Climate information for adaptation and development needs

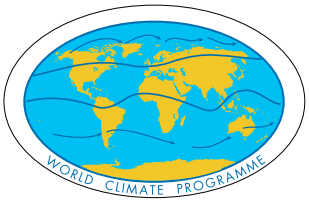
World Meteorological Organization
Weather • Climate • Water
WMO-No. 1025

Implementing the Nairobi Work Programme on impacts, vulnerability and adaptation to climate change through the World Meteorological Organization and National Meteorological and Hydrological Services

WMO-No. 1025

ISBN 92-63-11025-5

Produced by the World Climate Programme and the World Climate Research Programme



Cover illustration: pile house in Indonesia. Photo by Curt Carnemark (World Bank)

NOTE

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CONTENTS

FOREWORD

M. Jarraud, Secretary-General

Humans are highly resilient and have managed to adapt to a broad range of climatic conditions throughout the ages. However, never in the past was the rate of changes as fast as that projected in the Working Group I Summary for Policymakers, issued in February 2007 by the World Meteorological Organization (WMO)/United Nations Environment Programme (UNEP) co-sponsored Intergovernmental Panel on Climate Change (IPCC).

The National Meteorological and Hydrological Services (NMHSs) of the 188 Members of WMO have an essential role in the adaptation to and mitigation of climate change impacts. The most critical impacts are those potentially affecting human life and socioeconomic development, as well as those able to disrupt the structures we depend upon for food, water, shelter and transportation. For example, intense precipitation events can favour the spread of diseases and pests, soil erosion and, depending on the time in the crop cycle, agricultural production.

In May 2007, Fifteenth Congress approved the WMO Strategic Plan for the period 2008–2011 and beyond to provide a blueprint for the 188 Members to meet the changing needs of their communities for weather, climate, water and related environmental information. Successful use of the plan will contribute to the desired societal outcomes, such as improved protection of life, livelihoods and property; improved health and well-being of citizens; increased safety on land, at sea and in the air; sustained economic growth in both developed and developing countries; and protection of other natural resources and improved environmental quality.

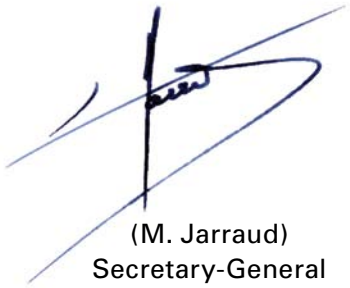
The societal and economic impacts of weather, climate, water and environmental conditions are great – and they are growing. Today, up to 30 per cent of a developed country's Gross Domestic Product (GDP) is sensitive to weather, climate and water conditions, and the corresponding share is often even higher for developing economies. At the same time, there are new opportunities for the application of weather, climate and water information to help governments improve the safety and well-being of their peoples, reduce poverty, increase prosperity and improve public health and security. There are also new opportunities to use this information to take decisions that protect the environment for future generations. In fact, scientific and technological advances are providing tools and opportunities to enable more effective action for adaptation to climate variability and change.

Adaptation is a response measure promoted by the United Nations Framework Convention on Climate Change (UNFCCC), and early warning systems are an effective way of reducing vulnerability and enhancing adaptive capacity to weather events and climate change. There is a need to establish and strengthen collaboration regarding climate change projections, impact assessment and response strategies related to disaster reduction. In this context, urgent measures should be taken for environmental planning, data and information pooling, improved observing systems, exchanging information on best practices, strengthened technical cooperation and close cooperation with policymakers. WMO, through its Strategic Plan and technical programmes, will continue to support these activities as well as those related to climate change including through the IPCC and the UN Conventions on Climate Change, on Biodiversity and on Desertification.

WMO's long-term objectives are achieved through a series of initiatives emphasizing five strategic thrusts: capacity-building; service delivery; science

and technology development and implementation; partnerships and efficient management; and good governance. One example is the WMO-sponsored World Climate Research Programme (WCRP) which provides the scientific basis for climate variability and change studies, that are later translated into climate application tools and services by the World Climate Programme (WCP). WMO welcomes the initiative resulting from the twelfth session of the Conference of the Parties (COP) to the UNFCCC, which adopted the Nairobi Work Programme on impacts; vulnerability and adaptation to climate change, and believes that the programme provides a basis for further global cooperation. The UNFCCC Secretariat has published a brochure which gives comprehensive information on the Nairobi Work Programme. WMO Members are committed to take a proactive role in planning national and regional programmes on adaptation to climate variability and change, and actively participate in the implementation of the Nairobi Work Programme based on the modalities and deliverables identified.

On the occasion of the thirteenth session of the Conference of the Parties (COP 13) to the UNFCCC and the third session of the Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol (COP/MOP 3), this brochure provides updated information on how climate science and services can enhance adaptation to climate variability and change, especially for development needs. The brochure highlights a few examples from the experience of NMHSs and collaborating organizations, to give an idea of real-life experience in utilizing climate knowledge to formulate and implement appropriate adaptive policies and strategies.



(M. Jarraud)
Secretary-General
World Meteorological Organization

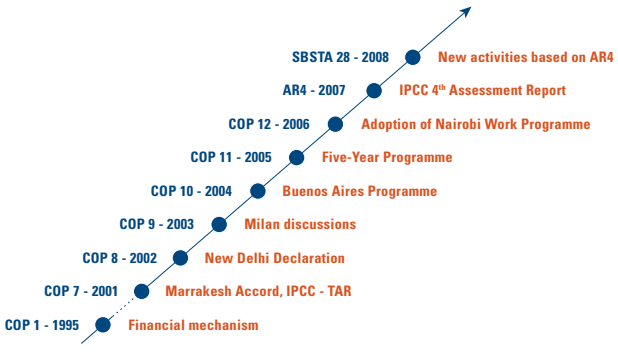
INTRODUCTION

WMO strategies are designed to respond to a number of challenges related to weather, climate and water issues. Climate change and its impacts, one of the most serious problems facing sustainable development globally, is of great concern to humanity and is being addressed by several global, regional and national organizations and institutions. Even if mitigation actions such as greenhouse gas emission reductions can help to slow the rate and the magnitude of climate change, it is widely acknowledged that climate change is now inevitable, and adaptation, through a range of technical, regulatory and behavioural changes, is one of the key methods available to the society for dealing with climate change. WMO, in collaboration with its Members comprising a global network of NMHSs, plays an infrastructural role in weather and climate observation, monitoring, scientific understanding of climate processes, the development of clear, precise and user-targeted information and climate predictions, and in providing sector-specific climate services, including advice, tools and expertise to meet the needs and requirements of adaptational strategies as well as decision-making.

