seasonal forecasts (several other countries run regional models, e.g. Kenya). While existing resources in Africa are extremely marginal to supporting these sorts of activities (models are costly to run), the sense of ownership in the seasonal forecasting process is a worthwhile by product of locally run models.

Regional Climate Outlook Forums (RCOFs) have become the principal vehicle for providing advance information about the likely character of seasonal climate in several developing regions, including Africa. At the same time they are the most significant institutional mechanism for linking climate science to society and, compared to the rest of the world, are a real success story in Africa.

RCOFs were formally initiated at the Workshop on Reducing Climate Related Vulnerability in southern Africa (Zimbabwe, October, 1996). The forums aim to generate consensus forecasts by bringing together climate forecasters and users.

Four forums exist in Africa: SARCOF (southern Africa), GHACOF (Greater Horn of Africa), PRESAO (West Africa) and PRESANOR (North Africa).

The forecast forums in Africa have stimulated regional development of seasonal forecasting systems. For the most part these are based around empirical statistical methods which often have the advantage of being developed on regional climate data and therefore do not suffer from the same resolution problems as many climate model generated products. There is also a growing use of empirical downscaling techniques – creating an effective collaboration between the international modelling centres and the NMSs. The forums are also beginning to provide forecasts in formats that are tailored towards specific application sectors, a move which is likely to enhance the relevancy of climate services within the continent.

A review of the international forums was written in late 2000. While the success of the forums was noted in this report, numerous recommendations were also made, the many of which are still to be addressed.

Climate change

Working Group I of the IPCC TAR (*The Scientific Basis of Climate Change*) contains a detailed review of regional temperature and rainfall changes projected by nine state-of-the-art GCMs (IPCC 2001b, Chapter 10). This presents climate changes in terms of the inter-climate model consistency (i.e. the agreement between models) for different regions of the world.

Table 3. A summary of inter-climate model consistency regarding future rainfall change for Africa caused by greenhouse gas emissions IPCC (2001b). definitions of consistency: seven out of nine GCMs must show a consistent change for results to be classified in agreement.
For temperature: rate of warming with respect to the global average which spans 1.2 to 4.5°C for emissions scenario A2 and 0.9 to 3.4°C for B2.
For rainfall: large increase (decrease) - agreement on increase with average change greater than +(-)20%. Small increase (decrease) - agreement on increase with average change between +(-)5 and +(-)20%. No change - agreement with average change between -5 and +5%. *Source: Adapted from IPCC (2001b, Box 10.1, Figure 2).*

Region	December to January		June to August	
	A2	B2	A2	B2
Temperature increases compared with global average				
Sahara	Greater than	Greater than	Greater than	Greater than
West Africa	Greater than	Greater than	Inconsistent	Inconsistent
East Africa	Inconsistent	Inconsistent	Inconsistent	Inconsistent
Southern Africa	Inconsistent	Inconsistent	Greater than	Greater than
Rainfall changes				
Sahara	Inconsistent	Inconsistent	Large increase	Large increase
West Africa	Small increase	Small increase	No change	Inconsistent
East Africa	Small increase	Small increase	Inconsistent	Inconsistent
Southern Africa	Inconsistent	Inconsistent	Small decrease	Small decrease

Warming is projected to occur more rapidly than the global average in the Sahara region and West (DJF only) and Southern Africa (JJA only). Warming occurs in all other regions and in both seasons but with lower consensus on the rate. For future rainfall patterns there is less consensus. For the main rainy seasons in southern Africa (DJF), parts of West Africa (JJA) and East Africa in JJA (important to large parts of Ethiopia and Sudan) there is no consensus. The clearest signal is the large percentage increase in JJA in the Sahara where absolute rainfall amounts are extremely low.

The significant influence of ENSO on rainfall in Africa is well documented. Future behaviour of ENSO will be critical to the manifestation of climate change, but this remains uncertain. GCMs present a wide range of possible ENSO changes with limited convergence towards no increase or a small increase in amplitude during this century. GHG forcing (emissions scenario SRES B2) tends not to produce major changes in ENSO-rainfall teleconnections, although some strengthening (southern Africa) and weakening (East Africa) of relationships occurs.

Changes in other aspects of African climate variability have received and are receiving very little attention (Table 4).

Table 4: Breakdown of IPCC AR4 Model Analysis Project Proposals (preliminary) by study location.
Note: 'Number' refers to number of times each study region was detailed, not to number of projects

	Number	**%**
Global	48	17.1
Pacific O.	34	12.1
Indian O.	15	5.4
Atlantic O.	17	6.1
Europe	12	4.3
N. America	18	6.4
S. America	11	3.9
Africa	**9**	**3.2**
Asia	24	8.6
Australia/NZ	9	3.2
Polar	31	11.1
Mid-latitudes	16	5.7
Tropics	18	6.4
Location-unspecific	18	6.4

Sector example: The agricultural impacts of climate variability and change
Agriculture is a key sector of society in Africa. Climate is a key determinant of crop yields over the vast majority of the continent. Thus research into the influence of climate variability and change on crop yields serves both as a case study of the predictability of impacts in general and as important information in its own right. This field effectively provides a bridge between the science of weather and climate and the more socio-economic study of climate change impacts.

The disparity in spatial scale between GCMs and traditional crop models has lead to a variety of methods of impacts assessments. Climate and/or weather information can be downscaled to the plot-level using a variety of methods, each with associated uncertainties. Alternatively, crop models can be constructed which operate on larger spatial scales. Crop models vary in their complexity from statistical regression to process-based models. The former may be pragmatic in the short term (a few years) but will fail to predict the impact of short episodes of extreme heat and water stress which may become a key determinant of yield in future decades. Hence the choice of method has implications for the validity of the results, in terms of both spatial and temporal scale.

The variety of methods used leads to a large range of predictions and associated uncertainties. For example, whilst most impacts studies predict a reduction of maize yields in Africa (anywhere up to 98%) under climate change, some predict an increase. Proper inter-comparison of the methods used, choosing a particular region, crop, and set of scenarios, would further our understanding. Observations of crop yield would also aid research efforts by constraining impacts assessments.

Section Summary

A sound platform of climate science is imperative if climate is to contribute effectively to the development process. Without this platform, the precise role of climate will remain unknown.

The state of the African climate observing system is worse than that on any continent and is deteriorating. The observing system underpins climate science, including satellite calibration, monitoring of change and variability, model evaluation, understanding of the climate system and climate prediction.

Relative to many parts of the world, the scientific understanding of the African climate system as a whole is low. For certain regions in Africa the level of understanding is reasonable, for other parts, such as the Congo basin (an important area in for the global climate system), very little is known.

Climate models are a key tool in climate prediction. Evaluation of global climate model products and the use of regional climate models (RCM) is crucial. The level of technical expertise needed to support modelling in Africa is very low, although some recent projects such as the application of the UK Met Office RCM, PRECIS, have been successful.

Seasonal forecasting, the provision of probabilistic climate information on time scales from months to a year, has been met with great engagement and enthusiasm in

Africa. Within a global context, seasonal forecasting in Africa thus far is a success story.

African climate, as with other parts of the world, will undergo climate change. Building adaptive capacity is arguably best done by support for climate prediction on shorter time scales first.

Section Five, Options for collective actions, takes up these components of climate science, namely observations, research and model development and prediction. For each, the status, benefits of development from both the African and international perspectives, funding considerations and time scales, interest within Africa and short term, quick-win as well as medium term options are presented.

2. Analysis, interpretation and communication of climate information: policy and planning decisions.

This section examines the pathways and evidence for consideration of climate variability and climate change in policies and planning processes in Africa. We are not aware of any systematic attempt to gauge whether and how policy processes have been informed or influenced by these issues. As a first attempt to undertake such an analysis, we identify four clusters of pathways: those related to climate variability and extremes, particularly the use of seasonal forecasts; activities resulting from the UNFCCC (Climate Convention) and the Kyoto Protocol, particularly the preparation of National Communications and National Adaptation Plans of Action (NAPAs); actions within development organisations and donors to address climate change; and other more nebulous links between awareness and concern about climate change and consideration in policy and planning.

