SUSTAINABLE DEVELOPMENT IN AFRICA

IS THE CLIMATE RIGHT?

IRI

COLUMBIA UNIVERSITY

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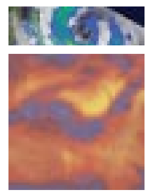

Sustainable Development in Africa: Is the Climate Right?

THE INTERNATIONAL RESEARCH INSTITUTE
FOR CLIMATE PREDICTION

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1. SUMMARY

Much better management of climate variability is essential if sustainable development is to be achieved in Africa.

1. Over the last 25 years, Africa has become significantly poorer. The population has doubled and the number of people living in poverty has increased. Today, some 200 million people in Africa go hungry, mostly in sub-Saharan countries. These people are comprehensively excluded from the shared benefits of sustained economic growth. It is vitally important to reverse this trend and integrate Africa into the Global Development Process. This is a huge challenge requiring great determination.

2. The new International Development Agenda is scaling up to address this challenge. The Millennium Development Goals (MDGs), World Summit on Sustainable Development, African Union reforms and NEPAD, the Millennium Project, the G8 and Africa Commission initiatives, all promote a comprehensive, multi-sectoral approach to development in Africa, with more proactive management of human and natural resources.

3. Climate Variability and the MDGs: Climate information is very important for achieving the MDGs and other development targets. Climate variability dominates rural food production, and strongly influences hunger, health, access to water, and hence poverty in so many countries. Integrated water resource management is impossible without good information on climate variability, and yet climate observation stations are in major decline. Mortality rates from diseases such as malaria are highly sensitive to climate variability. Yet we still proceed as if climate variability is an inescapable 'god given fate' rather than an increasingly predictable part of our physical environment.

4. Is knowledge well used? Rain and water are absolutely fundamental for life in Africa. But how much do we know about the climate? Is it changing and becoming increasingly variable? Do we know enough already to 'manage' our climate system better for development purposes, or will we continue to miss opportunities to benefit from abundant rainfall years, and suffer every drought as if it was the first time? Are we aware of the true extent of economic and social sensitivities to climate variability in Africa? Do we use already established best practices in climatology to mitigate such problems? No. In practice, use of climate information for development in Africa is still extremely poor.

5. Managing Risk: A rational approach to coping with climate variability involves encouraging proactive risk management based on best available information together with incorporation of new skills in seasonal prediction. It is very important that people have access to such environmental information in a democracy, to assist stakeholder agreement in decision-making and development of appropriate response strategies. Sharing information is a prerequisite of good governance.

6. Climate Change: And what about climate change? What can and should we do about that? The first essential step is to be able to cope with climate variability today. If we can do that, then we will be more resilient and in a much better position to cope with climate change tomorrow.

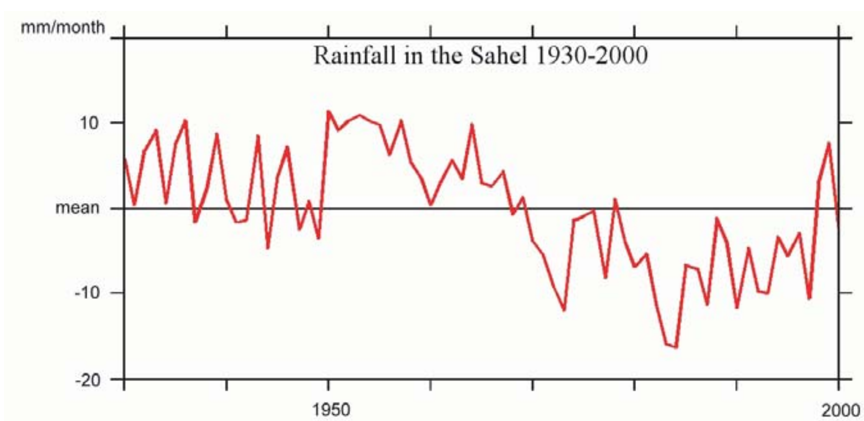
7. So what is needed? Strong leadership in addressing climate variability in important economic and social sectors is urgently required throughout Africa. We must enable the millions of people whose livelihoods are dominated by climate variability to cope better, with more opportunity and less risk. We must supplement existing practices with new techniques like seasonal prediction, monitoring and risk management, to ensure a whole range of better decisions, appropriate to the current climatic reality. We need to enable non-specialists to be able to access and use climate information effectively, in their daily tasks.

8. The International Research Institute for Climate Prediction (IRI) was established with a global mandate to assist societies cope better with climate variability. IRI partners with organizations in Africa that seek to use climate information more effectively in decision-making, towards achieving the MDGs in Africa.

2. INTRODUCTION

The purpose of this document is to set out the IRI position on managing climate information in the development process in Africa, and to provide a convenient point of reference for all people working on related matters. The main message is that much better management of climate variability in a number of key sectors is essential to achieve the Millennium Development Goals and Sustainable Development in Africa. IRI, as an international development organization, is committed to the MDGs and is actively engaging partners in new ways to assist the process.

The starting point is that climate variability is highly significant in most of Africa, and it can be a major impediment to development if it is not addressed properly and managed well, across a range of sectors. Unfortunately, there are few countries in Africa where climate variability is managed well today. As a consequence, improved *climate risk management* offers a low-cost opportunity for deriving greater benefit from existing land and water resources, through better use of knowledge already gained.



Annual-mean anomalies in precipitation averaged at 41 stations in the Sahel, 10N-20N across Africa, over the period from 1930 to 2000 (from NOAA's Global Historical Climate Network).

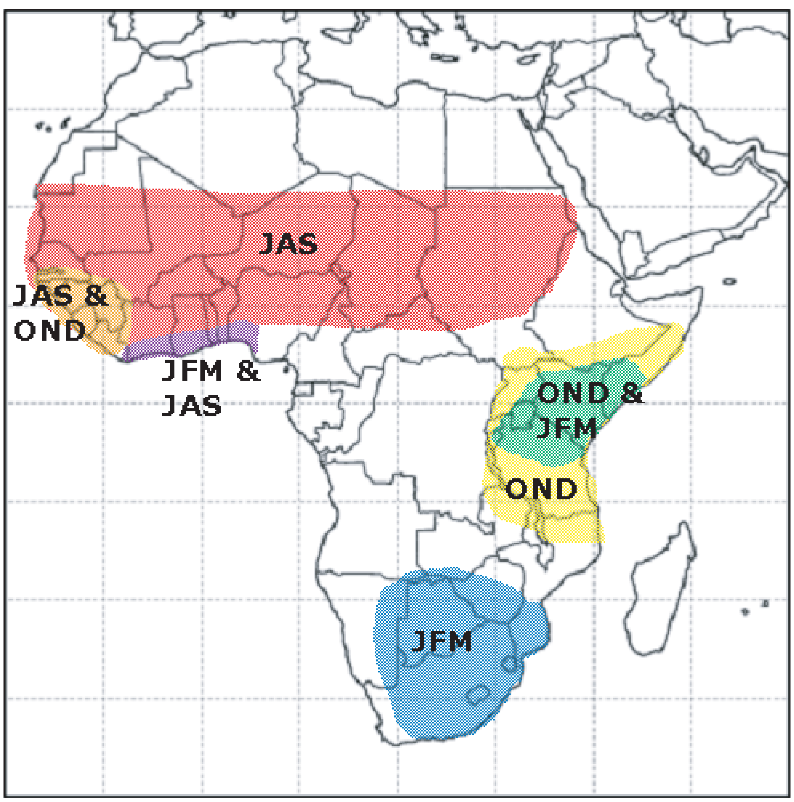
Following the droughts of the 1970s and 1980s, a number of institutions were established in affected regions of Africa to address problems of climate variability. As understanding has grown, these institutions and others have responded to the challenge, and progress has been made in forecasting seasonal climate towards managing associated risks. The IRI works with these partners to build mutual capacity to address climate-related problems. The result, a growing network with increasing capability to help manage risks, provides a foundation for much greater integration of climate information into decision-making and policies at all levels of African society, and in all climate affected sectors.

Since many countries in sub-Saharan Africa have not made economic progress during the last 25 years, it has been an exceptionally difficult period to promote uptake and realize impact from new techniques. With the changing development agenda in Africa however, opportunities for achieving real and lasting impact are improving. It is, therefore, more important than ever that all people who make climate sensitive decisions should be aware of both the benefits of *risk management* and its practice in relation to climate variability.

The main sectors affected by climate variability addressed in this paper are some of those most closely related to poverty elimination, namely Agriculture and Food Security, Water and Health. One of the most important lessons that the IRI interdisciplinary approach underlines is the importance of *integrated decision-making* to cope with climate variability. For example, promoting 'improved' agricultural practices for people with fragile livelihoods in a highly variable climate cannot be separated from also ensuring their food security in poor years.

Although seasonal prediction is more reliable in some parts of Africa than in others, the practice of incorporating a seasonal forecast into routine decision-making is an excellent first step towards risk management for many people. Once it is accepted that one doesn't have

Regions with Predictive Skill for Seasonal Precipitation



Delimited regions indicate areas where the seasonal precipitation can be simulated with a high degree of skill based on dynamical model simulations over the 1950-1995 period. The labels indicate the season(s) when predictability exists; these generally coincide with the regions' rainy seasons: January-February-March (JFM) for southern Africa; July-August-September (JAS) for the Sahel and western Africa; October-November-December (OND) for eastern Africa. Only these 3 seasons (JFM,JAS, OND) were considered in this analysis.

to be a passive receiver of climate variability but can make contingency plans based on objective assessments that accommodate important climate variations in advance, then risk management starts to become a feasible reality. Climate forecasts enable one to see how the climatic dice are 'stacked' before one places one's bets: gambling in the same sense that farmers gamble every day, while using the best information available to them.

IRI is well aware of the vast scale of interventions required to achieve the MDGs in Africa over the next 10 years, and recognizes that these goals will be even more difficult to achieve without full incorporation of all possible techniques to cope with climate variability. Further, climate changes will be a major challenge to sustainable development in Africa. Coping with climate variability is an essential first step towards coping with climate change.

3. A NEW AGENDA TO ADDRESS THE URGENT NEED FOR REAL DEVELOPMENT IN AFRICA

Africa is missing out on global development and the livelihoods of too many people are heavily dependent on agriculture in marginal climates. A number of significant new initiatives are being launched to address entrenched problems. The Millennium Development Goals provide a common focus for development in Africa.

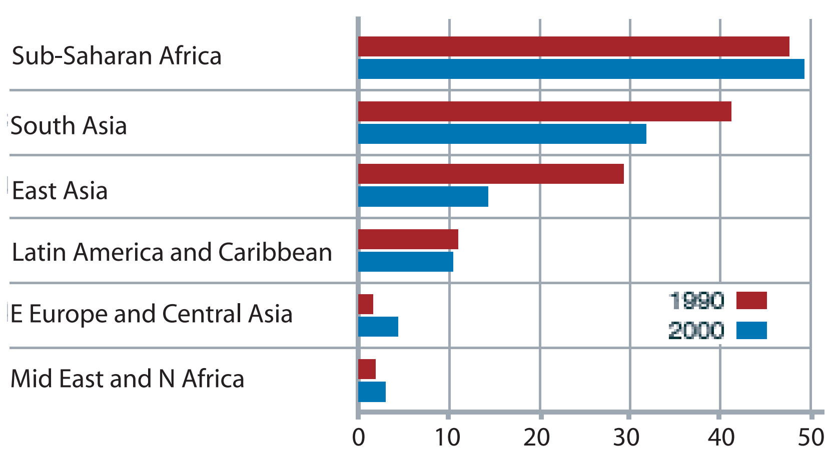
While national economies and societies around the world are generally developing well, poverty is widespread in much of Africa, and getting worse. Africa as a whole, with a population of some 813 million people in 2002, seems largely to be missing out on development, let alone sustainable development.