Through global partnerships in capacity-building, training, education and public awareness at all levels WMO contributes to mobilizing international action addressing climate change. By doing so, WMO provides active support to achieve the United Nations Millennium Development Goals (MDGs) of eradicating extreme poverty and hunger and of ensuring environmental sustainability through a vast reservoir of expertise and knowledge, among its Member States, programmes, technical commissions, partner institutions and organizations. The Climate Information and Prediction Services (CLIPS) project and the Regional Climate Outlook Forums (RCOFs), initiated and supported by WMO in different parts of the world to enhance climate applications and services, provide an effective mechanism for capacity-building, networking and user liaison at the regional and national levels, particularly in developing countries.

It is the ambition of WMO to halve the loss of life associated with natural disasters of meteorological, hydrological and climatic origin over the next 15 years. WMO has established a Disaster Risk Reduction (DRR) Programme to ensure optimization of the WMO global infrastructure and integration of its core scientific capabilities and expertise into all relevant phases of disaster risk management decision-making at the international, regional and national levels, particularly related to risk assessment and early warning systems.

TIMELINE OF DEVELOPMENT ON ADAPTATION IN THE UNFCCC PROCESS



ADAPTING TO CLIMATE CHANGE AND VARIABILITY

Adaptation is one of the main ways in which societies can deal with climate change. The IPCC defines adaptation as 'the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities'. Various types of adaptation can be distinguished, including anticipatory, reactive, private, public, autonomous and planned adaptation. Adaptive capacity is defined as the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences. Developing countries, especially the least developed countries (LDCs) and small island developing States (SIDS) are highly vulnerable to the impacts of climate change and climate variability. Their needs

Small islands are especially threatened by sea-level rise.

THE UNFCCC NAIROBI WORK PROGRAMME

The Nairobi Work Programme comprises two thematic areas, namely 'understanding and assessment of impacts, vulnerability and adaptation' and 'practical adaptation actions and measures to respond to climate change', each with several sub-theme activities. Common threads in these activities are methodologies, data and modelling and integration into sustainable development.

Following decision 2 taken at the eleventh session of the United Nations Framework Convention on Climate Change (UNFCCC) Conference of the Parties (COP 11), during the twelfth session (COP 12) it was agreed to invite relevant organizations and other stakeholders to implement the activities of the programme of work in nine main areas:

- Methods and tools;
- Climate data and observations;
- Climate modelling, scenarios and downscaling;
- Climate-related risks and extreme events;
- Socio-economic information;
- Adaptation planning and practices;
- Research;
- Technologies for adaptation;
- Economic diversification.

for adaptation, as is the case for all countries, should be coordinated with social and economic development in an integrated manner. It has also been recognized that countries are incorporating local and indigenous knowledge in their activities related to impacts, vulnerability and adaptation to climate change, with assistance from relevant international and regional organizations.

EXPECTED OUTCOMES OF THE NAIROBI WORK PROGRAMME

(a) Enhanced capacity at international, regional, national, sectoral and local levels to further identify and understand impacts, vulnerability, and adaptation responses, and to select and implement practical, effective and high priority adaptation actions;

(b) Improved information and advice to the COP and its subsidiary bodies on the scientific, technical and socio-economic aspects of impacts, vulnerability and adaptation, including facilitating the implementation of decision 1 of COP 10, where relevant;

(c) Enhanced development, dissemination and use of knowledge from practical adaptation activities;

(d) Enhanced cooperation among Parties, relevant organizations, business, civil society, and decision makers, aimed at enhancing their ability to manage climate change risks; and

(e) Enhanced integration of actions to adapt to climate change with sustainable development.

THE ROLES OF THE WORLD METEOROLOGICAL ORGANIZATION AND THE NATIONAL METEOROLOGICAL AND HYDROLOGICAL SERVICES

WMO, the specialized United Nations (UN) agency for weather, climate, hydrology and water resources and related environmental issues, in particular through the National Meteorological and Hydrological Services (NMHSs) of its 188 Members, will contribute actively to the Nairobi Work Programme through a range of modalities. WMO has a vast reservoir of expertise, knowledge, data and tools among its Members, programmes and technical commissions, as well as through its partnerships. It can thus bring strong scientific and technical capability along with local, regional and global knowledge, providing authoritative and targeted analyses for the UNFCCC Parties and Subsidiary Body for Scientific and Technological Advice (SBSTA). WMO will offer expert advice, guidelines, technical inputs and leadership in the implementation of some components of specific activities.

The WMO Convention reaffirms the vital importance of the mission of NMHSs in observing and understanding weather and climate and in providing meteorological, hydrological and related services in support of national needs in areas such as:

- Protection of life and property;
- Safeguarding the environment;
- Contributing to sustainable development;
- Promoting long-term observation and collection of meteorological, hydrological and climatological data, including related environmental data;
- Promotion of endogenous capacity-building;
- Meeting international commitments;
- Contributing to international cooperation.

The NMHSs have a long history of recording weather and hydrological observations, which when compiled over a long period of time provide the climatology of specific locations. They form an integral part of the WMO Global Observing System (GOS), which consists of a global network of observations over land, sea and in the atmosphere. Archived data by NMHSs have been used in the publication of world climatological statistics and a wide variety of climate diagnostics providing a deeper understanding of the climate variability and the associated processes. The NMHSs are national services that have been assigned specific duties for the collection, processing and archiving of systematic climate data, including the provision of access to the resulting data and related information. They are responsible for a network of observing systems whose data are exchanged among the international community using a well-coordinated and standardized communication system.

The NMHSs and WMO have a long lasting commitment to satisfy the needs of their users concerning weather and climate information. They maintain sustained relations with sectors such as marine, aviation, agriculture, health and water. They are committed to understanding the needs of all socio-economic sectors, regarding their interactions with weather, climate and water, and to maintaining a regular dialogue and partnership with them.

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Portable, automated weather station on the Baja Peninsula of Mexico

AREAS OF POTENTIAL CONTRIBUTION BY WMO TO THE NAIROBI WORK PROGRAMME

(a) Understanding and assessment of impacts, vulnerability and adaptation:

(i) Promoting development and dissemination of methodologies and tools for impact and vulnerability assessments, such as rapid assessments and bottom-up approaches, including as they apply to sustainable development;

(ii) Improving collection, management, exchange, access to and use of observational data and other relevant information on current and historical climate and its impacts, and promoting improvement of observations, including the monitoring of climate variability;

(iii) Promoting the development of, access to, and use of information and data on projected climate change;

(iv) Promoting understanding of impacts of, and vulnerability to, climate change, current and future climate variability and extreme events, and the implications for sustainable development;

(v) Promoting the availability of information on the socio-economic aspects of climate change and improving the integration of socio-economic information into impact and vulnerability assessments.