Policies and planning in relation to climate variability and extremes: use of seasonal climate information in Africa

This subsection addresses the evidence of use and communication of needs by user communities in Africa for the type of forecast products that are discussed in Task 1. First we present a summary of discussions with the African Centre for Applications of Meteorological and Climate for Sustainable Development (ACMAD) to show evidence of demand for and use of forecast information. Further evidence of use and needs is drawn from recent literature with particular reference to agricultural applications.

Summary of discussions with ACMAD, Niamey, Niger
Throughout Africa short-term forecasts products are provided by the NMSs but there is a significant need to develop the application of these forecasts in a number of sectors, including agriculture and disaster mitigation. Currently only limited use is made of medium range and monthly forecasts as African NMS only produce or disseminate short-term forecasts. They believe there are strong indications that user communities are particularly interested in forecasts at 10 day and monthly lead times for their operations. However, the integration of these products will require the use of pilot demonstration projects, to demonstrate their applications, and further training for local NMS forecasters in their interpretation and use.

ACMAD reports that during the summer of 2002 and 2003 10-day climate outlooks for the Sahel were issued through a pilot demonstration project. In the summer 2003, heavy rains and flooding were predicted in parts of the Sahel. These early warnings could not be acted upon as the emergency management services were not sufficiently coordinated at the regional as well as country levels. Some examples of users include a cotton production company in Burkina Faso (SODEFITEX) which uses seasonal forecasts for crop yield estimates and the Mali Meteorological service use seasonal forecast as a support tool to advise farmers on planting decisions.

Research on forecast users and their needs in Africa
Literature on the use of forecasting systems generally highlights the need to involve not just forecasters but also those who are working on climate applications, using forecasts of different methods of production and lead times. These papers also stress the need take a holistic approach and involve workers from other fields such as social science. Due consideration needs to be given to the operation of African societies, especially farmers and extension services. Group decision making

processes and the adoption or modification of coping strategies in the light of reliable forecast information are vital to the successful use of information.

NMS in Africa issue seasonal forecasts operationally but to date the utilisation of these forecasts have been limited. Climate information can potentially contribute to farmers' coping strategies but that different farmers will gain more than others from the use of reliable seasonal forecasts. Research on farming systems in Burkina Faso, arable and cattle based, shows that farmers expressed a strong interest in receiving seasonal forecasts but that that farmers found limited use of the 'total season forecast'. There is a clear need for information on the distribution and duration of rainfall, particularly the timing of the onset and end of the rainy season. Similar findings have been obtained the use of seasonal forecasts and climate information by commercial farms in Swaziland where the needs of the user can often be very specific and may be compounded by the complexity of the ENSO signal in the region. At present there may be large uncertainties with seasonal rainfall forecasts.

Examples of climate forecast information provided for pastoralists in southern Ethiopia and northern Kenya found that almost 90% of people surveyed understood the concepts of a probabilistic forecast. However, only about one-fifth of those surveyed had heard a forecast about the onset and duration of the long rains and the most common source of this forecast was the radio.

A study of the use of seasonal forecasts in Zimbabwe[1] identified six main constraints: forecasts need to be credible (skilful), legitimate (not perceived as conflicting with local knowledge), regionally targeted (as opposed to being for a large area), comprehensible and timely. They should also contain enough new information to alter specific decisions. The study concluded that participatory (i.e. collaborative) use of forecasts should be a key element in overcoming the constraints. The existence of SARCOF (Southern Africa Regional Climate Outlook Forum) is a considerable advantage in this respect to farmers in southern Africa.
There are a number of early warning systems in operation in Africa such as GIEWS, FIVIMS and FEWS.NET. These integrate many diverse sources of information including climate and yield forecasts in addition to information about infrastructure, trade, consumption, crop prices and food aid. These operational forecasting methods for early warning of crop yields are necessarily more integrated with the socio-economic aspects of food security than free-standing climate forecasts. As with projections of impacts into the future the more integrated the assessment, the less sophisticated, and the easier to implement, are the methods used for yield simulation. Operational methods tend to be empirical perhaps partly because of this tendency, and certainly because these methods prove to have some value.

Ways forward in seasonal forecasting
It is though establishing user feedback to the forecast community that forecast applications will improve and products and verifications will be developed that are of direct use to the user communities in Africa. This is where regional centres and NMS who already work with user communities in Africa could make a significant contribution to the development and use of this technology. There is certainly evidence of demand for forecast products in many rural communities in Africa. These products could make the basis of an adequate system if more data where made publicly available and if user defined verification could be initiated e.g. verification of rainfall onset.

---

[1] Patt, A. and C. Gwata (2002). Effective seasonal climate forecast applications: examining constraints for subsistence farmers in Zimbabwe. Global Environmental Change - Human and Policy Dimensions 12, 185-195.

Policies and planning in relation to the Climate Convention and the Kyoto Protocol

The most likely route for climate change to have influenced policy is through the process of African countries' preparing their submissions to the Climate Convention. To date 48 African countries are listed as Non-Annex I Parties to the Climate Convention (developing countries) and as such they are required to submit National Communications to report on the steps they are taking or envisage undertaking to implement the Convention. Table 5 lists the African countries that have submitted their National Communications and the date of their submission. Guidelines for the preparation of National Communications are provided by the climate convention secretariat. This assistance includes the organization of workshops, collaboration with bilateral and multilateral support programmes, the dissemination of information through participation in regional workshops and expert group meetings, promoting information exchange, and capacity-building.

Table 5. African countries that have submitted National Communications as of October 2004 and the date of their submission.

African countries that have submitted National Communications		
Senegal 01/12/97	Botswana 22/10/01	Kenya 22/10/02
Zimbabwe 25/05/98	Tunisia 27/10/01	Uganda 26/10/02
Egypt 19/07/99	Chad 29/10/01	Guinea 28/10/02
Lesotho 17/04/00	Congo 30/10/01	Sudan 07/06/03
Cape verde 13/11/00	Burundi 23/11/01	Central African Republic 10/06/03
Mali 13/11/00	Togo 20/12/01	Tanzania 04/07/03
Niger 13/11/00	Burkina Faso 16/05/02	Nigeria 17/11/03
DRC 21/11/00	Swaziland 21/05/02	Malawi 02/12/03
Cote d'Ivoire 02/02/01	Djibouti 06/06/02	South Africa 11/12/03
Algeria 30/04/01	Mauritania 30/07/02	Madagascar 22/02/04
Algeria 30/04/01	Eritrea 16/09/02	Zambia 18/08/04
Ghana 02/05/01	Namibia 07/10/02	
Ethiopia 16/10/01	Benin 21/10/02	

There have been five periodic syntheses of National Communications from non-Annex I Parties but the submissions are not subject to thorough review. We are not aware of any attempts to produce a synthesis of African National Communications, and it is not clear how they feed into other areas of policy and planning beyond the remit of those responsible for their production. The National Communications are generally compiled by government departments, often the NMS, with the help of various contributors. Dissemination of the reports and awareness of the process and outcome varies considerably between countries.

What evidence is there for policy impacts arising from the preparation process of the National Communications? The fourth UNFCCC synthesis report[2] states that Parties (signatories to the convention) indicated that climate change concerns would be taken into account in future policies. Some Parties also reported that they had initiated specific institutional frameworks dedicated to climate change activities such as communities involving government, the private sector and NGOs. Many of the Parties report research efforts on variability and impacts and monitoring and adaptation. They also document ongoing and planned activities for observations of

[2] UNFCCC (2002) Fourth compilation and synthesis of initial national communications from Parties not included in Annex 1 to the convention. FCCC/SBI/2002/16.

meteorology and hydrology. Some Parties also report on international collaboration in this area with organisations such as the WMO.