Part of the problem lies with the large number of rural people dependent on subsistence agriculture for their livelihoods. Too many such people have inadequate land with poor soils and marginal climates, and consequently their livelihoods are extremely vulnerable to climatic fluctuations. Furthermore, the national economies of some African countries are highly dependent on seasonal climate variability, and may suffer repeated 'shocks' from drought.

While most countries in the world have been getting steadily richer over the last 25 years, much of Africa has been getting poorer. ***Millennium project: Hunger task force.***

Slow growth in Sub-Saharan Africa has meant increases in both the share and number of the poor in the 1990s, leaving it as the region with the largest share of people living below $1 a day. The forecast anticipates per capita growth averaging 1.5 percent over the 2005-15 period - a reversal of the region's long-term historical decline. But even this is far short of the growth needed to reduce poverty to half the 1990 level. In fact the number of poor is expected to rise from 315 million in 1999 to 404 million people by 2015 in Sub-Saharan Africa. Africa also remains highly dependent on commodity exports and is still experiencing political and economic instability.

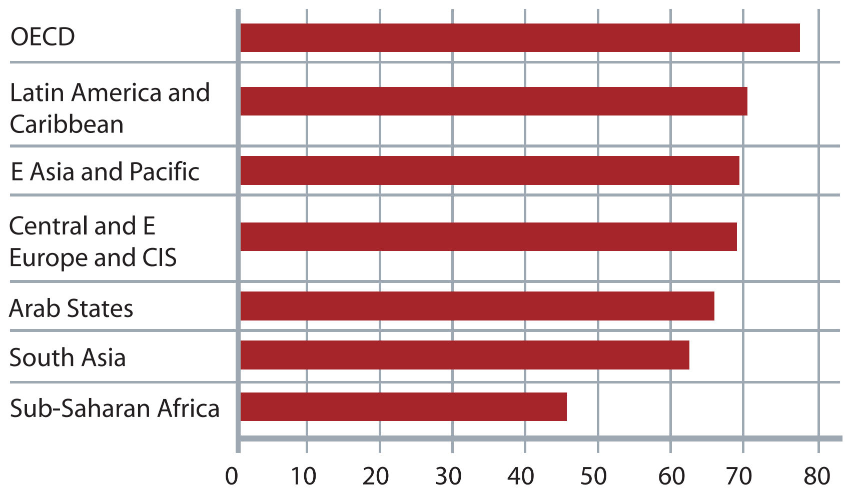
Proportion of people on less than $1/day (%)



SOURCE: World Bank

Half of Africa's population lives on less than US$1 per day, and alone among the continents, Africa is becoming poorer and poverty is on the rise. Alone among the continents, the average life-span in Africa is becoming shorter and is now 16 years less than in the next-lowest region and has dropped 3 years in the last 10. The rate of illiteracy for persons over 15 is 41 per cent, and Africa is the only region where school enrollment is declining at all levels, and particularly among women and girls. While Africa accounts for 13% of the world's population, Africa's exports account for less than 1.6% of global trade, and that figure is falling. Africa currently attracts less than 1% of global investment, and is the only major region to see per capita investment and savings decline since 1970; indeed as much as 40% of Africa's own savings are not invested within the continent. Total net Official Development Assistance (ODA) to Africa has fallen from previous levels of US$17 billion to US$12 billion today. ***G8 Africa Action Plan Highlights released by the Group of Eight, 27 June 2002***

Life expectancy



SOURCE: UNDP

African leadership and members of the international development community are well aware that Africa has fallen behind in terms of global development, and several major efforts are now underway to rectify the problem. These are not just 'more of the same' but include important new ideas and radical measures to really get to the heart of the problem.

The New Partnership for Africa's Development, NEPAD, represents a visionary attempt by African leaders to encourage Africans to take responsibility for their own development. It is a program of the African Union designed to meet its development objectives. The highest authority of the NEPAD implementation process is the Heads of State and Government Summit of the African Union[i]. NEPAD has set down certain principles for countries to abide by, and promotes a continent-wide development agenda based on sound national foundations, with much action at sub-regional levels.

The Millennium Development Goals with their time-bound quantified targets and development indicators show most starkly the extent to which Africa is excluded from development. The UN Millennium Project seeks to address the many fundamental problems directly with a specially developed program for Africa. The OECD is assiduous in monitoring the performance of member countries' development expenditure, and promoting greater coordination and efficiency of spending towards the MDGs.

Millennium Development Goals 1-7	
Goals and Targets	**Indicators for monitoring progress**
Goal 1: Eradicate extreme poverty and hunger	
Target 1: Halve, between 1990 and 2015, the proportion of people whose income is less than one dollar a day	**1.** Proportion of population below $1 per day **2.** Poverty gap ratio [incidence x depth of poverty] **3.** Share of poorest quintile in national consumption
Target 2: Halve, between 1990 and 2015, the proportion of people who suffer from hunger	**4.** Prevalence of underweight children (under-five years of age) **5.** Proportion of population below minimum level of dietary energy consumption
Goal 2: Achieve universal primary education	
Target 3: Ensure that, by 2015, children everywhere, boys and girls alike, will be able to complete a full course of primary schooling	**6.** Net enrollment ratio in primary education **7.** Proportion of pupils starting grade 1 who reach grade 5 **8.** Literacy rate of 15-24 year olds
Goal 3: Promote gender equality and empower women	
Target 4: Eliminate gender disparity in primary and secondary education preferably by 2005 and to all levels of education no later than 2015	**9.** Ratio of girls to boys in primary, secondary and tertiary education **10.** Ratio of literate females to males of 15-24 year olds **11.** Share of women in wage employment in the nonagricultural sector **12.** Proportion of seats held by women in national parliament
Goal 4: Reduce child mortality	
Target 5: Reduce by two-thirds, between 1990 and 2015, the under-five mortality rate	**13.** Under-five mortality rate **14.** Infant mortality rate **15.** Proportion of 1 year old children immunized against measles
Goal 5: Improve maternal health	
Target 6: Reduce by three-quarters, between 1990 and 2015, the maternal mortality ratio	**16.** Maternal mortality ratio **17.** Proportion of births attended by skilled health personnel
Goal 6: Combat HIV/AIDS, malaria and other diseases	
Target 7: Have halted by 2015, and begun to reverse, the spread of HIV/AIDS	**18.** HIV prevalence among 15-24 year old pregnant women **19.** Contraceptive prevalence rate **20.** Number of children orphaned by HIV/AIDS
Target 8: Have halted by 2015, and begun to reverse, the incidence of malaria and other major diseases	**21.** Prevalence and death rates associated with malaria **22.** Proportion of population in malaria risk areas using effective malaria prevention and treatment measures **23.** Prevalence and death rates associated with tuberculosis **24.** Proportion of TB cases detected and cured under DOTS (Directly Observed Treatment Short Course)
Goal 7: Ensure environmental sustainability	
Target 9: Integrate the principles of sustainable development into country policies and programs and reverse the loss of environmental resources	**25.** Proportion of land area covered by forest **26.** Land area protected to maintain biological diversity **27.** GDP per unit of energy use (as proxy for energy efficiency) **28.** Carbon dioxide emissions (per capita) [Plus two figures of global atmospheric pollution: ozone depletion and the accumulation of global warming gases]
Target 10:Halve, by 2015, the proportion of people without sustainable access to safe drinking water	**29.** Proportion of population with sustainable access to an improved water source
Target 11:By 2020, to have achieved a significant improvement in the lives of at least 100 million slum dwellers	**30.** Proportion of people with access to improved sanitation **31.** Proportion of people with access to secure tenure [Urban/rural disaggregation of several of the above indicators may be relevant for monitoring improvement in the lives of slum dwellers]

The G8 countries have committed themselves to support those African countries that commit themselves to NEPAD and its objectives. Besides political will, the G8 countries will make new resources available.

The G8 initiative[ii] will support a number of high priority sectors and

- Provide at least US$6 billion per year in new resources to go to Africa
- Increase the use of grants rather than loans for the poorest
- Provide up to an additional $US1 billion to meet the projected shortfall in the Highly Indebted Poor Countries initiative
- Work towards the objective of duty free/quota free market access for all products originating from ldcs
- Work towards enhancing market access for trade with African free trade areas or customs unions.

The Africa Commission[iii], following on from the G8 initiative, emphasizes the need to double aid investment in Africa if there is to be any chance of meeting the MDGs, and repeats the need for peace, good governance and a more enabling economic environment throughout the continent. It is well aware of the problems posed by climate change for sustaining hard won development gains.

This new agenda for Africa takes a more holistic view of development and seeks to include and address a greater range of interlinked problems than ever before, including climate change issues. The objective is real development that can be sustained in the long term.

It is going to be very difficult to achieve these extremely challenging development objectives, even with the global political support evident above. It will be even more difficult to achieve these objectives without taking into account climate variability today and climate change tomorrow. Because the lives of so many people in Africa are critically dependent on a highly variable climate, it is essential that climate variability and associated risks are managed intelligently, as an integral part of the development process.

4. THE IMPORTANCE OF CLIMATE IN KEY DEVELOPMENT SECTORS

Three critically important sectors in the new development agenda are particularly sensitive to climate variability, namely agriculture, water resources and health. Good management of these sectors is important to promote development and avoid disasters.

Climate exerts a profound influence on the lives of poor populations who depend on agriculture for livelihood and sustenance, who are unprotected against climate-related diseases, who lack secure access to water and food, and who are vulnerable to hydro-meteorological hazard.

For vulnerable communities, developing flexible, proactive responses to climate variability that enhance resilience is a crucial step toward achieving the MDGs by 2015, and a foundation for coping with the uncertainties of a changing climate into the future.

Furthermore, because climate has a confounding influence on many development outcomes, attention to climate variability is essential for measuring real progress toward the MDGs.

Agriculture in Africa

All the new initiatives for development in Africa emphasize the overriding importance of agriculture, both for eliminating hunger, and also as a local and national economic driver. The Millennium Project proposes major scaled-up interventions to enable smallholder agriculture to develop and sustain itself throughout the poorest regions of Africa. This is to be coupled with a 'safety net' to protect communities and local economies in disastrous years, so that all the gains made in the better years are not wiped out by unfavorable seasons, as happens so often at present. Such an ambitious program, designed to bring a hundred million people out of poverty by 2015 in sub-Saharan Africa, explicitly recognizes the importance of climate variability in its proposals.


CGIAR

Subsistence Farmers: For too many people in Africa, subsistence agriculture is a desperate form of poverty akin to slavery that requires major effort for relatively little return. With reduced fallow periods, smaller farm size, declining soil fertility, lower yields, increasing indebtedness and isolation from markets, such farmers have relatively few choices even before rainfall variability, crop pests

and diseases, malaria, AIDS and emigration of young labor make their lives even more onerous. Their predicament arises from several processes, but is largely based on the expansion of subsistence agriculture over the last 50 years, into ever more marginal agro-climatic zones. Such people are the most vulnerable to climatic variability, too often losing their entire season's effort. For many of these people, whose main input towards production is their labor and that of their family, agriculture would be an appropriate part time activity, were there suitable off farm employment opportunities.

Eradicating poverty (MDG1) in such climate averse areas will demand much better matching of agricultural activities to seasonal quality, together with greater food security in the frequent poor years. With good weather and climate information, and especially comprehensible information on the quality of the next wet season, subsistence farmers can derive certain advantages from adapting the timing and quality of their farming activities (soil preparation, planting, replanting, weeding, protecting from pests and diseases, and harvesting) though choices decrease as poverty increases.