(b) Practical adaptation actions and measures to respond to climate change:

(i) Facilitating communication and cooperation among and between Parties to the Convention and relevant organizations, business, civil society, and decision makers, and other stakeholders;

(ii) Promoting understanding and the development and dissemination of measures, methodologies and tools including for economic diversification aimed at increasing economic resilience and reducing reliance on vulnerable economic sectors;

(iii) Collection, analysis and dissemination of climate information relevant to past and current impacts (especially of extremes) and practical adaptation measures and actions;

(iv) Promotion of research on adaptation measures and diffusion of know-how and best practices.

HIGHLIGHTS OF WMO CLIMATE ACTIVITIES

WMO spearheaded global efforts to monitor the environment and address potential hazards such as global warming, climate change and sea-level rise. WMO co-established with UNEP the IPCC and played its part in paving the way for the adoption of the UNFCCC.

The Climate Variability and Predictability Project of the World Climate Research Programme (WCRP-CLIVAR) has a leading role in i) assessing the predictability of climate on seasonal to inter-annual timescales, and ii) in providing the IPCC state-of-the-art multi-model ensemble of climate change projections.

Additionally, the WCRP Tropical Ocean and Global Atmosphere (TOGA) programme, a breakthrough in climate forecasting, has improved the prediction of major deviations from climate norms in the tropical Pacific during warm episodes, commonly known as El Niño.

Through its Global Atmosphere Watch (GAW) programme, WMO plays a crucial role in the monitoring of greenhouse gases, which have a significant global radiative forcing impact.

Made substantial contributions to protecting the ozone layer, in line with the Vienna Convention for the Protection of the Ozone Layer and its Montreal Protocol. It monitors the ozone layer using the Global Ozone Observing System of the GAW and issues regular, open access bulletins on its condition.

Helped set up a global hydrological network, the World Hydrological Cycle Observing System (WHYCOS), for water quality monitoring and water resources assessment—an abiding prerequisite for sustainable development and for reducing water-related hazards such as floods and droughts. This network also supports various technical requirements of the United Nations Convention to Combat Desertification (UNCCD).

Issues annual global statements on the state of the earth's climate with particular attention to regional aspects, based on the regional information provided by the NMHSs and a worldwide network of experts.

Actively promoted a consensus approach and regional networking for the development and application of regional climate information and products, in particular through its Climate Information and Prediction Services (CLIPS) project, e.g. Regional Climate Outlook Forums (RCOFs), El Niño and La Niña updates and regional showcase projects.

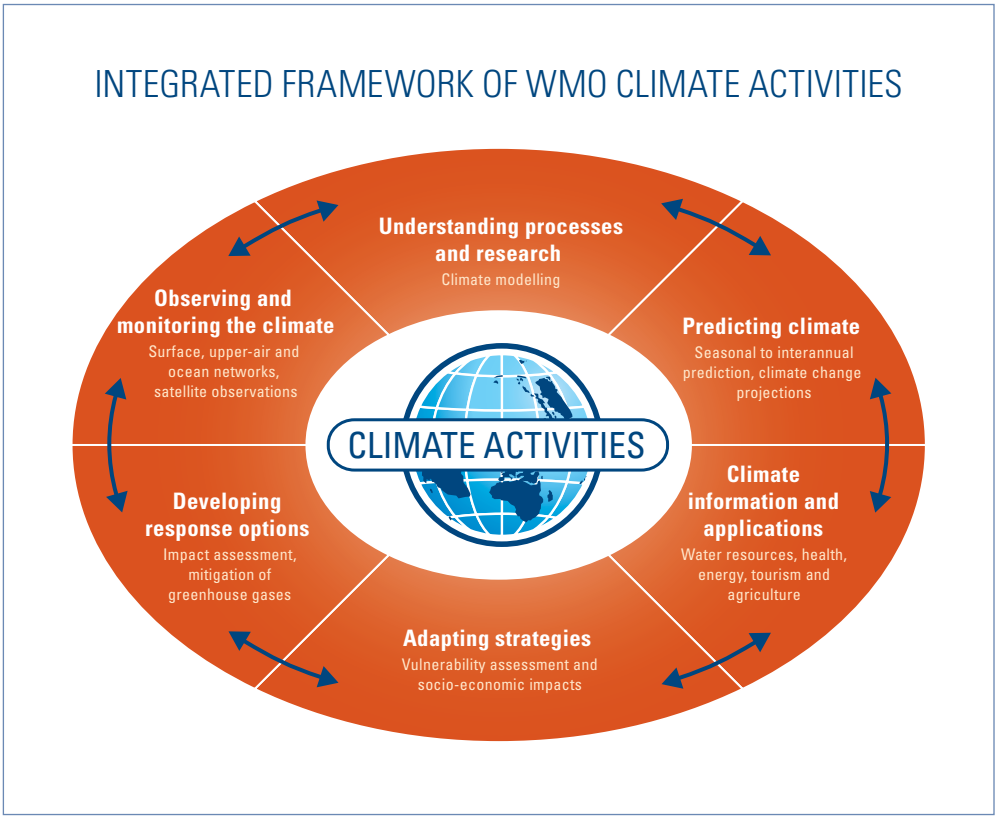
Helped the development of global and regional scale climate prediction infrastructure: the Global Producing Centres (GPCs); and pilot projects for the establishment and eventual formal designation of WMO Regional Climate Centres (RCCs).

WMO supports capacity-building in climate information and prediction services to help countries effectively incorporate climate issues into national sustainable development agendas.

Both WMO and NMHSs have been involved with the activities of the UNFCCC since its very inception in 1992.

WMO, through its World Climate Programme (WCP), World Climate Research Programme (WCRP), Atmospheric Research and Environment Programme (AREP), GAW monitoring network (greenhouse gases and ozone) and Disaster Risk Reduction (DRR) Programme, assists Members, in particular developing countries, to improve their understanding and assessment of impacts, vulnerability and adaptation and to make informed decisions on practical adaptation actions and measures to respond to climate change on a sound, scientific, technical and socio-economic basis, taking into account current and future climate change and variability.

The IPCC, established in 1988 after the First World Climate Conference held in 1979, contributes significantly to advances in climate change research, the assessment of vulnerability, impacts and adaptation, and the technology for the mitigation of greenhouse gases. So far, the IPCC has brought out four assessments, one special regional report and many other reports. Over the years, the IPCC focus has advanced from simple climate assessment to the science of vulnerability and adaptation and sustainable development. The IPCC assessments are contributing to the change



WMO implements a comprehensive integrating framework for all aspects of international climate-related programmes, including data collection and application and climate system research.

in direction of policies towards climate change and adaptation. In the Data Distribution Centre (DDC) portal of the IPCC, climate scenarios are available for vulnerability and adaptation assessment. Several NMHSs provide substantial support for the climate model development and production of climate change scenarios that underpin the IPCC assessments. The Task Group on Scenarios for Climate Impact Assessment provides technical support to scenario users with advice and through the development of guidelines. Many NMHSs act as focal points of the IPCC and scientists who contribute to IPCC assessments are nominated through the NMHSs. This procedure facilitates knowledge and technology transfer and, hence, contributes to capacity-building in the NMHSs.