Weaknesses exist in many of the vulnerability and adaptation components of National Communications and highlight a need to build capacity in these areas. This is supported by the contributions some of which report problems and constraints in their vulnerability assessments and many emphasise the need for training in this area. Stakeholder engagement in these processes appears to be fairly low as it is only mentioned by a few Parties. In addition, only a few Parties report activities in education, training and public awareness but generally there is very little detail and very few mention special awareness campaigns for specific groups such as decision makers and coastal communities. Some Parties report problems and constraints in research and monitoring (meteorology, water resources) due to financial resources and technical support. Many Parties also note the existence of significant gaps for establishing new monitoring stations, related to the improvement of capacity, equipment and strengthening of institutions responsible for education and training.

Beyond the National Communications and synthesis reports and without further consultation it is not possible to produce a clear assessment of their impact on panning and policy making within and outside of African government. The National Communications are available on the UNFCCC website and accessible for download and it is likely that they are used quite widely by other organisations and individuals, for example NGOs, researchers and so on.

There are two other areas of activity under the Climate Convention that will increasingly influence policy and planning: the Clean Development Mechanism (CDM) and funds coming through for adaptation.

The CDM aims to provide opportunities for countries to invest in emissions reducing activities in developing countries whilst also addressing development needs. The CDM will become active as the Kyoto Protocol enters into force, although several pilot projects have been implemented.

The adaptation funds consist of;

- The Least Developed Countries (LDCs) Fund to support LDCs in carrying out their respective NAPAs. See below.
- The Special Climate Change Fund to assist all developing countries for adaptation as well as mitigation.
- The Adaptation Fund under the Kyoto Protocol to assist all developing countries in carrying out adaptation measures.

A LDCs Expert Group has been established to give LDCs more voice in international adaptation planning. The guidelines for the preparation of NAPAs require public consultation.

Finally there have been concerted efforts by African and non-African organisations to develop the capacity of African country delegations to international meetings for the Climate Convention. Organisations such as the Energy Research Centre and ENvironmental Development Action in the third world (ENDA in Senegal) have been proactive in building capacity and raising awareness about African interests in the international negotiations. Other organisations such as the Climate Change Knowledge Network have worked towards building capacity for Southern developing countries and more specifically African delegates to help them participate more effectively.

Policies and planning in relation to activities on climate change by development organisations and donors

It is fair to say that until recently climate change has not received much attention in development activities and organisations. The last few years have seen efforts to initiate a more active engagement with the challenges that climate change represents to the achievement of development goals. These efforts have come from academic researchers working on interdisciplinary aspects of climate change, and now increasingly from researchers in development issues and development organisations themselves. In this last group there are now many examples of development organisations and donors that have commissioned reviews of the importance of and interactions with their activities and climate change impacts and international policy. Good examples are the multi-agency report ‘Poverty and Climate Change: Reducing the vulnerability of the poor through adaptation’ and the *Pro-Poor Climate Adaptation: an assessment of Norwegian development assistance and climate change and potential entry points*[3]. Studies have also been commissioned by the World Bank and the German development agency (GTZ) to look at linkages between their development assistance measures and climate change adaptation. The OECD initiated a project in 2002 on *Development and Climate Change* with the objective to explore possible synergies (partnerships and interactions between groups) and trade-offs in ‘mainstreaming’ responses to climate change within donor programmes[4]. Case studies were conducted in Bangladesh, Egypt, Fiji, Nepal, Tanzania, and Uruguay. Results from their review of donor programmes show that a significant amount of funding goes to sectors potentially exposed to climatic hazards but there are few examples where climate change is given clear consideration.

The review of 136 GTZ funded projects in Africa[5] found no references to climate change. Detailed reviews of five projects found climate variability was considered to some degree, although primarily in a reactive sense, with no consistent consideration of planning and preparation for climate extremes. A joint project between the International Institute for Sustainable Development (IISD), IUCN The World Conservation Union and Stockholm Environment Institute as part of a joint initiative on Climate Change, Vulnerable Communities and Adaptation has produced a framework paper on *‘Livelihoods and Climate Change’*. They suggest ‘win-win’ approaches to adaptation which serve immediate needs (a priority for poorer and more vulnerable communities) but also bring longer term benefits[6].

The review of Norwegian development assistance[3] considers the general linkages between climate change and development in terms of the effects of climate on development efforts and the effects of development efforts on climate and on vulnerability. They identify strategic entry points for adaptation in three key areas which ‘lie at the interfaces between three main areas of Norwegian development cooperation, namely: (a) humanitarian aid, (b) poverty reduction and economic

---

[3] Eriksen, S. and Lars O. N. (2003) Pro-Poor Climate Adaptation: Norwegian development cooperation and climate change adaptation - an assessment of issues, strategies and potential entry points. CICERO, Report 2003:02.

[4] Agrawala, S., and M. Berg (2002). Development and Climate Change Project – Concept Paper on Scope and Criteria for Case Study Selection. COM/ENV/EPOC/DCD/DAC(2002)1/FINAL, OECD, Paris.

[5] Klein, R.J.T. (2001) Adaptation to Climate Change in German Official Development Assistance—An Inventory of Activities and Opportunities, with a Special Focus on Africa. Deutsche Gesellschaft für Technische Zusammenarbeit, Eschborn, Germany, 42 pp.

[6] Burton, I., Soussan, J. and Hammill, A. (2003) Livelihoods and climate change. IUCN/IISD/SEI, 24pp.

development and (c) natural resources management' (paraphrased from their Executive Summary). The three areas are: livelihoods; local capacity and sensitivity; risk management and early warning. They go on to identify operational implications for development cooperation and discuss potential priority areas[7]:

- Instruments related to the climate convention
- Efforts aimed at realising synergies between conventions (Desertification and Biodiversity)
- Environmental assessments
- Coordination of support and mainstreaming in development country policies and strategies
- Humanitarian aid and disaster management
- Efforts related to the emerging area of Global Public Goods

Policies and planning for climate change in relation to other pathways

These consist of the rather nebulous interface between activities geared towards raising awareness about climate change by organisations such as the IPCC, NGOs and research programmes. Factors which are likely to have influenced this process in Africa are perceptions that climate change is a long-term problem and demands no actions in the short-term. There is uncertainty about the extent and detail of climate change and its impacts and much information about climate change demands technical understanding and ability to understand uncertainty and incorporate it into decision-making processes. Both these factors, coupled with the range of existing environmental and socio-economic challenges facing African countries, have reduced the political will of African countries to act. With low emissions of GHGs mitigation has also been seen as a concern for the North.

Summary

Use of seasonal climate information in Africa

- There is ample evidence of demand for forecast information by users in Africa.
- There are some important points for further consideration on both the supply side and demand side of seasonal climate information plus a need for effective communication between the communities.

  Supply of information:
    - An improvement in forecast skill and reliability is crucial for use and building confidence; the current level is a constraint to use in certain situations. Greater forecast verification is essential in this process.
    - Dissemination and communication of information is vital; current practice and effectiveness varies widely between providers and users across Africa.
    - Africa possesses substantial capacity for regional assessment and provision of climate forecasts, for example the Regional Forecast Forums. It is important to integrate these efforts with other Early Warning Systems, see below.

  Demand for information:
    - There is great demand for information on intra-seasonal time scales, for example the start date and end date of rainfall seasons and extended breaks in the rainy season.

[7] Eriksen, S. and Lars O. N. (2003) Pro-Poor Climate Adaptation: Norwegian development cooperation and climate change adaptation - an assessment of issues, strategies and potential entry points. CICERO, Report 2003:02. (page vii)

- o There is a need to work on means by which climate forecast can be incorporated into the livelihood strategies of potential users.
- o Integration of climate information within Early Warning Systems. Studies of forecast use demonstrate the importance of multidisciplinary approaches.