Cash Crop Farmers: Farmers that engage more with local markets and dealers, can also access credit and buy inputs (improved seeds, fertilizer, sprays for pest and disease control) to increase the value of their labors. Such farmers tend to be less risk averse and more proactive in their management choices, and as such, are in more of a position to access and take advantage of weather and climate information, particularly in their choice of seeds and other agricultural inputs. This form of agriculture is the backbone of the African economy, and is likely to continue to be so for the foreseeable future. The majority of the rural population depends on agriculture and, with very limited areas currently under irrigation, the well being of these people is intrinsically linked to the high year-to-year variation in rainfall. Communities who depend on rain-fed farming for sustenance and livelihood in high-risk environments are among those most affected by climate variability, but conversely are also often particularly well poised to benefit from improved management of climatic risk through appropriate use of climate information. It is important to empower rural populations to better manage risk and exploit opportunity by (a) providing relevant, timely information to the target populations; (b) fostering and guiding adaptive management responses; and (c) addressing resource constraints to adaptive responses.

Rural Livelihoods: In practice, the above distinction between subsistence and cash crop farmers is artificial. Most rural livelihoods fall between the two extremes described above, and comprise a mix of subsistence and income generation. But while it is clear that choices and options increase with wealth, and with access to markets, credit and information, it does not follow that the value of climate information is any less to the more marginal farmers. Risk aversion and the insurance value of information, the motivation that comes from vulnerability, and the tendency for predominately subsistence farms to be more diversified than predominately commercial farms, all favor greater value of climate information for the relatively poor. Opportunity to intensify in good years through increased input use, and a tendency to have better access to information are factors that favor the relatively wealthy, as well as the large commercial agricultural businesses.

Managing the rural economy: Without a healthy rural economy, farming communities cannot get the inputs they need to cope better with climate variability (agriculture, health, education ...), and so the cycle of poverty is perpetuated. There are many ways that governments can improve the rural economy (see the Millennium Project proposals for example) in ways that are sensitive to prevailing conditions. For example, modern methods of monitoring crop production from satellite are now routinely used in most regions of Africa. Coupled with seasonal climate prediction, these enable early yield estimation, extend the lead-time of food stock or relief decisions, and facilitate timely implementation of measures to help ensure local food security or cope with harvest surpluses. And knowing in advance the risk of food shortfall/surplus is very important information for central government economic advisers, and local government planners, in order to make contingency arrangements.

Water: Another Critical Issue

Improved water management is recognized as a critical issue for eradication of poverty and achieving the MDGs in Africa. This has been underlined at numerous international fora, and was given great emphasis at the World Summit on Sustainable Development (WSSD). In the Africa Water Vision for 2025 (produced by the Economic Commission for Africa, the African Union and the African Development Bank) three key problems are identified:

- The multiplicity of trans-boundary water basins;
- Extreme spatial and temporal variability of climate and rainfall, coupled with climate change;
- Growing water scarcity.

While further progress towards integrated water resource management (IWRM) is promoted as the only sustainable solution, there is as yet, inadequate capacity to manage this process effectively in Africa.

Fortunately, many African countries have risen to the challenges that confront them. In the field of water policy, strategy and institutional arrangements, a number of advances have been made. These include an increased awareness of, and political commitment to, integrated water resources management (IWRM). There is also an increasing commitment to water-policy reform and a strong trend towards decentralization of water institutions. Furthermore, there is a thrust towards financial sustainability in the water sector and a realization of the importance of treating water as an economic good, while providing a safety net for the poor.

Inadequate data and human capacity. *A key limitation at national, sub regional and continental level is the paucity of data on water resources. This limitation is linked to inadequate human capacity for the collection, assessment and dissemination of data on water resources for developing, planning and implementing projects.*

The skills for IWRM are not widely available in Africa. A massive program for capacity-building is therefore needed to produce a cadre of water professionals (both men and women) who are highly skilled in IWRM principles and practices. Under the Global Water Partnership, a capacity-building associated program is being developed to provide strategic assistance for developing the necessary skills for IWRM. The challenge is how to retain staff once they are given the requisite training. It is generally recognized that even if the trained staff are retained, the skills they acquire may become atrophied from lack of use unless appropriate incentives are introduced. A second challenge is, therefore, how to devise such incentives so that they are consistent with the aspirations of the staff and with the goals of the water sector. These are pressing challenges that call for immediate remedial action. The Africa Water Vision[iv]

Africa needs:

- Water for people in town and country to drink, wash and live healthy lives
- Water to grow food
- Water for commercial agriculture and commodity exports
- Water for hydropower, irrigation and industry
- Water for animals and to grow fodder, trees and firewood
- Water to keep the rivers flowing and recharge the aquifers
- Water to keep the environment healthy and provide sustainable services.

But unless carefully managed, this water also brings

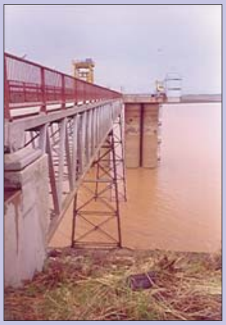
- mosquitoes, malaria and other diseases
- damaging floods
- erosion of hill-slopes
- disruption to transport.

All this water comes from rainfall, which is not only very variable in Africa, but also getting more variable in some places. And with climate change, temperatures will continue to increase, and rainfall variability may continue to increase. With so many human activities in Africa liable to be affected, it is critically important for today and for the future, that water from rainfall is managed better everywhere. In order to achieve this, the most important step is to ensure that rainfall variability is not simply accepted as an inescapable 'fate from the gods'. Rather it needs to be regarded as an environmental variable, influenced by increasingly

The Tana River Basin is a major river basin in Kenya in which climate affects hydropower generation and livelihoods. Droughts in 1999-2000 led to water shortages and severe cutbacks in power generation, causing power rationing and blackouts. All sectors of Kenya's economy were adversely affected. Flooding in June 2003 displaced an estimated 10,000 people.

The issues of stabilizing power generation and reducing negative impacts of flooding are linked. Flooding occurs when higher than expected rainfall leads to surplus water retained for power generation being spilled from the reservoirs upstream.

The Tana River Basin is in an area in which seasonal rainfall is highly predictable at least for the October-December season. Seasonal streamflow forecasts, therefore, have potential uses for reservoir operation. The forecasts would allow water levels to be graduated according to anticipated inflow, reducing the need to retain too much water for power generation in anticipated high-rainfall periods. The seasonal forecasts could also serve as a basis for increased flood planning during high-rainfall years. Currently, when surplus water must be spilled, people on the floodplain receive a flood warning three days in advance. Conversely, during expected dry conditions water retention could be increased and potential power shortages anticipated.



Partners: University of Nairobi, IGAD Climate Prediction and Applications Center, KenGen
Photo credit: Chris Oludhe

well-understood physical processes, that can be managed better by a whole host of decision makers in a diversity of economic and social domains, to great effect; just as happens in developed countries, many times each day.

Transboundary River Systems

Much ocean induced climate variability affects large areas of Africa and its effects are particularly noticeable at the scale of transboundary river basins. Attempts are being made through the African Network of Basin Organizations to improve management and decision-making in all transboundary river systems, to encourage greater cooperation between stakeholders, and to mitigate flooding and reduce competition and conflict over access to water. To do this effectively it is absolutely essential to incorporate seasonal water variability into decision-making, and where appropriate, early warning of this variability through seasonal forecasting. Capacity strengthening in water authorities to enable people to use these increasingly powerful tools is essential.

Reservoir Management

Reservoirs are designed to hold significant amounts of seasonal runoff to mitigate the effects of upriver rainfall variability. The Aswan dam in Egypt provided irrigation through 10 years of drought and sub-normal rainfall over Ethiopia in the 1980s. Very often however there are conflicting demands on reservoir managers to provide water for hydropower, irrigation and to manage flood and base flows for the health of lower river communities and ecosystems. Without knowledge of future rainfall, reservoir managers inevitably tend to be conservative. With reliable indicators of future rainfall quantities, reservoir managers are in a better position to make best use of the limited stored water available. Such decisions involve risk, and managing risk is an essential component of making the best of a scarce and highly variable resource such as water.

For example, improved predictability and understanding of climate variability could help in deriving optimal operating policies for water and infrastructure management, as at Angat Dam in the Philippines. This multipurpose dam supplies 97% of Metro Manila's water requirements, irrigates approximately 30,000 hectares and generates 240 MW of hydropower. The El Niño of 97-98 caused severe shortage in rainfall, which resulted in an unprecedented drop in water level. Dam authorities shut off water for irrigation and hydropower generation. This resulted in several thousand farmers losing their crops and the power companies having to buy emergency coal on the international market at higher prices. The obvious but expensive solution to this problem (which is not limited to the Philippines alone) would be to build more multipurpose dams and increase capacity. Instead, through better climate forecasting information and analysis of climate variations over the past many years, better decision systems for water distribution can be put into place. Farmers can be warned in advance not to rely on irrigation water for that season and policies can be put into place to help them with alternative, less water-intensive crops, or even alternative livelihoods strategies. Power companies can factor in this forecast and procure alternative resources for cheaper power production. Thus, understanding and predicting climate at seasonal to inter-annual scales can play an important role in developing adaptive water management strategies, which would play an integral role in achieving MDGs by 2015.

Water Summary: Climate variability not only affects the design and management of water and sanitation infrastructure, but also plays an important role in the planning and design of water resource systems. It is essential that knowledge of climate variability be incorporated in water management strategies at all time scales, as an integral part of knowledge-driven decision-making: optimal system management is impossible without it.

Climate variations across seasonal and decadal time scales have the potential to reverse successful interventions made through the MDG implementation projects. A strategy of strengthening global and national climate observing systems, and strengthening partnerships between institutions working on climate-sensitive development problems and providers of climate information is essential to provide the necessary foundation for enhancing climate resilience across the MDGs.

Health: A Third Critical Issue Dependent on Climate Variability

The European heat wave of 2003 had a dramatic impact on excess mortality causing more than 12,000 deaths in Paris alone. The consequences of unusual warm years in Africa pass largely undocumented. We all know from direct personal experience that dry-season illness tends to be different from wet season diseases. But how much does the overall incidence of disease, and hence death rates, depend on climate variability, and hence fluctuate from season to season and year to year? The answer is 'climate has an enormous impact on health.' There are in fact many diseases that are recognized by WHO as being climate sensitive[v]. These include: influenza, diarrhoeal disease, cholera, meningitis, dengue and malaria.

Malaria is widely appreciated as the most important of the climate-sensitive diseases. It is seen as a major impediment to socio-economic development particularly in Africa where 90% of the 1-3 million deaths it causes each year occur. If we are serious about reducing malaria, and associated maternal and child mortality as part of the Millennium Development Goals, then information on the seasonality of climate and its variability must be taken into account when planning and implementing routine health campaigns and epidemic preparedness. As with many infectious diseases, malaria has a climate-environmental component that helps to determine its spatial and temporal extent. Presently, where malaria is not adequately controlled, the seasonality of the climate largely determines the seasonality and endemicity of malaria. Along the margins of this 'climatic suitability for malaria' it is climate variability between years that helps determine which regions are prone to epidemics; and it is usually climate anomalies that periodically triggers epidemics. Climate information has been used to map the seasonality of malaria risk and to inform on disease endemicity. Analysis of climate variability has also been used to map those zones at risk of epidemics.

It is estimated that more than 110 million people in Africa live in regions prone to malaria epidemics[vi]. The populations affected have little acquired immunity to malaria and are therefore vulnerable to explosive epidemics that can cause high case fatality rates among all age groups. In spite of the severity and the magnitude of the problem, research on epidemic malaria is very limited and almost nothing is known of the economic burden of malaria epidemics in sub-Saharan Africa.

For malaria, climate is the primary factor in determining at least some epidemics (WHO 2004). There is a three-fold influence of meteorological/climatic factors on transmission and incidence of malaria:

- air humidity influences vector survivorship;
- air temperature influences parasite/vector development rates;
- rainfall influences mosquito abundance.

More specifically:

- Temperature influences development rates of both the malaria parasite and its mosquito host;
- Increased rainfall increases availability of breeding sites and therefore augments malaria vector populations if temperature is favorable;
- Increased rainfall is associated with increases in air humidity that results in higher adult vector survivorship and therefore greater probability of transmission;
- Higher temperatures shorten the parasite extrinsic incubation period and increase the stability of disease transmission.
- Rainfall much above normal can lead to "flushing out" of mosquito breeding sites and potentially lead to lower malaria incidence.