<table>
<tr><td colspan="4">WORLD WEATHER WATCH PROGRAMME</td></tr>
<tr><td colspan="4">WMO SPACE PROGRAMME</td></tr>
<tr><td colspan="4">DISASTER RISK REDUCTION PROGRAMME</td></tr>
<tr><td>WORLD CLIMATE PROGRAMME</td><td>ATMOSPHERIC RESEARCH AND ENVIRONMENT PROGRAMME</td><td>APPLICATIONS OF METEOROLOGY PROGRAMME</td><td>HYDROLOGY AND WATER RESOURCES PROGRAMME</td></tr>
<tr><td colspan="4">EDUCATION AND TRAINING PROGRAMME</td></tr>
<tr><td colspan="4">TECHNICAL COOPERATION PROGRAMME</td></tr>
<tr><td colspan="4">REGIONAL PROGRAMME</td></tr>
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The ten major scientific and technical programmes of WMO continue to provide assistance and guidance to the NMHSs in their contribution to curbing the impacts of adverse weather situations on sustainable socio-economic development and help in the implementation of the MDGs to improve the wellbeing of nations. In addition, within WMO, eight technical commissions advise and guide the activities of the programmes, and six WMO regional associations are in charge of their coordinated implementation.

WORLD METEOROLOGICAL ORGANIZATION PROGRAMMES AND THE NAIROBI WORK PROGRAMME

WMO, through its major programmes, contributes to the nine areas of activities (see box on page 8) for the implementation of the Nairobi Work Programme.

METHODS AND TOOLS

Climate watches

Extreme weather events, such as hurricanes, thunderstorms and tornadoes, require weather watches for which most NMHSs issue early warnings and undertake special monitoring. In a similar manner, 'climate watches' deal with climatic extremes such as heavy monsoons, flooding, cold waves, heat waves and droughts, which require long-term monitoring with historical observations and integration into the context of global climate patterns. By incorporating recent climate analysis as well as outlooks, climate watches serve as advisories and forewarnings of climate anomalies, and therefore enable continuous and timely climate related risk assessment and management to avoid damage to life and property. The necessary mechanisms have already been put in place in some parts of the world to issue climate watches, such as the North American Drought Monitor (NA-DM), the IGAD Climate Prediction and Applications Centre (ICPAC) in the Greater Horn of Africa, and Drought Monitoring Centres in Africa (for example South African Development Community Drought Monitoring Centre (SADC DMC)).

Climate Information and Prediction Services project

The provision of climate information and predictions improves economic and social decision-making and supports sustainable development. These

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are achieved through the Climate Information and Prediction Services (CLIPS) project which builds on rapidly developing atmospheric and oceanographic research as well as a wealth of data, experience and expertise within the NMHSs and related entities. This project has successfully demonstrated the immense potential of the concept in several regions worldwide. Training and capacity-building of the global network of CLIPS Focal Points are integral components of CLIPS, facilitated by the scientific expertise of WCRP. The CLIPS project can thus be an effective framework within which regional climate change information and the associated adaptation issues can be integrated. Development of training curricula, training workshops and regional showcase projects are key components of CLIPS, designed to cater to the growing needs of climate information providers as well as user sectors, particularly in developing countries and the LDCs.

Regional Climate Outlook Forums

Specific institutional frameworks have been established, with appropriate stakeholders taking the lead, to address relevant climate change issues at the local/regional and sector levels. The RCOFs, a concept conceived and supported by WMO as part of CLIPS activities, constitute an important vehicle in developing countries for providing advanced information on future climate information for the next season and beyond, and for developing a consensus product from among the multiple individual predictions available. The RCOFs stimulate the development of climate capacity in the NMHSs and facilitate end-user liaison to generate decisions and activities that mitigate the adverse impacts of climate variability and change and help communities to build appropriate adaptation strategies. There is great potential for the regional climate activities that currently take place under RCOFs to expand the use of currently

CLIMATE CHANGE AND HEALTH VULNERABILITY

For public health the first goal of adaptation is to reduce the risk of human disease, injury, suffering and death due to climate change and its effects on natural systems. The National Climate Change and Health Vulnerability Assessment conducted by the Canadian federal health department, to be published in October 2007, allows leading experts across Canada to contribute to a better understanding of how vulnerable Canadian communities are to climate change and to gauge the capacity of communities and institutions to adapt to risks associated with climate change and climate variability. The assessment followed the guidelines outlined in the publication *Methods of assessing human health vulnerability and public health adaptation to climate change*, developed in 2003 by the World Health Organization (WHO) in cooperation with WMO and UNEP. These guidelines, (www.euro.who.int/globalchange), provide practical information to governments, health agencies and environmental and meteorological institutions in both developed and developing countries on how to assess vulnerability and adaptation to climate variability and change at regional national and local levels. Flexible methods are described to achieve better understanding of the current and future vulnerability of specific populations.

available tools and to include downscaled information with more regional detail on climate change scenarios such as those created for the IPCC Fourth Assessment Report (AR4).

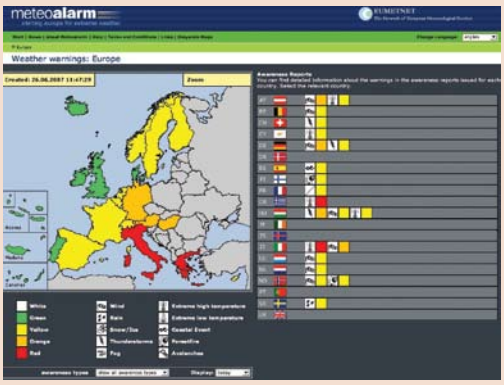
THORPEX—a global atmospheric research programme

The Observing System Research and Predictability Experiment (THORPEX), a part of the WMO World Weather Research Programme (WWRP), is an international research and development programme responding to the weather related challenges of the 21st century to accelerate improvements in the accuracy of one-day to two-week high impact weather forecasts for the benefit of society, the economy and the environment. The THORPEX research topics include: global-to-regional influences on the evolution and predictability of weather systems; global observing system design and demonstration; targeting and assimilation of observations; and societal, economic and environmental benefits of improved forecasts. The purpose is to provide accurate, timely, specific and definite weather warnings in a form

EARLY WARNING SYSTEMS IN EUROPE

Disaster risk reduction could be more efficiently achieved by deploying resources to strengthen early warning systems. Human diseases, injury, suffering and death, caused by adverse climate effects, can be reduced when climate alerts reach the community in a timely and easy-to-understand manner. The French Meteorological Service, Météo-France, has developed an interactive website (*carte de vigilance*, www.meteofrance.com/vigilance/index.html) that indicates climate risks on a scale from 0 to 4 for each region. For example, consulting this website on a daily basis during hot summers could help protect people from excessive heat waves.