The Climate Convention and the Kyoto Protocol

- Diffuse processes and lack of evidence make it difficult to gauge the impact of awareness and concern about climate change on policy makers and planning.
- The most direct route has been through African countries' National Communications but there is not enough evidence from the national preparation and dissemination processes to assess their influence on policy.
- Actions on adaptation through the Climate Convention (for example, the Clean Development Mechanism, National Adaptation Plans of Action) are taking off. It is important that these actions interact with existing African institutions and activities related to climate variability, risk management / early warning and development activities that are sensitive to climate.

Activities on climate change by development organisations and donors

- There is a need to better understand existing interactions between climate and society and climate and climate change's role in affecting development.
- The last few years have seen substantial efforts by development organisations and donors to initiate a more active engagement with the challenges that climate change represents to the achievement of development goals.
- These studies all point towards the importance of dealing with existing climate-related sensitivities with actions that bring short term benefits but that also recognise the possibility of climate change and therefore at the very least do not increase exposure or vulnerability over the longer term.

3. International support to meet climate needs

Funding available from a national level to support climate related activities in Africa is the lowest for any continent. It follows that international support has a particularly important role to play in the resurrection, maintenance and development of climate and its interface with sustainable development. How this is done and where the funding is applied is clearly a crucial issue. This Section provides an overview of the nature of available support. It is by no means exhaustive in coverage.

Monitoring: surface climate, radiosonde network and data rescue

It is the expectation of WMO that individual nations fund the retrieval and archiving of weather and climate data. As the material in Section 1 shows, this is a major problem in Africa and has led to the deterioration and, in some places, the collapse of the observing system. For many key areas of Africa, such as the Congo basin, an observing system has never properly existed.

While evaluation of the observing system is ongoing through GCOS-SBSTA-UNFCCC dialogue, it is clear that only long term international collaboration with the NMSs and their respective governments (given the problem of 'tied aid'), is going to relieve the current observing problems in Africa. At the same time, privatisation of the NMSs has helped to bolster internal funding (e.g. Tanzania, South Africa and more recently, Zimbabwe). As NMSs continue to adjust the service they provide to meet the needs of sustainable development, so the likelihood of funding basic observing increases. Seasonal forecasting plays an important role here. Workshops addressing these needs are ongoing (e.g. 5th GCOS Workshop, Western And Central Africa, Niamey, 2003, funded by GCOS, GEF, UNDP, ACMAD, UKMO, Meteo France).

The AMMA project, based in West Africa, is one example of an international project supporting observations. AMMA has a sizeable component (2 million Euros) given over to radiosonde observations alone. While the AMMA lifespan is finite, the project will see the regeneration of obsolete stations which is likely to have benefits beyond AMMA.

The World Hydrological Cycle Observing System (WHYCOS) project aims to provide the information to improve efficient management of the world's water resources. It is based on a series of regional projects providing technology and training to monitor hydrological parameters (rainfall, riverflow and evaporation) in the world's river basins. In Africa, there are two projects; in West/Central Africa (AOC-HYCOS funded by the French Ministry for Foreign Affairs), and Southern Africa (SADC-HYCOS funded by the EU).

The Statistics In Applied Meteortology (SIAC) programme has been run over a number of years by the University of Reading Applied Statistics Department in collaboration with ACMAD. The aim is to work with NMS's to provide tools and develop expertise to manage, process and make available climate data to a variety of users, but particularly the agricultural sector.

While substantial data rescue work has been undertaken in the Africa (e.g. by Meteo France in collaboration with the Francophone countries of Western Africa), many irreplaceable data records remain at risk. Current data rescue is resourced by the US NOAA Data Rescue project, WMO's DARE initiative and other domestic and external sources.

It has long been known that the Indian Ocean is crucial to climate variability in Africa. Development of a systematic observing system for the Indian Ocean is well behind those in the tropical Pacific and Atlantic Oceans.

Most of the interest in the Indian Ocean is centred on India and is funded by India (Indian National Program for an Ocean Observing System) and Japan. Other observation platforms (ADCP mooring and TRITON buoy) are part of OASIS (Observational Activities for the Study of the Indian Ocean Climate System) program of JAMSTEC/FORSGC, based in Japan. Future moorings will be discussed at the CLIVAR IOP meeting in Honolulu in December 2004. Planned moorings may be funded by France , South Africa and USA.

Modelling

Climate models are a key tool in climate analysis and prediction but their development is extremely resource intensive. Without exception, climate models are built at major international centres. Few centres in Africa are capable of running models and even fewer of experimenting with the components. If follows that collaboration in modelling efforts is a determinant of whether Africa has access to these key tools. Support tends to come in the form of:

a) the provision of the actual models and computers
b) supply of model products (essentially data)
c) training in the running and analysis of models (especially regional models and downscaling)

Meteo France and, more recently, UK Met Office (UKMO) has supplied model software to several African countries. In the case of the UKMO, the regional climate modelling system PRECIS has been set up and run in several countries. Along with PRECIS, training in its use and relevant background material on climate modelling, climate change and climate scenarios has been provided to scientists from institutes in these countries. This package has also been provided to scientists from ACMAD in more depth along with the training materials for them to use as a resource within Africa. Most progress has been made where engagement has been long term (e.g. Meteo France’s engagement in West Africa).

The IRI (New York) has set up contracts for the supply of model software and training (e.g. Kenya) and WMO and START has supported training workshops in the climate modelling. Meteo France has close collaborative links with a number of countries in West and North Africa. The NMSs receive direct data feed from Meteo France in Toulouse via dedicated lines. This support is ongoing.

AIACC (Assessments of Impacts and Adaptations to Climate Change) is a global initiative developed in collaboration with the UNEP/WMO Intergovernmental Panel on Climate Change (IPCC) and funded by the Global Environment Facility to advance scientific understanding of climate change vulnerabilities and adaptation options in developing countries. It currently supports 11 projects in Africa which aim to develop regional scenarios from GCM climate change simulations. A primary component of this work will be to extend existing capacity among African scientists in issues of method and implementation for regional scenario construction. The scenarios will be focused on spatial and temporal scales appropriate to the primary vulnerability sectors in Africa, and incorporate computationally efficient empirical downscaling and the more demanding regional climate models.

Without these efforts little would have happened with respect to climate models outside of say two or three countries in Africa. But even with this funding, Africa lags very far behind most regions.

Climate science research

Africa has an extremely low level of expertise in climate science. Perhaps as few as a dozen scientists routinely publish material internationally and many of these are from one or two countries. The number of climate scientists based outside Africa but working on African climate is also low. In the UK, African climate science is acknowledged by funding agencies to be a low priority. Bodies like CLIVAR VACS (the CLIVAR panel which deals with African Climate), while energetic in setting the climate science agenda, organising workshops and so on, has no funding resources itself and cannot realise scientific goals on its own. Funding available in first world countries tends to exclude the funding of Africans. Funding available for Africans normally excludes funding for scientists from first world countries. Collaborative work in this financial environment is challenging.

Interpretation and communication

There are a number of international efforts aimed at the interpretation and communication of climate information.

Regional Climate Outlook Forums (RCOFs)
The importance of the RCOFs has been stressed in the discussion of seasonal forecasting earlier in this report. Funding for the SARCOF meetings, for example, (which cost between US$50 000 and US$80 000) derived initially from the IRI, the European Commission, World Bank, UK Met Office, WMO/CLIPS, NOAA/OGP and SADC. In 1998 and 1999 the funding came from a World Bank IDF grant to SATCC (Southern African Transport and Communications Commission) on a case by case basis. DMC Harare has received funding from the Belgium Government.

The SARCOF process is currently in need of support. The question of the forum process relaxing back to a 'virtual' status carries with it the probable loss of countries which have recently joined the seasonal forecasting enterprise. The longer the forums can be maintained, the smaller the number of countries which are likely to withdraw from seasonal forecasting activities. If withdrawal happened immediately, only 4 SADC countries would be likely to continue.