Forecasting Malaria: Epidemics frequently occur when periods of drought (during which people can lose immunity to the disease) are

West Africa: A regional example

"Climate has had an enormous impact on health in West Africa. However, its underlying role in determining the burden of disease in the region on a yearly or decadal basis is not mentioned in key health policy documents, such as those that reflect the framework and indicators promoted for monitoring the achievements of Roll Back Malaria (RBM). Its absence is all the more remarkable given that the stated aim of RBM is 'to halve the burden of malaria through interventions adapted to local needs and strengthening of the health sector.' If observations indicating that climate variation alone may be responsible for changes in prevalence rates of 50% in some areas, then indicators of the effectiveness of RBM interventions (which do not incorporate climate variability as a confounding factor) may be either overly optimistic or pessimistic as a result.

There is considerable evidence that many infectious diseases such as malaria occur within a climate 'envelope' and vary between years in intensity as a result of inter-annual variation in climate and vulnerability. There is a clear need for researching and documenting more closely the extent to which morbidity and mortality from infectious disease, and their broad socio-economic impacts, is determined by climate, and whether or not climate/environmental information (such as seasonal forecasts or rainfall or vegetation monitoring) can, in practice, improve decision-making for control purposes in the affected countries.

Currently, there is much interest in developing adaptation strategies for poor countries to cope with the likely impacts of climate change, and yet we know little about how shifts in climate have affected health outcomes in the recent past. Whether or not the recent drought in West Africa is part of the natural cycle of climate variability or indicative of anthropogenic climate change, we can learn much from the region's experience in terms of impacts and adaptation to extreme shifts in the region's climate over a relatively short period of time."

Thomson MC, Connor SJ, Ward N, Molyneux D. Climate variability and infectious disease in West Africa. Ecohealth 2004;1(2):138-150.

followed by a return to normal or above normal rains. Combining information on malaria trends and vulnerability with rainfall information can provide warnings for high transmission years prior to the peak malaria season. For example, the case of Botswana has demonstrated a strong impact of December-February rainfall on malaria incidence anomalies, which make it possible to alert the Ministry of Health of increased risk of an epidemic before the peak transmission period of March and April. Seasonal climate forecasts can supply even earlier warning of changes in malaria risk. A seasonal climate forecast in November can provide information about the expected extent of the next malaria transmission period five months before the peak of the malaria season and three-four months earlier than warnings that are issued based on observed rainfall.

Many regions in Africa could benefit from a Malaria Early Warning System. The SADC region held the first Malaria Outlook Forum in 2004 to consider how advance climate information can be used in malaria forecasting and preparedness. Prime interventions include planning integrated vector management; information, education and communication campaigns; as well as timely procurement of drugs.

Other climate-sensitive diseases:

Meningitis: Meningococcal meningitis occurrence in the Sahelian dry season is associated with increase in temperature and decrease in humidity, and related to dust. Epidemics occur in environmentally suitable districts during the dry season and end with the first rains. There is a moderately strong relationship between climate and outbreaks of meningitis although people don't really know why.

Cholera: outbreaks are associated with increase in sea and air temperatures as well as El Niño events, in addition to sanitation and human behavior. The association between climate and cholera outbreaks is strong[viii].

Rift Valley Fever: epidemics (animal and human) are related to rainfall increase. Cold weather is associated with the end of epidemics. Rift Valley Fever is moderately sensitive to climate[ix].

Leishmaniasis: Visceral Leishmaniasis is associated with an increase in temperature and rainfall. Outbreaks of Leishmaniasis show a moderate variability based on climate[x].

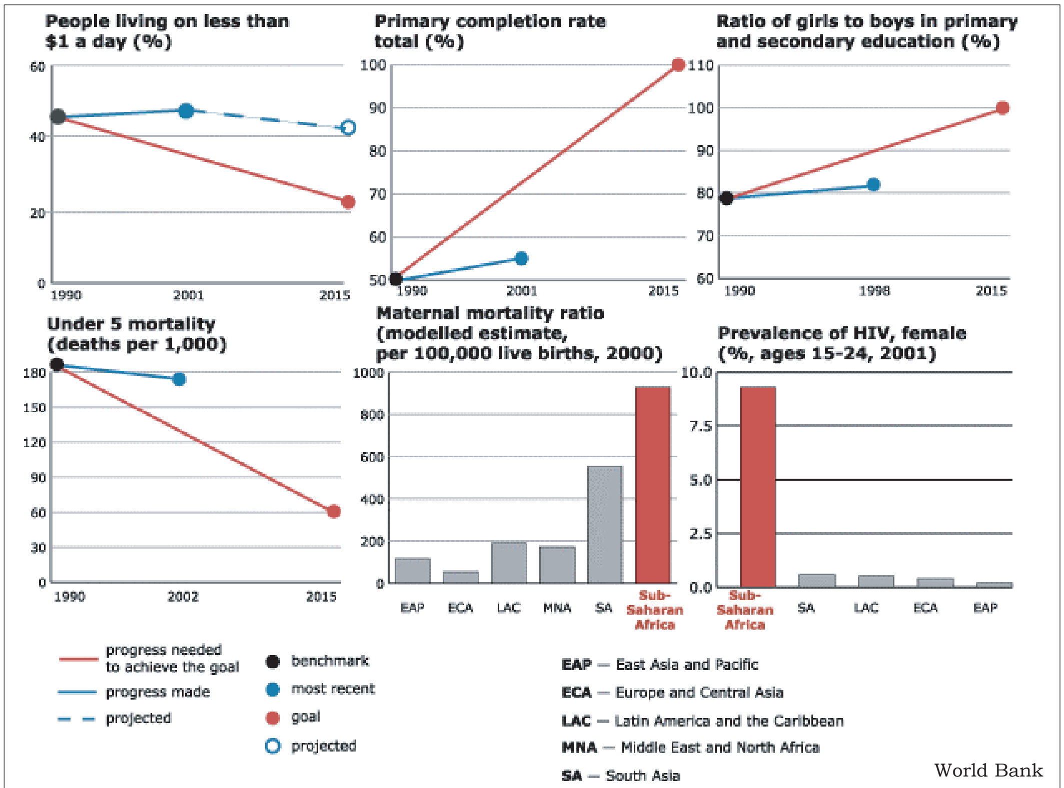
5. CLIMATE VARIABILITY AND THE MILLENNIUM DEVELOPMENT GOALS (MDGS)

The MDGs cannot be achieved in Africa without good management of climate variability: too many livelihoods are over-dependent on the weather.

The challenge to mankind presented by the MDGs in Africa is truly colossal. Within the next 10 years we are going to reverse deeply entrenched trends towards ever-greater poverty, and enable more than a hundred million people in Africa to escape from poverty, permanently!

Integrating climate risk management measures into the many actions necessary to achieve these goals is absolutely essential. This is in part because climate variability is so important, but also because the impacts of climate variability, the nature of risk management interventions, and the associated institutional and policy requirements to ensure maximum impact, are specific to each MDG (as shown in Table 1 at the end of this section).

Where the necessary conditions are in place or can be put into place, seasonal climate prediction offers the opportunity to manage climate



World Bank

variability, and to respond proactively to adverse conditions and exploit favorable conditions. But even where predictability at the seasonal time scale is weak, climate-sensitive elements of the MDGs can benefit from greater attention to climate variability coupled with environmental monitoring.

Climate risk management has appealing synergies with other interventions recommended in individual MDG task force reports , but will need to be pursued aggressively. A successful strategy to provide the necessary foundation for enhancing climate resilience across the MDGs must include maintenance and strengthening global and national climate observing systems; and strengthening partnerships at all levels, between institutions working on climate-sensitive development problems and providers of climate information. This does not exist at present.

The Scale of the Problem

Interventions to achieve the MDGs must be appropriate to the vast scale of the problem. If 100 million people are to be assisted out of poverty in sub-Saharan Africa by 2015[xii], then this is not 'business as usual'. Existing approaches to managing climate risk will need scaling up many thousands of time, in proportion to the need. In many cases this will not be feasible; there are not sufficient trained manpower and resources in existence. In many cases completely new approaches to climate information management are required, involving non-specialists. The use of mass media innovations (for example rural radios) will be important in raising awareness and in disseminating seasonal forecast and other advisory information.

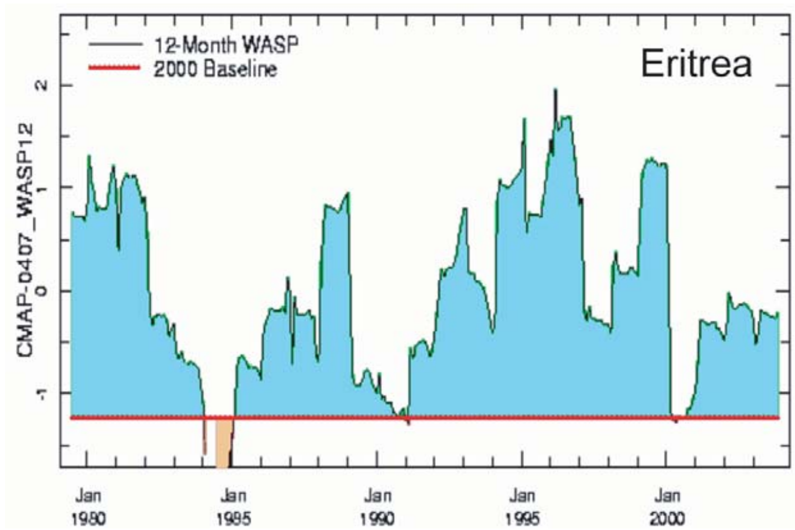
Measuring the MDGs

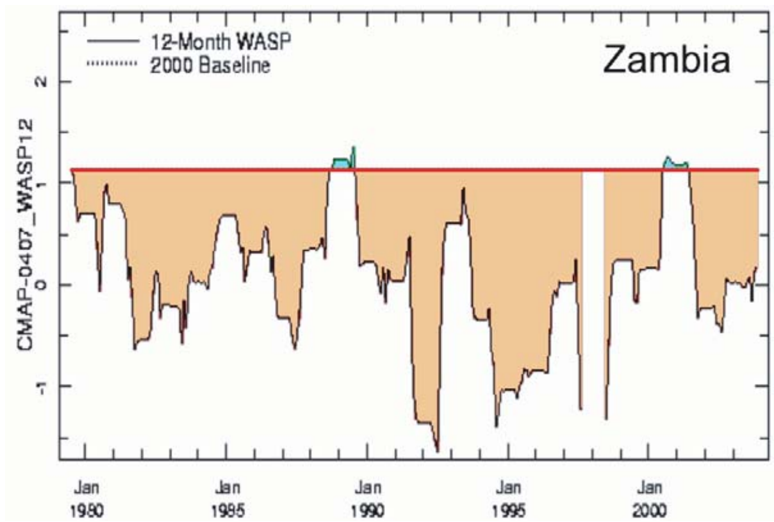
Because climate variability impacts many of the MDG indicators, climate fluctuations on seasonal to decadal time scales have a significant confounding influence that may complicate accurate assessment of the outcomes of interventions. Without taking these influences into account, there is a danger that MDG outcome measurements may appear misleading.

For example improved control of malaria would dramatically affect Goal 6 (combat HIV/AIDS, malaria and other diseases), and would help contribute to the achievement of Goal 4 (reduced child mortality), and Goal 5 (improved maternal health). Factors such as epidemic malaria however, are not only acutely dependent on climate variability, but have a major effect on mortality and maternal health. Thus for any area of interest, a natural run of wet years or a run of dry years after the baseline year will tend to distort the outcome of attempts to improve malarial health care. As a consequence, there is need for specially adapted methods for measurement for climate sensitive MDGs, and related international development goals.