The *Meteoalarm* websites provide the most relevant information needed to prepare for extreme weather expected to occur at a given place of interest over Europe. They alert people about the possible occurrence of severe weather, such as heavy rain with risk of flooding, severe thunderstorms, gale-force winds, heat waves, forest fires, fog, snow or extreme cold. At a glance, users can see where in Europe the weather might become dangerous. Clicking on the country leads to national and regional warnings depicted in the 'awareness colours' orange and red. *Meteoalarm* is developed by EUMETNET, the Network of European Meteorological Services, and is an important contribution to WMO's objectives (www.meteoalarm.eu).



DEMETER PROJECT ON CLIMATE-RELATED DISEASES

In many parts of the world, climate drives the evolution and spread of diseases. Modelling studies are carried out in various research institutes, to estimate the risk and future burden of diseases and provide early warning services to people directly affected, health officials and international aid organizations. For example, the timing and quantity of precipitation drive both the migration and spread of the parasite-carrying mosquito and the developmental rates of the parasite that causes malaria. This climate-mosquito relationship has long been used in the past to predict malaria epidemics. Latest research at the European Centre for Medium-range Weather Forecasts (ECMWF), in cooperation with the International Research Institute for Climate and Society (IRI), has developed multi-model ensemble techniques under the Development of a European Multimodel Ensemble system for seasonal to inTERannual prediction (DEMETER) project to predict the risk of malaria incidence far ahead of the rainy season. The ensemble work was pioneered at a workshop of the World Climate Research Programme. Skilful climate forecasts that not only predict the most likely evolution of climate but also the uncertainty in such prediction, provide early warning of changes of risk in epidemic-prone regions where approximately 1.3 million humans die annually from malaria. The increase in warning time up to four months ahead of the maturation of the mosquito gives health officials crucial time to optimize the allocation of the limited resources available to fight against malaria. This forecast technique is currently operationalized in the national malaria control programmes of Botswana and some other African countries.

Malaria patient near Alem Kitmama, Ethiopia

IMPACT OF CLIMATE CHANGE ON TOURISM

Tourism forms the backbone of the economy in many local communities worldwide and is one of the fastest growing sectors. Poor climatic conditions can seriously harm tourism operations and the host communities that depend on them.

Climate change concerns for tourism and adaptation measures include: cyclones and high wind speeds; big waves and sea surges; sea-level rise; water shortage; intensive rainfall events, flooding and landslides; drought and the risk of wildfire; coral bleaching and damage to other sensitive and biodiversity-rich ecosystems; insufficient snow coverage in winter sports destinations in mountain areas; and health impacts. These impacts pose a risk to tourism infrastructure, tourists, tourism staff and local communities.

The First International Conference on Climate Change and Tourism, convened by the World Tourism Organization (UNWTO) in Djerba, Tunisia, in April 2003, in collaboration with WMO and other UN and intergovernmental organizations, was an important initial step to address the complex relations between climate change and tourism. The Djerba Declaration on Climate Change and Tourism provides a basic reference and framework for further action by the major stakeholder groups.

that can be readily used in decision support tools, to improve and demonstrate such tools in order to reduce the impact of natural hazards and to realize societal and economic benefits of improved weather forecasts.

Disaster Risk Reduction Programme

Between 1980 and 2005 natural disasters worldwide took the lives of nearly two million people and resulted in economic losses above one trillion US dollars. During this period, weather-, water- and climate-related hazards and conditions accounted for 89 per cent of the total number of disasters, 72 per cent of loss of lives and 75 per cent of the total economic loss. However, over the last few decades, significant developments in monitoring, detecting, analysing, forecasting and warning of weather-, water- and climate-related hazards have led to significant opportunities for reducing the impacts of related disasters. For example, over the last 25 years, there has been nearly a four-fold increase in the number of disasters and a five-fold increase in the associated economic losses, whereas the loss of lives has in fact decreased to nearly one-third of its previous value. This is due to several factors, a critical one being the continuous development of natural hazard monitoring and detection and of the development of specific end-to-end early warning systems, such as those for tropical cyclones.

The international movement in disaster risk management is supported by the Hyogo Framework for Action 2005–2015: Building the Resilience of Nations and Communities to Disaster (HFA), drafted and approved at the World Conference for Disaster Reduction, Kobe, Japan, January 2005, which represents a set of outcomes and results that must be achieved if disaster risk is to be reduced. The HFA describes a range of key thematic areas that need to be addressed, particularly in high-risk nations and communities. These include: organizational, legal and policy frameworks (governance); risk identification, assessment, monitoring and early warning; knowledge management and education; reducing underlying risk factors; and the preparedness for effective response and recovery.

WMO EXPERT TEAM ON CLIMATE AND TOURISM

WMO continues to have a long commitment to climate-related issues in the tourism sector. In January 1995, WMO initiated a Meeting of Experts on Climate, Tourism and Human Health in Cuba, and in 1998 WMO published the *Handbook on Natural Disaster Reduction in Tourist Areas*. The recently established Expert Team on Climate and Tourism by the Commission for Climatology (CCl) of WMO addresses the impacts of climate variability and climate change on the tourism industry, especially in sensitive areas such as coastal zones and mountains, with a view to supporting sustainable tourism. Accurate weather and climate information, as well as the prediction of extreme climatic events, are becoming increasingly important, given that the programming of many tourism activities is heavily climate-dependent, and that insurance practices in tourism are greatly impacted by natural hazards. Climate change will constitute an increasing risk for tourism operations in many destinations.

Climate-related hazards can impact on tourism activities.

CLIMATE DATA AND OBSERVATIONS

Lack of adequate and reliable climate data is considered to be a major constraint in developing an accurate understanding of the current and future climate variability and change, particularly in developing countries and LDCs. The NMHSs, through WMO, coordinate their efforts in capacity-building, training, research and development to address this gap and provide reliable climate observations, which can be transformed into useful products for stakeholders to make use in the development of their adaptation strategies. The NMHSs can contribute significantly through the development and use of modern Climate Data Management Systems (CDMSs) and through the 'rescue' of historical records that are at risk of deterioration, in order to secure complete and safe long-term climate records. Improved climate observations are vital to address climate related issues. Through its various programmes, WMO can provide a platform for a coordinated global framework for obtaining climate data needed for climate change detection and its impacts on vulnerable sectors, research, policy information and national economic development.