Options currently posed by DMC Harare are to incorporate SARCOF into SATCC structure. This is under consideration by Sub Committee on Meteorology (SCOM) of SATCC with cost sharing under discussion.

RANET (http://www.ranetproject.net)
Slow internet access in Africa is an extremely wide spread problem. RANET is an international, collaborative project which delivers weather and climate information via a satellite simulated internet. The project is coordinated from ACMAD and the project is supported in various ways by USAID, NOAA/OGP, WMO, CIMMS, University of Oklahoma, UK-Met Office, WorldSpace Foundation, CFAR, METEO France.

Key climate institutions in Africa

In addition to the NMSs and universities, there are three main climate institutions in Africa: ACMAD (Niamey, Niger), DMC (Harare) and ICPAC (formerly DMC Nairobi).

The objective of ACMAD is to contribute to the sustainable development of various socio-economic sectors of the African continent through its fields of investigation, namely Meteorological and Climate. Its main activities are short average term weather forecasting, seasonal forecasting and its applications, on-job training, development and transfer of new technologies to the Met Services of Member States. ACMAD was established with funding from the Economic Commission for Africa (ECA), WMO, and membership fees from African states. Other important contributions comes from UNDP, UNEP and FAO.

The DMCs were initially funded by UNDP. DMC Harare is currently funded by SADC, but exists at a very low level of staffing. Funding has to be sought for activities.

START, the global change SysTem for Analysis, Research and Training, was established under the aegis of the International Council of Science (ICSU), to establish and foster regional networks of collaborating scientists and institutions in developing countries. These networks conduct research on regional aspects of environmental change, assess impacts and vulnerabilities to such changes, and provide information to policy-makers. START acts to enhance the scientific capacity of developing countries to address the complex processes of environmental change and degradation through a wide variety of training and career development programs. It is co-sponsored by the International Geosphere-Biosphere Programme, the World Climate Research Programme, the International Human Dimensions Programme on Global Environmental Change, and DIVERSITAS. The START Secretariat in Nairobi is an example of a vibrant office which has achieved much on limited resources.

International African climate related institutions

The African Desk (at CPC, NCEP) was established in 1994 to focus on short term climate monitoring and predictions for Africa. The objective of the African Desk is to develop a partnership between NCEP and the African Meteorological Services through data and NCEP product exchange. The African Desk conducts three main programs: Training, Operations, and Research. The training program is managed jointly by NCEP, the International Activities of the National Weather Service, and the World Meteorological Organization, providing training in methods of climate monitoring and prediction. The African Desk works closely with the CPC component of the USAID/Famine Early Warning System Project to put together products tailored to assess vulnerability in Africa related to food security and water supplies.

DFID (UK) will be undertaking a research needs assessment exercise for climate change research in 2005. DFID is the largest bilateral contributor to The Global Environment Facility (GEF).

GEF, established in 1991, helps developing countries fund projects and programs that protect the global environment. GEF grants support projects related to biodiversity, climate change, international waters, land degradation, the ozone layer, and persistent organic pollutants. In Africa, over 140 climate change proposals have been supported (a total of US$320 million between 1991 and 2000). A third of these proposals dealt with energy issues, about 20% with a first response to UNFCCC and Natational Adaptation Programmes for Action respectively. GEF funds are contributed by donor countries. In 2002, 32 donor countries pledged $3 billion to fund operations between 2002 and 2006.

FEWS NET (Famine Early Warning System Network), funded by USAID, aims to strengthen the abilities of African countries and regional organizations to manage risk of food insecurity, through the provision of timely and analytical early warning and vulnerability information.

Summary

International support for African climate is diffuse and largely discontinuous. Funding for specific initiatives originates largely in the USA, although the USA tends to view Europe as the provider of international support. Within Europe, France has taken a long term and key role.

4. The background to collective action

Preamble

It may be useful to define possible design objectives for any options for collective actions. This report has been written taking a primary climate perspective, whereas in practice climate is frequently only a single factor in any decision process; the relative weight of climate may vary from being the only factor of note through to being a minor player. No discussion of the proportionate role played by climate in relation to other factors has been made in the following, the focus being on examining gaps and requirements in order that climate information is able to play any role necessary in decision making.

Climate variability and climate change
"Climate" itself is a word that is used to cover an amalgam of weather across all periods longer than those typically associated with "weather". Climate *per se* thus covers a wide range of time scales, and is stationary on none. The word "climate" itself is often taken to refer to weather conditions averaged across 30 years, a period recommended by WMO. Calculated thus, dissimilarities are always found for climate across two 30 year periods, even when they overlap to an extent. Climate variability, as indicated by such dissimilarities, is found on all time scales from the shortest, such as month to month, through the medium, annual to a few years, to the longest, decades and upwards. Variability is both naturally inherent in the system and inevitable; on long time scales it can lead to anything from warmer conditions than current through to ice ages. Climate variability is rarely cyclic in the true sense, but rather follows somewhat disorganised patterns.

Given the above, "climate change" becomes a difficult concept to define, as all natural 'change' is merely a reflection of variability on appropriate time scales. The UNFCCC addresses this problem by defining climate change only as that component induced by anthropogenic activities. Thus, in the strictest sense, all activities under the UNFCCC banner address only the anthropogenic component, and provide no support for activities related to natural variability on whatever time scale. The Terms of Reference of the IPCC, on the other hand, require it to consider both natural and human-induced variability and change. Nevertheless the IPCC has tended to focus its activities on climate some decades into the future, time scales on which anthropogenically-forced change is expected to become readily demonstrable.

Climate change, in terms of the UNFCCC definition, is frequently interpreted in terms relating to specific adaptation actions that address issues that will only have effect in the future – sea level rise, shifts of agricultural production areas, depletion of water resources, and so on. The early signs of anthropogenic climate change can be seen already in temperatures, both across the globe and regionally. Whether these temperature increases translate, as sometimes claimed, into modified weather patterns and onward environmental impacts remains to be proven, although it is reasonable to state It has been demonstrated that the early signs of climate change can be seen already in the environment. For claims relating to changes in many weather patterns and the consequences of these, proof generally is still wanting though it is reasonable to state that many (not all) observed changes appear consistent with predictions for anthropogenically-forced climate change. Actions to adapt to these existing changes may already have been taken (e.g. responses to increasing insect infestations), but there is little doubt that most adaptation activities currently under way relate more to management of climate variability in its current form than to adaptation to the changed climate of 2080. Most decision making under the headings of sustainable development, MDGs, and so on, relate to time scales out to a few years, and generally include minimal immediate concern for time scales into the latter part of this century. There may well be good reason for this, as it is widely agreed that the ability to handle current climate variability is a vital and prime requirement, but not a sufficient requirement, for managing a future changed climate. Adaptation is frequently endogenous rather than managed, and endogenous adaptation will inevitably form much of the response to anthropogenically-induced change. The excess adaptation required may need to be handled in a managed manner, but it may be argued readily that the current imperative is to address climate variability in its present form and to take advantage of that in the development of strategies for handling future climate change.

It has been demonstrated throughout this report that an immediate challenge in Africa is to build the capacity needed to handle climate variability. Coping strategies for climate variability that existed perhaps one hundred-and-fifty years ago, including migration, diversification and warfare, are no longer relevant in an era of international boundaries, globalisation, urbanisation and growing populations. Developing capacity within the context of variability will contribute significantly towards sustainable development, in addition to UNFCCC, objectives. Thus the prime focus in the suggested Options for Collective Actions (Section 5) is on activities that may provide policy benefits over a few years. Whether these proposals directly address climate variability or climate change is immaterial – they address both. Whichever term, 'variability' or 'change', is used in the following it is used within this overarching context.