It is important to consider climate when establishing baselines and measuring the impacts of climate sensitive interventions over time. The two graphs show a time series of rainfall over a 25 year period (1979-2004). In this example the year 2000 is set as the baseline year. It can be seen that in Eritrea, 2000 corresponds with one of the driest years in the series. In Zambia by contrast, 2000 is one of the wettest years.

CMAP is a merged rainfall monitoring product based on satellite and ground-based observations. WASP is a Weighted Anomaly Standardized Precipitation index based solely on monthly precipitation data summed over 12 months.





IRI Data Library

Such methods must adequately distinguish between the impact of interventions, and the impact of varying climate on MDG outcomes. In the absence of such 'climate normalized' methodologies the measurement of achievements may be over-optimistic (in climatically favorable years) or overly pessimistic (in years when climatic factors are unfavorable). Appropriate use of climate information can eliminate this confounding factor and establish the true impact of interventions on important climate sensitive targets, such as food production, morbidity and mortality.

Table 1. Relationships between Climate Variability and the Millennium Development Goals

Goal	Impacts of Climate Variability	Role of Climate Interventions
Goal 1: *Eradicate extreme poverty and hunger*	Drought and flooding triggers acute hunger from loss of agricultural production. Extreme climatic events cause loss of infrastructure and productive assets. Climatic uncertainty is a disincentive to investment, intensification, technology adoption, fertilizer use, and high value agricultural enterprises. Repeated disasters stagnate economic growth. The poor are trapped in a downward, vicious cycle of increasing poverty and asset loss, because they never recover from climate shocks.	Climate-based food insecurity early warning increases lead-time, aids targeting of relief efforts. Climate information (monitoring and prediction) empowers poor farmers to better manage risk, and to exploit opportunity in favorable years. Advance information can be used to manage grain stocks to stabilize prices and availability, and adjust supply of credit and production inputs to farmers. Climate information provides opportunity to spread risk through social insurance schemes that provide a safety net for the poor during climatic shocks. Prediction of hydro-climatic extremes helps societies prepare and mitigate disasters, reducing losses in infrastructure and productive activities.
Goal 4: *Reduce child mortality*	Poor sanitation from both water shortages and flooding contribute to morbidity and mortality from diarrhoeal diseases. Malaria (whose endemicity and epidemicity are impacted by climate) during pregnancy is associated with lower birth weight, increased infant mortality.	Climate monitoring and forecasts help identify high-risk areas prone to water contamination based on water shortages or flooding. Climate forecasts can prompt malaria early warning, increasing lead-time for mobilization and distribution of resources to remote areas.
Goal 5: *Improve maternal health*	Climate variability impacts on food production and nutrition affecting pregnant women and the development of embryo and fetus. Pregnant women are more likely to contract and die of malaria (a disease whose endemicity and epidemicity are impacted by climate variability).	Climate-based food insecurity early warning increases lead-time for organizing interventions. Climate prediction provides advance information for activating relevant aid and raising awareness on the ground (e.g., maternal education programs).
Goal 6: *Combat HIV/AIDS, malaria and other diseases*	Climate variability influences endemicity and epidemicity of malaria and other infectious diseases transmitted by insects. Climate variability impacts on food production and nutrition affect susceptibility to HIV/AIDS, malaria, and other diseases. People infected with HIV are more likely to develop AIDS and die of it if they contract malaria.	Climate monitoring supports targeting high-risk areas. Climate-based early warning increases lead-time of epidemic detection, prevention, and control of climate sensitive diseases, e.g., malaria early warning can facilitate activation of funds for preventive measures (Insecticide treated nets and insecticides) and medicines and their distribution to remote areas.
Goal 7: *Ensure environmental sustainability*	Climate variability constraints both quality and quantity of water supply. Resource management regimes fail because they ignore the impact of climate variability, e.g. for water or pastures. Resource degradation is blamed on people who are actually responding to climatic variations. Floods overwhelm water and sanitation infrastructure, management and operations. During heavy rains, slum dwellers are highly vulnerable to flooding impacts on lives, dwellings, and water quality.	Climate information enables design of sustainable resource management regimes that account for variability and climate-human interactions. Water reservoirs can be managed more effectively for multiple purposes under both scarcity and surplus, using reliable climate forecasts. Managing rangelands based on understanding of climate-human-livestock interactions enhances sustained productivity. Improved designs of water infrastructure systems, using climate information, mitigate adverse environmental consequences of extreme climatic events.

6. LEARNING TO MANAGE CLIMATE RISK

Do we actively manage development in accordance with the climate or do we passively let the climate manage us? Climate variability has received less attention than other development issues, in part because it has been considered part of the environmental baseline that is not amenable to intervention. However, it clearly impacts development, and our ability to achieve the MDGs. If we are to do better at managing climate risks in future then we need to understand why we haven't made much progress to date, and incorporate lessons learned into future strategies.

The impacts of climate variability on development are two-fold, direct and indirect.

Direct: Climatic extremes, such as drought and flooding, take a direct toll on lives, health, livelihoods, assets and infrastructure, while their unpredictability is an impediment to development even in years when climate conditions are favorable. Climate directly impacts food and fibre production, and the epidemiology of infectious diseases. Severe or repeated climate shocks can push vulnerable households into a persistent poverty trap when their individual coping responses involve divestment of productive assets, such as livestock or land. Without advanced warning, societal safety nets are costly, and difficult to mobilize and target effectively.

Indirect: Although less visible than extreme events, the indirect impact of climatic uncertainty is an equally serious impediment to development. The inability to anticipate when climatic extremes will occur is a disincentive to investment, adoption of innovation and the success of other development interventions. For the risk-averse decision maker, climatic uncertainty necessitates short planning horizons and conservative risk management strategies that buffer against climatic extremes, but often at the expense of inefficient resource use, reduced average productivity and profitability, and accelerated resource degradation due, for example, to under-investment in soil fertility inputs or conservation measures.

But in spite of its pervasive importance, and powerful new advances in climate-related science, opportunities have been largely underexploited in decision-making in Africa. Lip service is paid to the climate and its variability, but in practice, study after study has shown that climate information is rarely, if ever, incorporated into planning and management decisions as effectively as it could be.

Why should this be so? By far the majority of water supplies and agricultural production in Africa is dependent on rainfall, which fluctuates considerably from year to year. If water availability and food production are both in such short supply as to be a major brake on development, surely use of climate information to optimize use of these scarce resources should be a top priority?

Many reasons contribute to the low priority given to incorporating climate variability into decision-making. It is most important that these be understood and addressed in concert because together they present a formidable obstacle to progress. Reasons include:

1. Whose responsibility? In many instances the ability of national 'resource management systems' to respond to climate information is very weak or non-existent. Resources are not so much 'managed' as collectively exploited. Such a system works adequately when population density is low in relation to the resource base, but as populations grow and resource use becomes more intensive, seasonal variation in water (rainfall) becomes ever more important to a growing multitude of stakeholders. Well-informed, co-ordinated and timely decision processes to pro-actively manage resources then become most important, but this is difficult if neither the information (due to collapse in observing and extension networks) nor the system for making appropriate decisions exists, until an emergency is declared.

2. Reluctance towards risk management: In the past, the occurrence of periodic drought was almost welcomed by mid-level government administrators. All sorts of project failures from the colonial East African Groundnut Scheme onwards, were written off 'because of the drought', and no further questions asked. It is important that collectively, we become more proactive in resource management and include climatic risk in our calculations, amending management decisions as a continuous process, rather than working to a fixed schedule.

3. Research-extension gap: The agricultural research literature is populated with studies showing the importance of climate variability, and how best to cope with it in different areas. The research system however is often isolated from the communities they serve, and beneficial outcomes are difficult to achieve when messages are too complicated for a poorly trained or non-existent extension service to improve on current practice in farming communities. New approaches to mass communication of such information are required.

4. Insufficient climate data available: There has been a major decline in the number of climate observing stations in Africa over the past 40 years. While this has been compensated, to some extent, by the development of operational weather satellites covering Africa, adoption and use of these new technologies in climate applications has been slow. In some areas the basic climate network has become so sparse that it will be difficult to detect and quantify climate change trends in these areas, let alone inter-annual variability. Improving the basic network in Africa is a current concern of the Global Climate Observing System, based in WMO, among others.

5. Institutional obstacles: Climate management is an interdisciplinary subject, affecting many economic sectors and aspects of life, but it has no effective champion. In most national meteorological services, the application of climatic knowledge in agriculture, health, water and other sectors is a low priority activity, poorly staffed and weakly focused. Relatively few meteorological services in Africa are fully engaged in their own national development agendas. Supporting civil aviation services and participating in the global meteorological agenda, have for many years been much higher priorities. As a consequence, most climatic networks are badly run down, the data that exists is of limited utility, and it is analyzed in a fragmented way if at all. The introduction of policies to commercialize such services or seek cost recovery for data collection has been an unmitigated disaster, and the establishment of regional drought monitoring centers has not done much to repair the situation.

6. Farmers know best: People who have been working fields for years in the traditional manner have usually developed more or less successful coping strategies based on managing risk. They often have traditional 'seasonal forecasting' methods based on bird, animal and plant observations. Traditional practices by definition are resistant to change:

- Until new forecasts are shown to improve on traditional methods, they will not be adopted.
- Traditional methods may not be able to cope with rapid population growth and land fragmentation, or systematic climate change (as in the Sahel during the 1970s and 1980s)
- Farmers will not change from a risk reduction to a production maximization strategy until they have an adequate safety net to support them through bad years.

7. No reliable climate forecast capability: For many people the very idea of long term or 'seasonal' climate forecasting is considered an unrealizable dream, or one that challenges a divine prerogative. While short-term weather forecasting has radically improved with the refinement of satellite coverage and global models, its forward view is restricted to a few days at

most, so (they ask) how can one possibly give credit to a three-month forecast? But seasonal climate variations no longer need to be accepted as a total unknown. Seasonal variations are influenced by interactions between the atmosphere and the more slowly varying ocean and land surfaces, such as those associated with the El Niño-Southern Oscillation (ENSO) in the tropical Pacific. Improvements in our understanding of these interactions, advances in modeling the global climate system, and substantial investment in monitoring the tropical oceans together, now provide a useful degree of predictability, with a seasonal lead-time in many parts of the world. This information can be very useful indeed, if used well.

Towards Resolution: Improved Governance and Improved Science: All these problems can and must be overcome. They are reflections of some of the many problems in Africa over the last 25 years, and concomitant weak governance. In other parts of the world, application of climate science is moving forwards rapidly, stimulated both by practical everyday requirements to optimize resource management as well as by the urgent need to understand global warming and climate change impacts.

One of the most practical consequences of this process is that seasonal forecasting is now becoming a very useful tool in certain areas. In recognition of the need for a leading interdisciplinary climate center, the National Oceanic and Atmospheric Administration (NOAA) in the USA established the International Research Institute for Climate Prediction (IRI) to promote climate applications for the benefit of society. The seasonal forecasts developed and communicated by IRI offer a vital key for unlocking the potential of pro-active management of climate variability in large parts of Africa.

7. TOWARDS BEST PRACTICE: EXAMPLES OF BETTER MANAGEMENT OF CLIMATE VARIABILITY

Examples of good practice in managing climate variability need to be scaled up and integrated into operational decision-making across the continent, as 'best climate practice'.

Agricultural Support: A Strategy to Help Reduce Rural Hunger
Very much more needs to be done to reach to the heart of the poverty problem. With this in mind, climate-related interventions targeting rural hunger and poverty have been worked through in detail, based on much practical experience in the field, including ongoing pilot work at Machakos in Kenya, and Southern Province Zambia. In particular, there is acute need to focus on the following action areas.