Data rescue

For a comprehensive climate analysis, apart from having good observational networks, it is extremely

Only a few of the world's climate data archives have digitalized data from before the 1940s.

THE RADIO AND INTERNET (RANET) INITIATIVE

Adaptation measures in the agricultural sector aim at securing food production and reducing poverty. It is imperative for decision-makers, including farmers, herders, business owners and others, to receive climate information in a timely and easy-to-understand manner.

RANET (RAdio and interNET, www.ranetproject.net/) is an international collaboration to make weather, climate and related information more accessible to remote and resource-poor populations in Africa and various South Pacific islands.

RANET aids day-to-day resource decision-making and preparedness against natural hazards. In this respect, the programme has strong ties to WMO through the Meteorological Services in its Member States. The RANET initiative serves many of the needs highlighted by WMO*. The programme combines innovative technologies with appropriate applications and partnerships at the community level in order to ensure that the networks it creates serve all community information needs. Community ownership and partnership are the core principles of RANET's sustainability strategy. RANET activities include: awareness raising, training, partnership development, pilot activities to demonstrate various community technologies, broadcast management, and the development of dissemination networks through partnership and platform development.

* RANET is a truly international collaboration relying primarily on the guidance and support of National Meteorological and Hydrological Services, related national entities, and development NGOs. Primary programme support and management occurs through regional centres in Africa, Asia, and the Pacific, with the backing of the USAID Office of Foreign Disaster Assistance, the US Government's NOAA Office of Global Programs, and NOAA-National Weather Service International Activities Office.

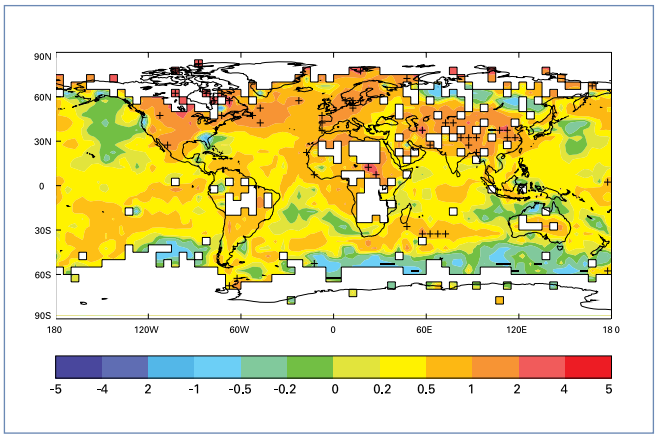
important to preserve the collected climate records properly in an easily accessible and usable form. WMO has defined and set guidelines for its Members on data rescue methodologies. The aim is to take special measures to preserve all data at risk of being lost due to deterioration of the medium, and to digitize current and past data into computer compatible form for easy access. The data rescue projects are of high priority for WMO and its Members. Many of the world's climate data sets contain digital data back to the 1940s, but only a few have digital archives of all available data before this time. Therefore, an immediate expected outcome from such projects is to meet the IPCC needs for the detection of observed climate variability and change with long records of high quality climate observations.

THE WORLD AGROMETEOROLOGICAL INFORMATION SERVICE (WAMIS) INITIATIVE

WMO aims to enhance food security through the application of agrometeorological products to improve land use, crop selection, locust control and management practices. Enhanced assessment of water availability and quality is essential for sustainable development, as is international cooperation, especially within river basins shared among countries. The desert locust plague in 2004 drew the attention of the world to the threat locusts pose to the food security of affected countries, especially in the developing world. All the different phases in the life cycle—from the solitary phase to the gregarious phase which causes widespread damage—require specific meteorological conditions. To ensure more effective monitoring and control of desert locusts, the Commission for Agricultural Meteorology established the World AgroMeteorological Information Service (WAMIS, www.wamis.org/) which provides a dedicated webserver for disseminating agrometeorologial products such as 'locust weather updates' and regional specific bulletins.

Climate monitoring

Through CCl and in cooperation with its Members, WMO has been issuing Annual Statements on the Status of the Global Climate since 1995. These statements document the extreme weather and climate events within a regional context, and provide a historical perspective on the variability and trends of surface temperatures that have occurred since the 19th century. WMO is also working with the NMHSs, academics and scientific centres to develop climate change detection tools and software to compute indices that reflect the best estimate of climate trends within countries.



MET OFFICE, UK

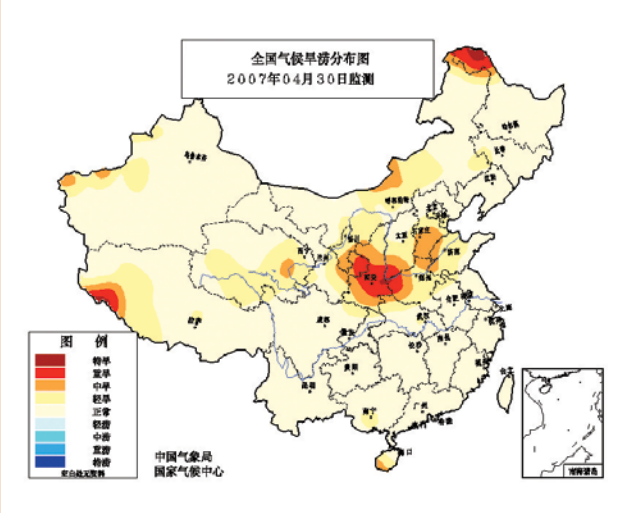
Global surface temperature anomalies in degrees Celsius, relative to 1961–1990 for 2006

World Weather Watch

The World Weather Watch (WWW) network of WMO, with the active participation of the NMHSs, provides vital input to weather and climate forecasts worldwide and forms the basis of international climate activities. Real-time weather data and innovative products and their communication allow the world's populations to be better prepared and

DROUGHT MONITORING BY THE CHINA METEOROLOGICAL ADMINISTRATION

A tool for drought monitoring has been developed for China. The 'drought maps' produced by the Beijing Climate Centre (BCC, http://bcc.cma.gov.cn/en/) of the China Meteorological Administration (CMA) have been operational since 1995. Today, the maps are based on a 30- and 90-day average in precipitation and evapotranspiration (Comprehensive Index, CI). Rainfall and soil moisture are determined from an agricultural meteorological station network and from satellites. The information on the state of drought in different parts of the country is distributed through bulletins targeting governmental agencies; there are weekly broadcasts and daily drought monitoring maps made available on the BCC website.