Climate issues within the African context
It has been argued in this report that Africa has the most limited capacity of any region on the globe in terms of climate expertise and resource, and that this restricted capacity inhibits progress towards sustainable development on the continent. Further it has been noted that the detailed scientific knowledge of African climate lags behind that of other regions, knowledge that would ultimately contribute to building capacity in all its contexts. The slate is not bare, far from it, but the on-going activities to building equivalent knowledge and capacity in other regions (such as the VAMOS projects in South America) bear testament to the gaps in Africa.

In examining options for actions the issue of legacy has been one priority. Sadly some past climate activities in Africa have donated little legacy for the continent itself, although they may have generated substantial legacy within an international context (GATE, 1973, is an example). Exceptions exist of course, SAFARI and work at TAMSAT being examples. While international partnerships might be required, in all cases it is envisaged that the activities suggested in Section 5 will build legacies appropriate to Africa. Suitably managed these legacies should feed back into the international arena, thus helping raise the profile of the continent within that regard.

In part the current position from the international perspective has developed from the perceived lesser importance of Africa within the context of providing predictions on the global scale, especially in the view of key funders such as the US. This view *might* be correct, but cannot be validated on the basis of current scientific knowledge. In one respect, in the genesis of Atlantic hurricanes, Africa is seen as playing an important international role, and that consideration, in part, formed the basis of GATE, and also featured in the US AMMA proposal. Satellites now provide much of the information over Africa required in monitoring these genesis processes. With the development of the international environmental research projects – WCRP, IGBP, IHDP, DIVERSITAS – new projects focussed on, or with components, within Africa are being developed. These projects will build not only the knowledge of African climate and environment, but will also develop capacity and legacy. All, however, are being created from the relatively low capacity background, and further activities are undoubtedly needed.

Lack of capacity is not the only barrier to progress within the continent. Climate is often seen at national level as a lesser priority compared to other spending needs, and the case for higher investment has not been accepted in all countries (despite the 1999 Geneva Declaration). Ready access to climate services sourced from outside Africa does little to assist the case for national government support of NMSs. While commercialisation of NMSs has begun to progress, and may be expected to accelerate, within Africa, globalisation is seen as a threat to the continued status of both commercial and public good NMSs, a status that many NHSs have difficulty defending given their limited resources. Traditionally many African NMSs have developed around either transport or military demands, climate being a minor player. However, with the UNFCCC and, more recently, the events surrounding the 1997/98 El Niño together with the development of seasonal forecasting, NMSs have become far more aware of climate issues and their need to encompass these, but also of their resource limitations within this regard. External climate expertise may then be seen as both a threat and an opportunity for empowerment. Further, where commercialisation has occurred it has been achieved in terms of short-range services, with limited thought sometimes given to the commercial foundations of climate services carried along in their train.

Many NMSs have responded to perceived threats by taking protective stances where possible. Stances taken include a tendency for reduced partnership building where threats are perceived, the wish to develop new capabilities (such as advanced modelling) perhaps beyond resource, and the protection of “crown jewels”, predominant amongst which are national climate data. These stances produce impediments to resource development, both within countries and internationally, but positions might be adjusted were national capacities increased. Equitable collaboration might also help address any protectionist stance.

5. Options for collective actions

The list below covers the main areas where actions might be considered. Details are provided for each option of its importance in terms of national, regional and international considerations, as well as in terms of funding considerations. All proposed options have been considered critically regarding the delivery of African needs, in terms of capacity building, vulnerability reduction, creation of capabilities within Africa that fill essential gaps regarding development, building partnerships within and external to Africa, and raising the national, regional and international profiles of Africa within the climate, development and decision making communities.

A summary list of the options follows, in which are reviewed funding terms, partnership opportunities, legacy for Africa, the benefits and urgency of each option, capacity building benefits, and the magnitude and sourcing of initial and on-going costs. Following this is a second table in which are indicated known impediments in terms of bottlenecks, policy issues and other external influences.

Observations

- *Status:* Essential underpinning to all climate activities, from simple climate description, through delivery of services, to development and validation of complex models; and also in supporting sustainable development in most respects; reduced and sub-optimal networks in many parts of the continent, often with limited and insufficient funding; network decline is on-going
- *Benefits of development from the African perspective:* Enhanced resource for all activities involving data, including, not least, sustainable development; improved ownership, status and contribution from international perspective; capacity building that needs Ph.D.-level skills for leadership but lesser skills otherwise
- *Benefits of development from the International perspective:* Development of African input into the solution of global issues; value of the data in many research/development areas, including calibration of satellite data, model validation, prediction verification
- *Funding considerations:* Observing systems are generally relatively inexpensive to install and to develop necessary expertise, but are often expensive to maintain
- *Time scales:* New observing platforms take a number of years before records have been built sufficiently for activities such as sustainable development, but they may contribute rapidly to synoptic, satellite calibration and other short-term demands; activities that enhance data availability may be undertaken in the short term and provide lasting benefit in multiple regards
- *Interest within Africa:* Recognised by NMSs as critical, but often not supported at policy level; despite the 1999 Geneva Declaration (which called *inter alia* for more investment in observation networks) networks continue to decline in many countries
- *Short-term, quick-win options:*
    - **Data Rescue (DARE)** – multiple opportunities – urgent before further decay of records – builds African capacity and develops long-term records with numerous benefits – inexpensive and no recurrent costs – needs to be done at national level – relatively small immediate international benefits
    - **Support for data archiving facilities** – multiple opportunities at both national and community levels – delay expands the problem and may result in further DARE needs – builds African capacity and highly beneficial in terms of all development activities – inexpensive with low on-going costs (in general assumed funded by countries) – needs to be done

    at national level – databases potentially provide benefits nationally and internationally
  - **Resource building in use of satellite data** – multiple opportunities alongside current EUMETSAT MDD activities – builds important African capability and extends opportunities for international contribution – important in terms of development activities – done at national or regional levels within important potential partnership benefits – inexpensive with low on-going costs (in general assumed funded by countries)
  - **African sustainable development atlas** – potentially an international collaborative exercise in African capacity building – depending on scope of atlas may be of considerable benefit to sustainable development activities – might be impeded by data issues – would be of international importance – needs to be done at full international level – should involve communities other than climate – medium investment but no on-going costs
- *Medium-term options:*
  - **Targeted support for observation platforms** – selected opportunities for supporting platforms seen to be priority in terms of, say, GCOS, synoptic observations, research into African climate systems, etc. – systems might be both in situ and remote – opportunities for expanding systems supporting sustainable development (e.g. soil moisture) – might provide significant gearing in terms of international activities – builds African capacity – increases African input into international activities – indirect benefits for sustainable development – done at national level – set-up costs depend on platform with appropriate on-going costs (that may exceed capacity of countries)

Research and model development

- *Status:* Research is generally essential for the provision of even the most basic services to development, as well of course for higher-level, including international, activities; much national research information is retained in local publications of limited distribution; lack of resource often provides minimal inducement for the few experts to stay; few numerical models are available in Africa, although empirical models for seasonal prediction are common; research productivity in Africa is amongst the lowest in the world; international research activity on Africa is underrepresented and often attracting lower funding priority
- *Benefits of development from the African perspective:* Focussed research will bring overall benefits to Africa, including to sustainable development; much needed basic research does not require Ph.D.-level skills, but Ph.D.-level direction is often required; models can bring substantial benefits to Africa, but need to be distributed and used appropriately if they are not to be unproductive drains on limited resources
- *Benefits of development from the International perspective:* Depending on the nature of the research the international benefits could be substantial, raising the profile of Africa in the community and addressing the role of Africa in the global atmospheric circulation; there is an on-going resource limitation in model validation studies that African scientists might help address
- *Funding considerations:* Research tends to carry few overheads except where specialised facilities are required; costs for introducing models developed elsewhere to Africa are low; staff costs are on-going; training costs need to be included; international funding rules often prohibit collaboration with African scientists and African rules with international scientists – good will is frequently the only process circumventing these funding restrictions