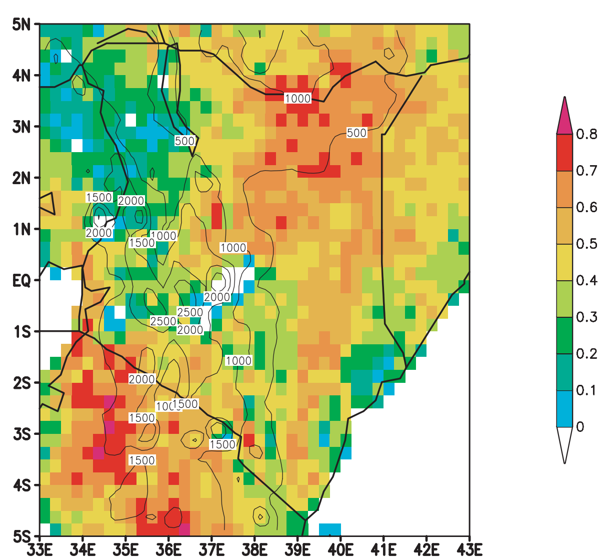
- Enhancing early warning systems to support appropriate external assistance;
- Empowering vulnerable farming populations to better manage risk;
- Preventing large-scale secondary economic shocks through policy or market interventions;
- Strengthening institutional capacity and coordination to support generation, communication and application of appropriate climate information.

To be successful, these action areas need addressing *together* in a long-term coordinated approach, as an integral part of (e.g.) the Millennium Development Project in Africa. Particular aspects are elaborated below.

1. Enhance early warning systems to support appropriate external assistance: The ability to anticipate shocks and associated losses through monitoring and forecasting creates an opportunity for external agencies - governments, NGOs, international organizations and donors - to provide targeted, temporary assistance to replace lost food income and maintain households at minimum food intake requirements. This intervention stabilizes consumption, alleviating the need for households to liquidate productive assets. With this safety net in place, households and communities can begin to achieve economic security, reducing vulnerability to future shocks.

Effective use of scarce relief resources requires knowing who is hungry, where and when. This information can be used to further distinguish between the chronically hungry and food insecure versus those who are episodically hungry and food insecure, or barely food secure. In the case of the chronically hungry, an assessment of constraints in relation to livelihood options is needed in order to devise strategies to increase livelihood options or subsidize consumption until food security is achieved. In the case of tenuous food security or episodic food insecurity, mapping livelihood systems at sub-national scales and assessing risks posed by climate-related and other shocks in relation to different types of household livelihood strategies creates the potential to supply information and other assistance through which food security is pursued. Several national and regional early warning systems provide information to aid organizations about emerging food security crises. Advances in environmental monitoring and prediction have the potential to improve the lead-time, accuracy and geographic specificity of such early warning systems. For example, the IRI and others have developed methods that increase lead-time and accuracy of geo-referenced crop yield and NDVI-based forage forecasts by incorporating seasonal climate forecasts.

2. Empower vulnerable farming populations to better manage their risk: While climate variability causes direct losses, and creates uncertainty that discourages development, it also creates opportunities for increased production and income during favorable conditions. For the rural poor and hungry who depend largely on agriculture for sustenance and livelihood, advance climate information can support adaptive production and livelihood management responses that enhance resilience and exploit opportunity. Potential adaptive responses to climate fluctuations, relevant to food security, are numerous. At the farm level, they include selection of livelihood activities, crops and cultivars; allocation of land and household labor; soil, water, crop and livestock management; securing credit and production inputs; and marketing, savings and investing strategies. Credit and seed supply, water resource management and epidemic disease control decisions are sensitive to climate, and impact farm decisions and outcomes.



Prediction skill for December values of the Normalized Difference Vegetation Index (NDVI) in Kenya can be made using a climate model. The model uses September sea-surface temperatures to predict December NDVI in October, two months in advance. The correlation between observed and predicted NDVI is highest in northeastern Kenya for this particular season. Corrected NDVI data provided by USGS.

Recommended interventions include:
a) Providing relevant, timely information to the target populations;
b) Fostering and guiding adaptive responses;
c) Addressing resource constraints to adaptive responses.

3. Prevent large-scale secondary economic shocks through policy or market interventions: As a complement to local-level decision-making by the population at risk, there is a range of more centralized, larger scale options for using climate information to prevent or dampen secondary climate-related shocks that affect food security. These include manipulation of imports and national grain reserves to stabilize prices, preemptive borrowing for balance of payments support and adjustments in water allocation from multipurpose reservoirs to ensure irrigation water availability. Where markets are closed or inefficient, climate-induced variations of aggregate production can result in large fluctuations in prices. Price swings can negate production benefits of favorable climatic conditions in good years, and cause hardship to poor consumers in poor climatic years.

4. Strengthen institutional capacity and coordination to support generation, communication and application of appropriate climate information: A strategy of maintaining and strengthening global and national climate observing systems; and strengthening partnerships, at all levels, between institutions working on climate-sensitive development problems and providers of climate information, will provide the necessary foundation for climate-related interventions across several of the MDGs. National meteorological observing systems are the foundation for understanding climate variability and for locally relevant prediction. In many countries in Africa, there is a need to increase the number of operational observing stations, particularly for rainfall, in regions with high vulnerability or under-exploited opportunity.

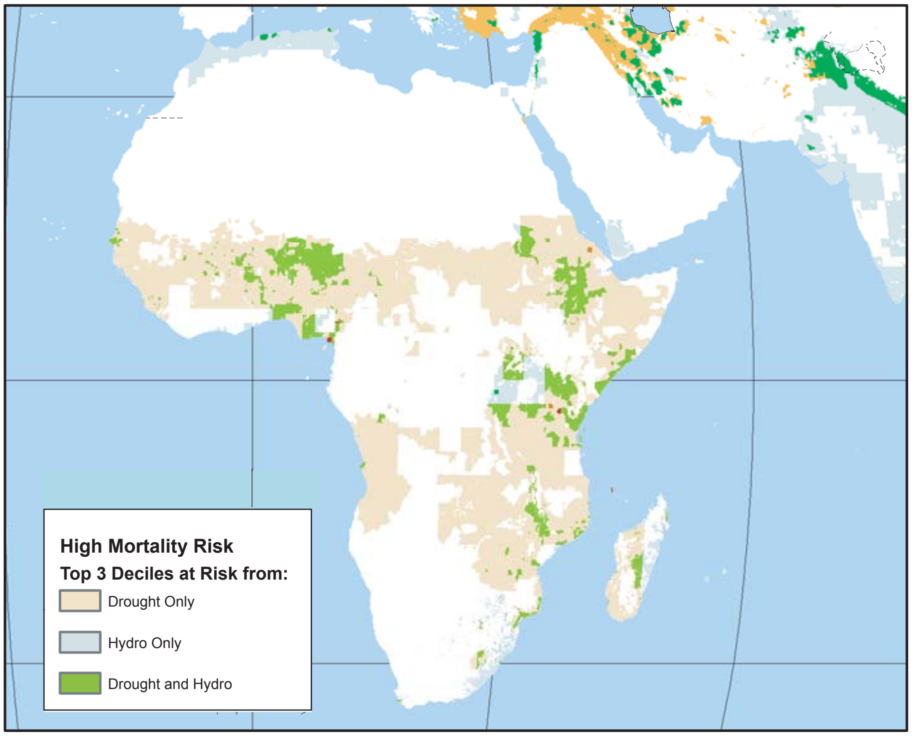
Addressing climate-related constraints to food and livelihood security requires partnership between climate and agricultural development institutions. However, agricultural and meteorological institutions are typically separated at the highest levels of national government, and even within the United Nations. Countries should seek to bridge this gap in a manner that empowers meteorological services to serve development needs.

Enhancing Early Warning Systems to Prevent Disasters

Work on improving early warning systems typically deals with large-scale problems such as climate-related disasters, drought and food security crises, disease epidemics and pest outbreaks.

Food Security: Combined use of seasonal climate forecasts, analyses of trends in climate, vulnerability and environmental monitoring can increase the lead-time, accuracy and geographic specificity of the various

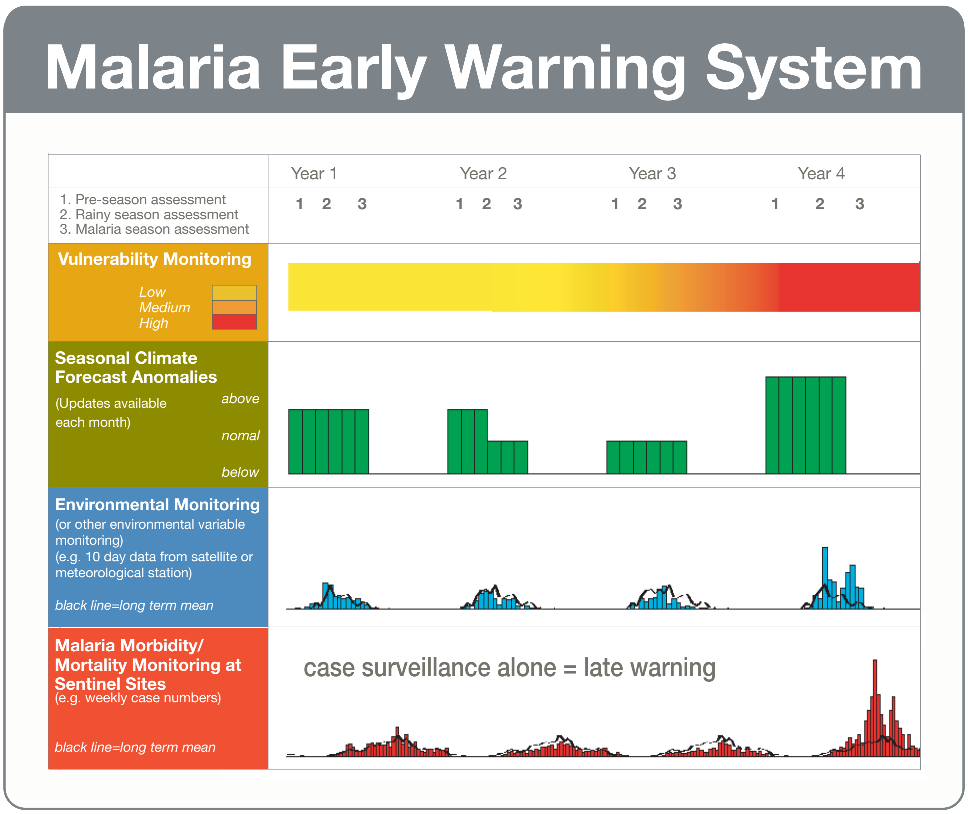
Disaster Risk Hotspots (Columbia University, World Bank). Risks of disaster-related mortality associated with climatic hazards in Africa are among the highest in the world. Reducing risks of climate-related losses is key to achieving the Millennium Development Goals. Partners: World Bank, CIESIN, CHRR, UNEP, UNDP