BEIJING CLIMATE CENTRE

adapt themselves to prevailing climates especially during the occurrence of extreme weather conditions. A challenge is to maintain an up-to-date and efficient World Weather Watch System.

Global Climate Observing System

The role of the GCOS in ensuring the availability of adequate climate observations has been an important one. As the Parties to the UNFCCC increasingly embrace the need to develop effective adaptation policies, the importance of high quality, long-term climate observations, at all scales, for adaptation needs has become obvious. Efficient observing systems at global, regional, and national levels are of fundamental importance for the development of user-driven climate services and effective climate risk management that are required for adaptation to climate variability and change and for sustainable development generally. Over the last five years, it has assisted NMHSs and other stakeholders in the development of Regional Action Plans (RAPs) that focus on addressing the highest priority observing system needs in each region. Encouraged by the Conference of the Parties, facilitating implementation of these plans by the regions is now a high priority for the GCOS. The plans contain projects to eliminate gaps and deficiencies in atmospheric, oceanic and terrestrial climate observing networks and improve related data management and telecommunications functions.

DROUGHT MONITORING IN THE GREATER HORN OF AFRICA

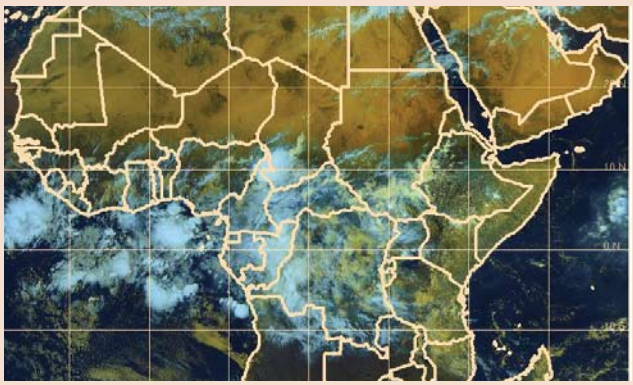
The Greater Horn of Africa, including Burundi, Djibouti, Eritrea, Ethiopia, Kenya, Rwanda, Somalia, Sudan, the United Republic of Tanzania and Uganda, has experienced prolonged droughts during recent decades. Tens of millions of people have been in serious danger of starvation. The Drought Monitoring Centre for the Greater Horn of Africa, the IGAD Climate Prediction and Applications Centre (ICPAC) in Nairobi, Kenya (www.icpac.net), aims at minimizing negative impacts associated with climate extremes through enhanced monitoring and timely availability of weather and climate information and prediction products, together with the availability of effective disaster preparedness policies. ICPAC provides regular regional climate advisories including ten-day, monthly and seasonal climate bulletins as well as timely early warning information regarding climate hazards such as droughts and floods and their associated impacts. Consensus seasonal climate outlooks are regularly provided within the framework of WMO Regional Climate Outlook Forums.

NIALL CROTTY

A family winnowing their grain close to Addis Alem in Ethiopia

METEOROLOGICAL AND CLIMATE COOPERATION FOR DEVELOPMENT IN AFRICA

The African Centre of Meteorological Applications for Development (ACMAD, http://www.acmad.ne) was created in 1987 by the Conference of Ministers of the United Nations Economic Commission for Africa (UNECA) and WMO. It has been operational in Niamey since 1992. It is composed of 53 Member States. To ensure its mission, ACMAD functions in particular with meteorologists seconded from its Members States.



ACMAD

The centre's mission is to provide weather and climate information and support sustainable development in Africa (notably within the context of national strategies for poverty eradication), in the fields of agriculture, water resources, health, public safety and renewable energy.

It carries out its mission through capacity-building for the 53 National Meteorological Services (NMSs) of its Member States, in weather prediction, climate monitoring (of extreme events and other events), RCOF activities for Western Africa, transfer of technology (telecommunications, computing and rural communication) and research.

Climate model data

In 2005, a unique data set comprising all the climate projections created for the IPCC Fourth Assessment Report (AR4) was made internationally available through the WCRP Group on Coupled Climate Models and Anthropogenic Climate Change (CMACC). This very rich resource has already been exploited by many countries, with over 220 papers published by mid-2006. However, to date, much of the benefit has not been realized in developing countries. Since the provision of appropriate future climate services is predicated on access to climate information, it is essential to ensure participation in the construction of climate scenarios for all world regions and, as far as possible, for all nations. WMO facilitates this by capacity-building initiatives for climate scenario construction and by supporting the exchange, archiving and user-friendly access to all climate data including the state-of-the-art climate scenarios developed during the IPCC AR4 and any future assessments. Numerical models are also used to assimilate historical climate observations and generate re-analyses providing comprehensive four-dimensional data that represent the observed climate system over the past few decades. These re-analyses data, the generation and evaluation of which are actively supported by WMO, provide valuable information in data sparse

SCIENCE-BASED TOOLS FOR ADAPTATION STRATEGIES

The Global Environmental Change And Food Systems (GECAFS) project of the Earth System Science Partnership, with the WCRP as one of the partners, aims at understanding the links between food security and global environmental change. The ultimate goal of the 2001 launched project is to deliver science-based tools for analysing the socio-economic and environmental consequences of adaptation strategies and to determine strategies which will be designed to help policymakers and managers to evaluate the best options for reducing vulnerability of food systems to global environmental change while minimizing further environmental degradation. Regional research integrated with studies on vulnerability, impacts and adaptation are being conducted in the Caribbean, the Indo-Gangetic Plain and various areas in Southern Africa.

GISELA ROYO

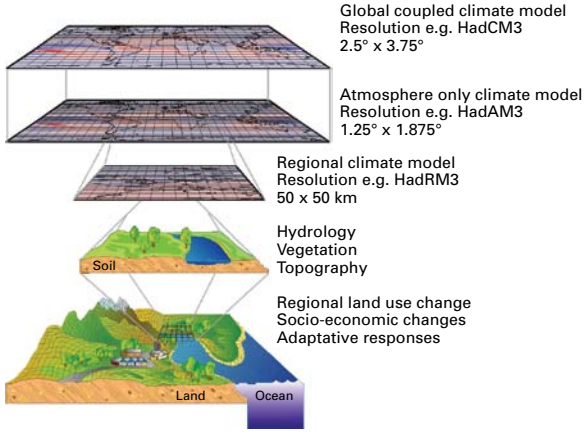
regions. However, access to such model-generated data and their analysis, either in terms of scenarios or re-analyses, is critically dependent on computational, storage and Internet bandwidth facilities, which is a major challenge for developing countries and LDCs.