- *Time scales:* Provided the skills exist, the development of research projects/programmes and/or the introduction of models can be done on relatively short time scales; time scales for capacity development vary
- *Interest within Africa:* Research is often viewed within NMSs as an exercise providing status, and the introduction of models as more so; governments may prioritise only research they view as strategic; NMSs are likely to respond positively to opportunities to join international research activities provided these are not seen to undermine their national positions; much research within Africa is supported, at least in part, from outside, with limited funding originating within many countries and few opportunities to extend this
- *Short-term, quick-win options:*
    - **Scientist support fund** – multiple opportunities – builds African capacity and develops international links – topics could cover many research areas, including use of models – there is the issue of securing the resource developed – can be done at national, regional or international level and be used to build partnerships – could include users of climate information – medium-cost
- *Medium-term options:*
    - **Support for downscaling projects** – can be based on both empirical (to provide full African ownership) and numerical (to provide international links) methods – may be impeded by lack of data – direct benefits for sustainable development – probably best to do at national level but with objective of building partnerships – could include users of climate information – set-up and continuing costs relatively low

Prediction

- *Status:* Prediction in Africa, as elsewhere, is focussed primarily into that for a few days; NMSs have usually developed around support, including prediction, for military or transport demands, and generally have limited capacity in prediction at longer time scales and at all time scales for development; most predictions are supplied from international centres external to Africa; prediction models running within Africa have been supplied internationally in collaborative agreements; the majority of African nations have developed empirical models for seasonal prediction, in which they take strong ownership and often priority over international predictions; the Regional Climate Outlook Forum approach has been adopted more strongly in Africa than anywhere else, but its sustainability is uncertain; EWSs appear to be based on monitoring only with no direct predictive inputs at present
- *Benefits of development from the African perspective:* All services would be enhanced through improved understanding of prediction methodologies and predictability by African scientists; improved ownership of predictions will strengthen the position of NMSs; partnership arrangements will help integrate African scientists into international structures; extent of in-country developments should be balanced against resource; possible enhancement of EWSs
- *Benefits of development from the International perspective:* Improved understanding and use of predictions will enhance international status of Africa; partnerships will also raise status
- *Funding considerations:* Capacity and partnership developments are low to medium cost; international-standard prediction systems require expensive computers and improvements to data telecommunications systems that are likely unjustified by cost (and duplication) for most countries; however seasonal prediction systems can be run on inexpensive computers, in principle at low cost; however seasonal prediction systems have input needs that can only be provided

by international centres; both seasonal and climate change prediction systems can be developed in partnership at low cost

- *Time scales:* Installation of models on inexpensive computers, with related initial training, can be done in short time, but partnership outcomes may take a year or more to achieve
- *Interest within Africa:* Ownership, either direct or in beneficial partnership, of prediction systems is seen as important within Africa
- *Short-term, quick-win options:*
    - **Extension of predictions in terms of EWSs** – facilities exist (e.g. the UKMO has recently placed Darfur predictions on a UN web site) and integration is, in principle, straightforward – readily achieved in partnership with Africa on a regional basis – would involve users of climate information – using current facilities, set-up and on-going costs low
    - **Prediction facility support fund** – to support capacity and facility development (including verification, interpretation and decision making) in prediction on any appropriate time scale – done on a national or regional basis, with strong potential partnership benefits – initial costs low to medium, on-going costs low to medium, depending on facility
- *Medium-term options:*
    - **Support for downscaling projects** – see under Research and Model Development

Delivery of climate services

- *Status:* Basic services vary widely, from excellent in some countries in support of, say, agriculture, to almost non-existent; basic services depend on both data availability and the sophistication of analysis techniques employed; few non-government organisations provide climate services; delivery of services may be inhibited through government policies; communications issues inhibit service delivery to remote areas, although this has been improved through projects such as RANET; service delivery following RCOFs varies substantially between countries; sustainable development requires information for time scales out to perhaps, five years, periods not completely covered by predictions and for which approaches are in their infancy
- *Benefits of development from the African perspective:* Clear benefits to all activity sectors of African society through correctly focussed services, including sustainable development; potential improvements to statuses of NMSs; some argue that improvements in service delivery represent the single most beneficial available development in Africa
- *Benefits of development from the International perspective:* Improved resource utilisation within Africa
- *Funding considerations:* Costs depend on activity, with gearing important where available; costs per country may readily be reduced through partnership approaches
- *Time scales:* Support for the basic development of services can be done relatively quickly using available computer packages; longer time scales are often required for the more complex and partnership approaches
- *Interest within Africa:* Service delivery seen by NMSs as critical; governments may react positively only on demonstration of benefit
- *Short-term, quick-win options:*
    - **Seasonal prediction input to EWSs** – might involve Africans with international contributors – done on a national or regional basis, with strong potential partnership benefits – would involve communities other than climate – set-up costs low and on-going costs low
    - **African sustainable development atlas** – see under Observations

  - **Support for further extension of RANET activities** – builds international partnerships but done on a national and regional basis – would involve users of climate information at all levels, including in defining presentation formats – gearing should make costs low – on-going costs depend on extent
  - **Training fund for African climatologists and those engaged in managing sustainable development** – multiple opportunities, including in use of existing data, models, predictions – builds African capacity and international links – could be done on a national or regional basis with options to develop partnerships – establish links between climatologists and users – costs on-going
  - **Research project/programme fund** – multiple opportunities, including in decision processes for use of climate information – builds African capacity and develops international links – done on a national or research basis with potential partnership benefits – depending on scope may develop links with users of climate information – costs on-going
  - **Develop Foresight project to examine options for African climate services and sustainable development needs** – project scope could be directed in a number of ways – might form foundation for further development of services – best done on regional basis in partnership – depending on scope may develop links with users of climate information – would develop African capacity
- *Medium-term options:*
  - **Conference on African climate and, perhaps, sustainable development** – may or may not produce desired legacy – should be international – would involve a wide range of users of climate information – perhaps best used in support of other activities
  - **Create international research programme on African climate variability and its relationship to sustainable development** – opportunity to build African capacity and international links – opportunities to develop partnerships – involves users of climate information – costs on-going
  - **Run a collaborative regional project on climate variability in relation to sustainable development** – might be targeted in East or southern Africa – opportunity to develop African capacity and regional plus international links – costs depend on scope – involves a wide range of users of climate information – future costs depend on follow-up activities, of which there may be a range of options
  - **Support for establishment of a WMO-authorised Regional Climate Centre** – support might be in terms of capacity and resource development – builds potentially important facility for Africa and focus for international links – WMO policy is that on-going costs are the responsibility of the region
  - **Creation of an African Climate and Sustainable Development Institute** – builds potentially important facility for Africa and a focus for international links – forms partnerships with users of climate information – might be associated with the RCC approach above – set-up costs might be high and on-going costs would be incurred

Summary Table 1 - Brief summary of options for collective action

NOTE: Low, medium and high are used below only in a relative sense within context – thus 'low' does not indicate 'without value'

Option	Funding Term	Partnerships/African Legacy	Benefits/Urgency	Capacity Building	Initial Costs	On-Going Costs
Observations						
Data Rescue	Short for each individual project	International support useful (e.g. WMO DARE), but can be handled within country; legacy of extended data series for all development needs	National: Medium (gives ownership) Regional: Medium International: Medium	Builds important resource for development activities; expertise development limited	Low	None
Data Archiving	Short for each individual project	International support useful (e.g. WMO CLICOM), but can be handled within country; legacy of accessibility of data for development needs	National: High (gives ownership) Regional: High International: High	Builds vital resource for development activities; expertise development moderate	Low	Low – expected to be handled within countries
Resource building in use of Satellite Data	Short for set up	International support necessary; legacy of capacity in using advanced data streams	National: High (gives ownership) Regional: High International: Medium	Builds valuable physical and human resources	Low	Low – expected to be handled within countries
African Sustainable Development Atlas – see under **Delivery of Climate Services**						
Support for Observation Platforms	Medium for set up	Builds into various international activities that suffer lack of African input; legacy for Africa of improved network, international legacy also	National: High (gives ownership) Regional: High International: High	Major physical resource development	Dependent on platform – low to high	Dependent on platform – normally handled within countries
Research and Model Development						
Scientist Support Fund	Short for set up, but on-going	Opportunities to develop partnerships across Africa and internationally; legacy of African expertise	National: High (gives ownership) Regional: High International: Medium	Builds capacity which may not exist in some countries	Medium	Medium – needs to be adequate to retain scientists within Africa
Downscaling Projects – see under **Prediction**						