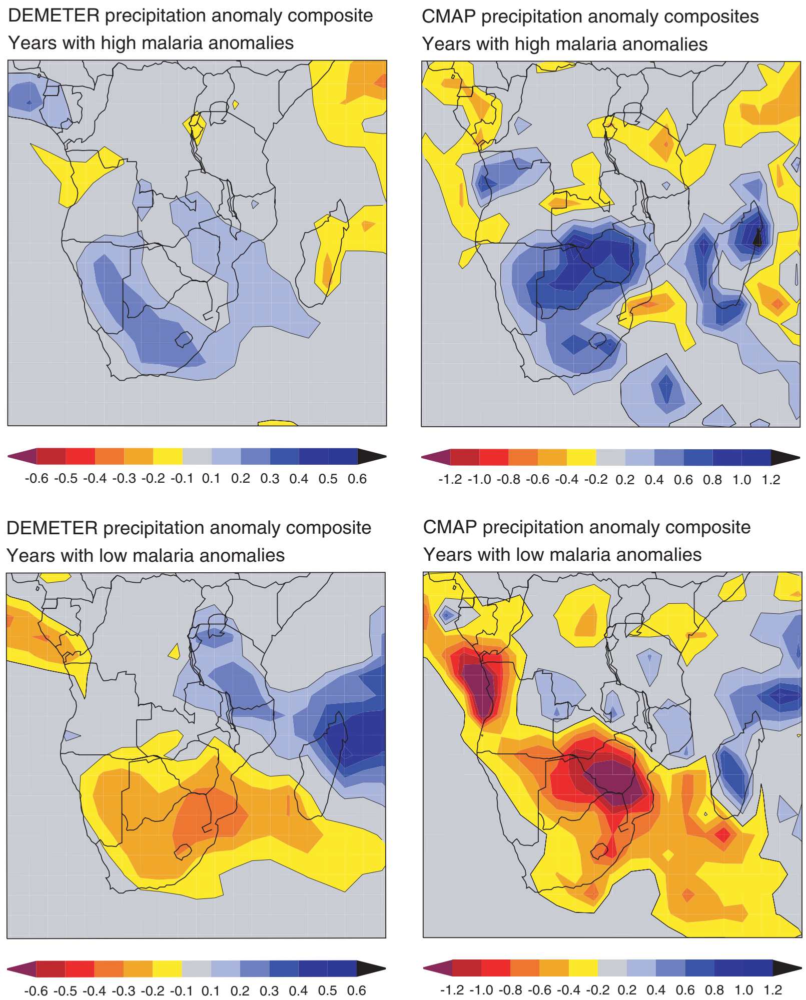
components of food security. Tailored climate information combined with population vulnerability models provide probabilistic assessments of food insecurity within an integrated operational decision framework, as in the Greater Horn of Africa. The IRI and the IGAD Climate Prediction and Application Center (ICPAC) have provided a framework for developing capacity to apply climate information for managing food security risks over the Greater Horn of Africa. Enhanced collaborations between the two institutions has initiated a framework in building regional and national capacity in seasonal forecast operations, training and applications activities with key partners in transforming climate products in vulnerability analysis and food security, as well as hydrological modeling and water resources assessments. Discussions have begun for extending this approach into West Africa working with CILSS and AGRHYMET.

To minimize problems due to the devastating damage to food production/security from locust swarms, FAO has established and implemented an operational early warning system in 21 countries. However, the effectiveness of this early warning system, based on observed climate/environmental factors, would be greatly enhanced by climate forecast information for the regions in question.

Pastoralist support: In the horn of Africa, millions of livelihoods in some of the poorest countries depend on livestock. Heavy rains associated with the 1997/98 El Niño led to major outbreaks of Rift Valley Fever (RVF), a mosquito-borne virus affecting livestock and humans. Fears of the spread of RVF led livestock importing countries in the Middle East to ban the import of livestock from 'suspect' countries for several years, causing hundreds of millions of dollars in losses to pastoralists in exporting countries. Now a model is being developed[xiv] that anticipates climate conditions associated with mosquito breeding. The model is being developed with full support from Chief Veterinary Officers and livestock trade policy-makers in the region and Middle East. When operational, it will support animal health and trade decision-making with the intent of minimizing future trade stoppages based on assessment of environmental RVF risks.



Epidemic Early Warning: Malaria is now rightly coming to be recognized as a preventable disease for African countries. The pressing need to predict, prevent and control epidemics in the semi-arid and highland margins of disease transmission has been a cornerstone of the



Joint work between IRI, ECMWF, and MoH has shown that the rainfall over southern Africa in years in which there is high (or low) malaria incidence, can be forecast accurately using the DEMETER suite of models.

Global Malaria Control Strategy and the Roll Back Malaria partnership. An integrated framework for Malaria Early Warning Systems (MEWS) in Africa has been developed by WHO and partners[xv], which features increasingly in national and regional malaria control strategies for epidemic prone areas as a result of new resources, new knowledge and changing policies across the continent. (See also inside back cover).

Malaria: As with many infectious diseases, malaria has a climate/environmental component that helps to determine its spatial and temporal extent. Presently, where malaria is not adequately controlled, the seasonality of the climate largely determines the seasonality and endemicity of malaria. Along the margins of this 'climatic suitability for malaria' it is climate variability between years that helps determine which regions are prone to epidemics; and it is usually climate anomalies that periodically trigger epidemics. Climate information has been used to map the seasonality of malaria risk and to inform on disease endemicity. Analysis of climate variability has also been used to map those zones at risk of epidemics.

a) **In West Africa,** the IRI is developing a cross-border pilot project in Niger, Mali and Burkina Faso, where IRI and partners seek to build the evidence for the importance of using climate information in the development and implementation of health policy including malaria and meningitis early warning systems.

b) **In Southern Africa**, the IRI is also involved in sub regional malaria early warning activities where demand for an early warning model developed in Botswana, has seen it extended by all epidemic prone countries in the Southern African Development Community (SADC).

c) **In East Africa,** the IRI has been involved in the stratification of malaria in Eritrea and informing the development of a national early warning system. Extending this work elsewhere, within East Africa is proposed by the WHO Inter-Country Program and will begin with Ethiopia where epidemic malaria and meningitis are major public health issues.

Hydropower, Reservoir and River Basin Management

Managers of the Seven Forks Dam on the Tana River in Kenya currently use climate information to assist decisions in water allocation. Assessments and lead-time analyses are made for the coming season with respect to setting up contingency planning for optimal allocation to water-reliant sectors.

Guidance on potential improvements in water use by different stakeholders is also provided. The Tana River System supplies up to 50% of the entire power demand for Kenya and provides flood control benefits during the two rainy seasons. The ongoing analyses for this project aim to assess the potential for seasonal hydropower generation and the development of monthly operational rule curves that would be updated using climate forecasts. Policies on crop selection for irrigated agriculture, resource mobilization for power sector management and its relevance to forecast lead-time is being explored in more depth. The objective is improved management of river basin catchments and stream-flow. Where climate information enables forward decision opportunity and contingency planning, it will form an important basis for the further development of hydropower generation and irrigated agricultural opportunities, which are considered essential requirements for broadening the national development base for Kenya and other countries in the region.

8. CLIMATE CHANGE AND SUSTAINING DEVELOPMENT IN THE FUTURE

Climates are always changing, but current rates of change need to be taken seriously. There is much that we can do now in order to cope better with future changes.

How will climate change affect the different parts of Africa? While we don't yet know with any great confidence, there is evidence that climate change is already affecting Africa, as many other parts of the globe. And future climate change is important for policy decisions now, because it is a major threat to sustainable development, and has the potential to undo hard won development gains.

Temperature: The continent of Africa is warmer than it was 100 years ago[xvi]. Warming through the twentieth century has been at the rate of about 0.5ºC/century. The six warmest years in Africa have all occurred since 1987, with 1998 being the warmest year. This rate of warming is not dissimilar to that experienced globally and the periods of most rapid warming - the 1910s to 1930s and the post-1970s - occur simultaneously in Africa and the world.

"One problem we have is that in some regions, the mean ocean temperatures have been slowly but consistently rising, making our earlier concept of 'normal climatology' misleading: Most of the last 10 years would rank as the warmest years of the previous 30. Normal climatology is traditionally based on the average over a recent 30-year period. In a changing climate, however, the utility of such a definition is questionable." - IRI forecaster Tony Barnston in conversation.

Rainfall: Interannual rainfall variability is large over most of Africa and for some regions, most notably the Sahel. Multi-decadal variability in rainfall has also been substantial. Comparing the Sahel, East Africa and southeast Africa shows contrasting rainfall variability characteristics[xvii] :

- The Sahel displays large multi-decadal variability with recent drying
- East Africa shows a relatively stable regime with some evidence of long-term wetting
- Southeast Africa also shows a stable regime, but with marked inter-decadal variability.

Adaptation: Even with a near-global agreement on climate change mitigation efforts, it is clear that there are significant risks of climate changes in the immediate and foreseeable future. We must learn how to adapt to changes in climate as they occur. How ready is Africa to cope?

Implications: The risk of increased climate variability translates into risks of greater fluctuations in food production, at local and global scale. With a) global reduction in surplus cereal production, b) China recently becoming a significant food importer for the first time, and c) significant parts of urban Africa still being dependent on food aid imports, it is difficult to escape the conclusion that food security in Africa is increasingly at risk from a changing climate in a globalized world.

"Some of the severest impacts seem likely to be in the currently food insecure areas of sub-Saharan Africa with the least ability to adapt to climate change or to compensate for it through greater food imports." Prabhu Pingali (FAO) at Development and Climate Change meeting, Global Forum on Sustainable Development, OECD, Paris, November 2004

What must Africa do to cope with climate change?

1. Africa must learn how to manage evolving climate variability.
2. Africa must maintain enough long-term climate observation stations to be sure that it can detect and measure trends in climate change sufficiently early to respond effectively.
3. Africa must make sure that it has a productive 'climate-tuned' agriculture, producing local alternatives for food deficit areas, in the event of a global grain shortfall.

And one thing is sure: if we cannot cope with the climate variability of today, we are going to find it even more difficult to cope with the variability of tomorrow.

9. WHAT ACTIONS ARE NEEDED?

The first step is to recognize both the problem that results from so few people using climate data well today, and the opportunity presented by an integrated approach to managing risk.

Strong leadership to address climate variability in important economic and social sectors is urgently required throughout Africa. We must enable the millions of people whose livelihoods are dominated by climate variability to cope better through being more aware of opportunities, with greater food security. We must supplement existing practices with new techniques such as seasonal prediction and risk management, to ensure a whole range of better decisions appropriate to the current climatic reality. We need to enable non-specialists working at farm to transboundary river basin scale, to be able to access and use climate information in their daily tasks. This requires a coherent, continent wide, proactive approach to managing local climate variability.

To integrate climate management into key development activities and make the MDGs more achievable, there is need for a range of appropriate activities, including:

1. **Political lead:** by AU, AMCOW, NEPAD, and regional economic communities to ensure that managing climate variability is firmly on the development agenda.

2. **Institutional Development** of a partnership of stakeholders: climate institutions with strong development focus need to work closely with both development and relief institutions on a convergent agenda, strengthening collective capacities to manage climate-related matters together.

3. **Economic Approach** with clear prioritization of climate sensitive sectors and development of risk management mindset towards mitigation of climate shocks

4. **Social focus** on climate and livelihoods, poverty eradication and sustainable management of natural resources in a variable climate with built in safety net

5. **Awareness raising** on risk management processes and dissemination of appropriate techniques to assist everyone involved to make better climate-related decisions, and especially including people in poor communities

6. Technical approach making best use of modern techniques and global centers of excellence, learning from each other and sharing best practice

7. Legal: helpful data policy with free access to environmental information for all

8. Environment: mainstreaming environmental considerations throughout the spectrum of development activities especially where water is concerned

9. Information management: making best use of best practice, shared experience and mass communications (ICT) to include rural communities in the partnership: top quality web sites with high quality information for climate risk management, and open to all

10. Good governance: important role for government in *promoting access* to such environmental information, so that all stakeholders can be well informed

11. Sustainability perspective: rational approach to coping with climate change through better management of climate variability today.

10. HOW THE INTERNATIONAL RESEARCH INSTITUTE FOR CLIMATE PREDICTION CAN ASSIST

IRI was established with a global mandate to assist societies with management of climate variability. IRI partners with organizations in Africa that want to use climate information more effectively in decision-making, towards achieving the MDGs in Africa.

Managing the impacts of climate variability for the benefit of developing countries, lies right at the heart of the IRI's *raison d'être*.

The mission of the IRI is "to enhance society's capability to understand, anticipate and manage the impacts of seasonal climate fluctuations, in order to improve human welfare and the environment, especially in developing countries".

The IRI recognizes the overwhelming importance of meeting the Millennium Development Goals for the future of Africa, and offers its skills to help achieve those targets that are climate sensitive.

The IRI itself is a young, dynamic, international science and development organization, well focused on priorities in the African development agenda. Through its specialist staff, including agricultural, water resource and health as well as climate scientists, it maintains an interdisciplinary approach to risk management as a practical way of living with, and making the most of, climate variability in all its forms. Renowned for its pre-eminent technical skills in seasonal forecasting, IRI works with partners on a wide range of social, economic and technical problems where climate variability is important, throughout Africa.

"… the seasonal forecast products from the IRI for South Africa during the past 3 or 4 years have been very useful for forward planning." Delegate from African water industry at UNOOSA symposium, Graz, Austria, September 2004

On a technical level, the IRI works with partners to enhance the utility of climate information products by

a) downscaling to the scale of impacts and decisions;
b) incorporating relevant aspects of within-season variability - "weather within climate";
c) advancing methods to communicate forecasts in transparent, probabilistic terms;
d) developing methods and tools to predict relevant impacts, such as crop and forage yields, and risks of crop and livestock pests and diseases.

e) assessing the policy and institutional context in which climate information can be made useful

The IRI recognizes that its impact will be greatest when climate applications are driven by widespread demand, and are fully integrated with other synergistic development initiatives. A wide range of research and development organizations and networks are aggressively seeking to enhance peoples' food security, health and access to water, reducing rural poverty and protecting the natural resource base within sub-Saharan Africa. IRI will continue to raise awareness and foster appropriate partnerships with such organizations, in order to maximize its impact on development in Africa.

11. GLOSSARY

The atmosphere fluctuates across a continuum of time scales, ranging from aspects of our daily 'weather' to longer-term 'climate' changes.

Weather is the day-to-day evolution of the atmosphere. We experience it as wet or dry, warm or cold, windy or calm.

The most basic aspect of climate is the long term average of weather. It's what we expect for a particular region at a particular time of year

Climate variability refers to 'the variation of a climatic parameter around its long term mean' and 'the difficulty of predicting exactly what value this parameter will have during any particular future period'. *Climate variability* may occur over time scales ranging from months to decades, falling between the extremes of daily weather and the long-term trends associated with climate change.

Climate change is used more to refer to 'significant changes in mean values', and/or 'significant changes in the degree of variability itself'. Clearly these definitions are not mutually exclusive, in that one persons 'variability' can be the next persons 'change'. In statistical terms, climate variability is about 'variance' and climate change is about trends in the mean, and trends in the variance.

Climate risk management is the process of incorporating probabilistic risks of particular climate outcomes into (e.g.) resource management decisions in advance of the events. It makes use of all information available on probable climate outcomes and the vulnerabilities to particular outcomes, in an adaptable decision-making process.

El Niño Southern Oscillation (ENSO) is a warming in the equatorial Pacific Ocean, which has significant and predictable influence on many local climates around the world. ENSO is the strongest climate 'signal' known, and is the basis of much seasonal forecasting.

Seasonal Climate Prediction makes use of information derived from ocean and land surface anomalies to indicate, on a probabilistic basis, whether the climate over the next several months is likely to be significantly different from the mean for that time of year.

12. ABBREVIATIONS

AGRHYMET	Centre Regional de Formation et d'Application en Agrométéorologie et Hydrologie Opérationnelle, Niger
AU	African Union
AMCOW	African Ministerial Council on Water
CILSS	Comité Permanent Inter-Etats de Lutte Contre la Sécheresse dans le Sahel
CC	Climate Change
CV	Climate Variability
DFID	Department for International Development in UK
ENSO	El Niño Southern Oscillation
FAO	Food and Agriculture Organization of the UN
GCOS	Global Climate Observing System
ICPAC	IGAD Climate Prediction and Application Center
ICT	Information and Communication Technology
IGAD	Inter-Governmental Authority on Development
IPCC	Intergovernmental Panel on Climate Change
IRI	International Research Institute for Climate Prediction
IWRM	Integrated Water Resource Management
Ldc	least developed country
MARES	Malaria: Alert and Response for Epidemics in the Sahel
MDG	Millennium Development Goal
MEWS	Malaria Early Warning System
NEPAD	New Partnership for Africa's Development
NGO	Non Government Organization
NMS	National Meteorological Service
NOAA	National Oceanic and Atmospheric Administration
OECD	Organization for Economic Cooperation and Development
RBM	Roll Back Malaria
RVF	Rift Valley Fever
SADC	Southern African Development Community
UN	United Nations
UNOOSA	United Nations Office of Outer Space Affairs
USAID	Agency for International Development
WHO	World Health Organization
WMO	World Meteorological Organization
WSSD	World Summit on Sustainable Development

13. ENDNOTES FROM TEXT

[i]See NEPAD website http://www.nepad.org/

[ii]G8 Website http://www.state.gov/e/eb/rls/othr/11515.htm

[iii]Africa Commission website: http://www.commissionforafrica.org/commission/Commission.htm

[iv]The Africa Water Vision for 2025: Equitable and sustainable Use of Water for Socio-economic Development. UN Water/Africa. 2004

[v]WHO (2004a). Using Climate to Predict Infectious Disease Outbreaks: A Review. Communicable Diseases Surveillance and Response. Protection of the Human Environment. Roll Back Malaria. Geneva.

[vi]WHO (2004b). Malaria Epidemics: Forecasting, Prevention, Early Warning and Control. From Policy to Practice. Report of an Informal Consultation, Leysin, Switzerland, 8-10 December 2003. Geneva.

[vii]WHO (2004a). Using Climate to Predict Infectious Disease Outbreaks: A Review. Communicable Diseases Surveillance and Response. Protection of the Human Environment. Roll Back Malaria. Geneva.

[viii]ibid

[ix]ibid

[x]ibid

[xi]See the Millennium Project reports http://www.unmillenniumproject.org/html/about.shtm

[xii]Millennium Project: Interim Report of Task Force 2 on Hunger, 2004

[xiii]See for example the Assessment of Potential for use of Seasonal Forecasting for Improved Drought Risk Management in Southern Africa for ODA & World Bank, Williams J B et al, 1995

[xiv]The Rift Valley Fever climate based prediction model is being developed by IRICP, the Drought Monitoring Center in Nairobi, the Inter-African Bureau for Animal Resources, the Red Sea Livestock Trade Commission, the U.S. Geological Survey and the African Regional Centre for the Mapping of Resources for Development in Nairobi.

[xv]Malaria Early Warning Systems, Concepts Indicators and Partners: World Health Organization and many other partners , WHO/CDS/RBM/2001.32

[xvi]Hulme, M., Doherty, R. M., Ngara, T., New, M. G. and Lister, D. (2001). African climate change: 1900-2100. Climate Research 17, 145-168.

[xvii]ibid

THE

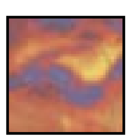
INTERNATIONAL

RESEARCH INSTITUTE

FOR

CLIMATE

PREDICTION



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Malaria Surveillance, Forecasting, Preparedness and Response in Southern Africa

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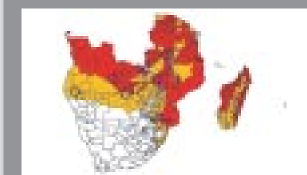
Cross-Border Activities


SAMC

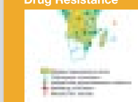
Post-Season Assessment

Annual national and regional consultation and planning conference

Vulnerability Monitoring

There are many factors that increase the vulnerability of a population to malaria epidemics (Bates, Fenton, et al., 2004a; Bates, Fenton, et al., 2004b) and increase the severity of disease outcome, should a malaria epidemic occur.

Drug Resistance


doi:10.1016/S1473-3099(02)00239-6

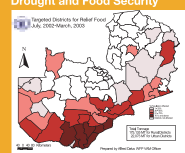
Population Movements


UNHCR/P. Moumtzis

Co-infection with Other Diseases

For example HIV/AIDS

Drought and Food Security

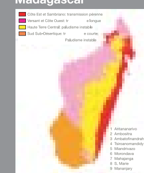


MALOF 2004 Proceedings

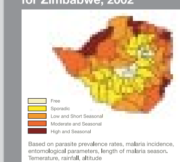
Risk Mapping

Risk Areas for Malaria Epidemic

For example:
Eco-epidemiological Stratification Map for Madagascar


MALOF Proceedings 2004

For example:
Composite Stratification Map for Zimbabwe, 2002

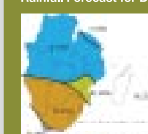


MALOF Proceedings 2004

Seasonal Climate Forecast

In recent years there have been significant scientific advances in our ability to predict climate on the seasonal timescale (Goddard, Mason, et al., 2001). The skill associated with these predictions varies from region to region, but is generally higher within the tropics. Updates are available each month.

Rainfall Forecast for December 2004 – February 2005


Map A. Probability of Dry
Map A indicates a decreased chance of unusually* dry conditions over the northern part of the region (regions I and II), but an increased chance over the southern part (regions II and IV).

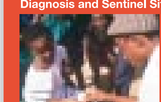

Map B. Probability of Wet
Map B indicates that over much of the northern part of Southern Africa the chances of unusually* wet conditions are increased (regions I and II), and these increases are largest over north-eastern parts of Tanzania (region I). The chances of unusually wet conditions are decreased fairly substantially over the southern part of the region (regions II and IV), although the possibility of tropical cyclones should not be ruled out.

http://www.dmc.co.zw/ SeasonalForecasts/SARCOF_2004_STATEMENT.pdf.

Sentinel Case Surveillance

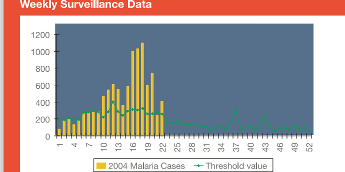
It is of paramount importance to develop good health information and sentinel site sueillance systems. The process of developing malaria early warning systems strengthens integrated health systems surveillance. It is in itself dependent on good epidemiological data for testing and validating the relationship between the component parts.

Diagnosis and Sentinel Site Surveillance


WHO/TDR/Lindsay


WHO/TDR/Crump

Weekly Surveillance Data



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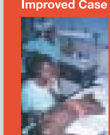
Improved Case Management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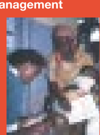
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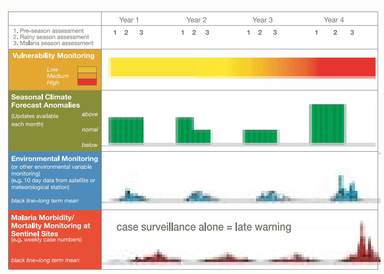
Chart Legend

Malaria Early Warning System



Southern Africa Regional Epidemic Outlook Forum

Collaboration

WMO — National Meteorological Services — SAMC — National Malaria Control Programmes — SADC Drought Monitoring Center — WHO

What does the seasonal climate forecast mean for malaria transmission?
Will the coming rainy season be wetter or drier than the last?
Will this rainy season be as wet as during the last epidemic?

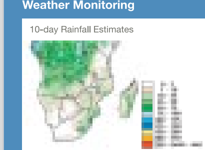
Distribution of Forecast

Countries → Provinces → Districts

Environmental Monitoring

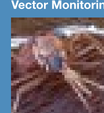
Environmental variables pertinent to malaria transmission are rainfall, temperatures, humidity, and flooding. Two sources of such information are periodic summaries available through the internet from SADC DMC, FEWS-NET, or IRI websites, or directly from national meteorological services.

Weather Monitoring



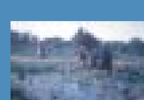
http://igskmncnwb015.cr.usgs.gov/adds/

Vector Monitoring, EIR

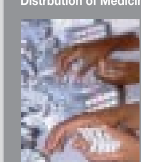

Oliver Meckes

Flood Monitoring


MALOF 2004 Proceedings


WHO/TDR/Service

Timely Procurement and Distrbution of Medicine


WHO/TDR/Crump

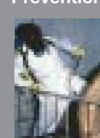
Preparedness


Epidemic Emergency Containers (Credit: Ishata Conteh)

Protection


WHO/TDR/Crump

Prevention and Community Education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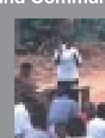
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