Option	Funding Term	Partnerships/African Legacy	Benefits/Urgency	Capacity Building	Initial Costs	On-Going Costs
Prediction						
Extension into EWSs	Short for initiation	Full international partnership opportunities; legacy of improved mechanisms for mobilising resources	National: Medium Regional: High (gives ownership) International: Medium	Extends current capabilities, mostly on the regional scale	Low	Low
Prediction facility support fund	Short for set up, but on-going	International partnership options, with possibility of within-Africa lead; legacy of improved meteorology/climate services	National: High (gives ownership) Regional: High International: Medium	Develops both physical and human capacity	Low to Medium	Low to Medium - expected to be handled within countries
Downscaling Projects	Medium for set up	Empirical techniques can be handled alone; advanced techniques need international support; legacy of targeted capability specific to many development activities	National: High (gives ownership) Regional: High International: Medium	Builds important human and physical capacity to support development	Medium	Low - expected to be handled within countries
Delivery of Climate Services						
Seasonal Prediction input into EWSs	Short for initiation	Full international partnership opportunities; legacy of improved mechanisms for mobilising resources	National: Medium Regional: High (gives ownership) International: Medium	Extends current capabilities, mostly on the regional scale	Low	Low
African Sustainable Development Atlas	Short for set up, medium for project delivery	Full international partnerships, both within and external to Africa, needed; partnerships between the climate and development communities necessary; legacy of valuable document for guiding development activities	National: High (gives ownership) Regional: High (gives ownership) International: High	Builds valuable expertise across communities	Medium	None
RANET Extension	Short for set up	Builds within existing international partnership; legacy of improved climate service communication	National: High (gives ownership) Regional: High International: Medium	Valuable communication expertise	Low	Low - expected to be handled within countries
Training for climatologists and those in sustainable development	Short for set up, but on-going	Cross-community within-country partnerships developed, with links regionally and internationally; legacy of African expertise	National: High (gives ownership) Regional: High (gives ownership) International: High	Cross-community capacity built	Medium	Low - expected to be handled within countries but needs to be adequate to retain scientists within Africa

Option	Funding Term	Partnerships/African Legacy	Benefits/Urgency	Capacity Building	Initial Costs	On-Going Costs
Research project/programme fund	Short for set up, but on-going	Partnerships both regionally and internationally; also cross community; legacy of African expertise	National: High (gives ownership) Regional: High (gives ownership) International: High	Multi-faceted capacity building potential	Medium	Medium – might require international support but needs to be adequate to retain scientists within Africa
Foresight Project	Short for set up, medium for project delivery, might be on-going	International partnerships likely, but could be within-Africa; legacy of African expertise	National: Medium (gives ownership) Regional: Medium (gives ownership) International: Low	Builds human and cross-community capacity	Low	None
Climate Conference	Medium for set up	Major opportunity for partnership development; multiple legacy potential	National: Medium Regional: Medium: International: Medium	Depends on legacy	Medium	None
Research programme on climate variability and development	Medium for set up; on-going	International and regional partnership options; multiple legacy potential	National: High (gives ownership) Regional: High (gives ownership) International: Medium	Builds human and cross-community capacity	Medium	Medium - might require international support
Targeted Regional Project	Medium for set up; medium for project delivery	Strong regional partnerships, with international links; multiple legacy potential	National: High Regional: High (gives ownership) International: Medium	Builds human and cross-community capacity	Medium	Medium - might require international support
Regional Climate Centre	Medium for set up; on-going	Builds within international structures; legacy of improved delivery of climate services	National: High Regional: High (gives ownership) International: Medium	Builds human and physical capability	Medium to High	Medium - might require international support
African Climate and Sustainable Development Centre	Medium for set up; on-going	Full partnerships across and beyond Africa; multiple legacy potential	National: High Regional: High International: High	Builds human, physical and cross-community capacity	High	Medium

Summary Table 2 - <u>Key bottlenecks, policy issues and broader influences</u>

	Bottlenecks	Policy issues	Broader influences
Observations	• Restricted and sometimes non-operative observing networks in many countries • Observing networks have never existed in some countries • Limited resource trained in remote sensing techniques	• Lack of priority in government spending affects some networks	• Wars/political instabilities have devastated observing networks in a number of countries • Non-exploited and/or non-accessible climate data from numerous sources available in many countries
Data Distribution	• Communication networks are inadequate in places	• For climate data use of WMO Resolutions 25 and 40 often results in restricted access to data	• Data remain a major *raison d'être* of many NMHSs and they wish to retain control
Data Storage	• Creation and maintenance of national data bases is supported by WMO, but resource issues exist in some countries • Many historical data are being lost through source degradation etc. because of limited recovery resources	• Regional Climate Centres proposed by WMO to include, where agreed, data centres • Current pertinent centres include ACMAD, AGRHYMET, ICPAC (was DMC(N)) and SADC DMC (was DMC(H))	• Data remain a major *raison d'être* of many NMHSs and they wish to retain control
Research	• Most countries have limited resources, both physical and human • Limited on-continent quality teaching/research facilities	• Data access issues frequently geographically limit research to home countries	• Qualified researchers often move away • Political instabilities have reduced resources in some countries • Research concepts still often based on high-latitude theory introduced during WWII
Model Development	• Most countries rely on models developed outside the continent • Resource limited for developing models, and can remove resource from other activities • At seasonal time scales empirical models have been developed in most countries	• Use of models is often seen nationally as conferring more status than other research activities	

	Bottlenecks	Policy issues	Broader influences
Prediction	• Most countries rely on external provision of predictions but most have their own empirical seasonal prediction systems • Seasonal prediction information often in form users find difficult to interpret • Restricted flexibility of users to respond to seasonal predictions • General lack of understanding of probability information and of limitations of predictions	• Traditional focus and experience of NMHSs has been on short-range prediction, particularly for transport, thus expertise in climate is often limited	• Issues of confidence following positive predictions of severe drought from some quarters ahead of 1997/98 El Nino • Momentum has been maintained in RCOFs (perhaps better than anywhere else) but financial sustainability of Forums is questionable • Ready accessibility of international predictions often perceived to lower value of NMHSs • Countries often prefer their empirical model predictions at seasonal scales over other predictions
Broadcasting of climate information	• Limited rapid communications facilities in many countries, particularly in rural areas – RANET tries to address • General lack of understanding of probability information and of limitations of predictions	• NMHSs wish to be seen as sole weather/climate information providers • Limited remit of NMSs in some countries makes it difficult for them to justify broadcasting of climate information	• Traditional knowledge is often seen positively in comparison to modern science • Perceived insufficient demonstration of benefits in some countries
Integration into sustainability and poverty reduction activities	• Limited expertise in most countries • Limited integration of climate into planning activities	• Limited resource and planning to cope with climate variability in many countries • NMHSs tend to have limited climate expertise through historical focus on services to support transport • NMHSs are often asked to handle UNFCCC and IPCC matters	• HIV/AIDS may be affecting resources in some countries • Awareness of the role of climate, and of the potential input of climate services, remains low in some areas • AIACC, CLIMAG, etc., projects already working in some countries