Monitoring atmospheric composition

Adaptation is complementary to mitigation. The NMHSs have often the responsibility of monitoring the concentration of greenhouse gases in the atmosphere. WMO coordinates the WMO Global Atmosphere Watch (GAW) programme responsible for greenhouse gas measurements. In October 2006, WMO established the WMO/GAW Global Atmospheric CO_2 and CH_4 Monitoring Network as a comprehensive network of GCOS. In March 2006, WMO released the first in a series of Annual Greenhouse Gas Bulletins. These bulletins represent the consensus of a consortium of networks operating since 1975. The data are reported by participating countries and archived and distributed by the World Data Centre for Greenhouse Gases at the Japan Meteorological Agency.

FROM GLOBAL CLIMATE PROJECTIONS TO REGIONAL ADAPTIVE RESPONSES: A UK INITIATIVE

The Hadley Centre of the Met Office in the UK developed a regional climate modelling system known as "Providing REgional Climates for Impacts Studies" (PRECIS) in order to help generate high-resolution climate change information for as many regions of the world as possible (http://precis.metoffice.com). The intention is to make PRECIS freely available to groups of developing countries in order that they may locally develop climate change scenarios, simultaneously building capacity and drawing on local climatological expertise. These scenarios can be used in impact, vulnerability and adaptation studies. PRECIS training workshops have been held in South Africa, Cuba, Bhutan, Brazil, India, Turkey, Argentina, Ghana, including five in the United Kingdom. PRECIS formed the backbone for a recently completed Indo-UK research programme on climate change impacts in India, sponsored by the UK Department for Environment, Food and Rural Affairs (DEFRA) and coordinated by India's Ministry of Environment and Forests (http://www.defra.gov.uk/environment/climatechange/internat/devcountry/india2.htm). Eight inter-related research projects were carried out as a part of this collaborative programme. Two projects developed climate change scenarios and socio-economic scenarios for India, and these data were used by the other six projects to ensure consistency in assessing climate change impacts. The six topical projects looked at the impacts of climate change on specific sectors, namely water resources, agriculture, human health, forests, industry and sea level.



CLIMATE MODELLING, SCENARIOS AND DOWNSCALING

Climate and earth system models

Fully coupled climate models are making rapid strides towards realistically simulating the climate and providing consistent projections of its future state at a global scale for various greenhouse gas emission scenarios. However, there is still considerable uncertainty in these projections associated with the inability of models to fully and accurately represent all the complex processes and interaction in the earth system. One of the most significant problems

ADAPTATION FOR PROTECTION FROM VECTOR-BORNE DISEASES

Malaria is the most important vector-borne disease in the world, occurring generally in tropical and temperate countries with prevalence generally increasing towards the equator. Malaria causes more than 1 million deaths annually worldwide, over 80 per cent of which occur in sub-Saharan Africa. Epidemic malaria may be responsible for 12–25 per cent of the malaria deaths worldwide. Outbreaks of malaria often follow periods of increased precipitation and/or temperature, and impacts can be severe following prolonged periods of drought and famine.

National and regional meteorological/climate and health services, the climate and medical research communities, and international organizations including WMO and WHO are developing and implementing early detection and warning systems that will identify the locations, timing and severity of potential epidemics. Part of this approach involves collection of surface-observed and remotely-sensed data on risk factors (e.g. temperature and precipitation), and of health surveillance data. Modelling and analysis by experts in the climate and health communities can produce useful outlooks and advice, up to three to four months ahead, of areas potentially at risk of outbreaks.

To combat malaria in the Southern African Development Community (SADC) countries in Southern Africa, the WHO Southern Africa Intercountry Programme on Malaria Control and the SADC Drought Monitoring Centre jointly launched a regional South African Epidemic Outlook Forum in September 2004, in Harare. Experts reviewed epidemiological trends; identified vulnerable areas; learned about seasonal climate prediction and how these could support their decision-making; and, amongst other things, reviewed the role of environmental factors in epidemic risk. From this beginning, the partnerships between health and climate sectors in the region (WMO, NMHSs, the SADC Drought Monitoring Centre in Harare, WHO programmes, the Malaria Early Warning Systems (MEWS) programme and the research community) have strengthened, and successful subsequent Malaria Outlook Forums (MALOFs) have been held. In March 2007, the first MALOF was held in the Greater Horn of Africa region, at the invitation of the IGAD Climate Prediction and Applications Centre (ICPAC).

The information developed jointly by climate and health experts in these sessions, together with information on population immunity, food security and previous control activities, gives the health community a longer lead time over which to optimize the allocation of the resources available to combat malaria. The concept is being considered for application in other vulnerable regions, including South-East Asia, Western Africa and in north-western South America. Such activities are excellent examples of locally-driven, partnership-based measures that will help countries prepare for and adapt to changing environmental conditions due to climate change.

arises from the need to run models on a relatively coarse spatial numerical grid. The models therefore have difficulties in representing high intensity weather events such as tropical cyclones, mesoscale storms and localized phenomena such as convective clouds.

Regional downscaling for high-resolution projections

Regional downscaling, both dynamical and statistical tools, aim at a better description of local topography and land-use, to deliver projections that are more relevant to the interests of small nations, (e.g. SIDS) or where heterogeneous surface conditions (i.e. for regions of complex topography, coastal locations, etc.) are highly sensitive to fine-scale climate variations that are parameterized in coarse-scale models. Concerted efforts are being made by some of the NMHSs and leading international climate modelling groups, under the coordination of the WCRP, to develop Regional Climate Models capable of providing regional scale (typically 25 x 25 km, and higher resolution with appropriate computing facilities), climate information for impact studies, to facilitate their use in developing countries, and to provide training as necessary. WMO spearheads global efforts to bridge the existing gaps between developed and developing countries in their understanding of climate change impacts through capacity-building and regular updates of the occurrence of extreme events and their associated damage. While downscaling using regional climate models is valuable, there is also a need for higher-resolution global simulations to capture the global patterns that are an integral part of weather and climate. This will require the coordination of many scientists working together to build the next generation of climate prediction models.

MEZŐ FERENC

Critical products and services help assess the vulnerability of communities to water-related hazards.

CLIMATE-RELATED RISKS AND EXTREME EVENTS

Disaster risk reduction

The Disaster Risk Reduction Programme (DRR) was established to ensure optimization of the WMO global infrastructure and integration of its core scientific capabilities and expertise into all relevant phases of disaster risk management decision-making at the international, regional and national level, particularly in relation to risk assessment and early warning systems. WMO and NMHSs have the capability to develop and deliver critical products and services to the entire disaster risk management decision process. These include the multidisciplinary science to understand the vulnerability of communities to weather-, climate- and water-related hazards and hazards information for planning emergency response and disaster mitigation and prevention. These systems operate alongside educational and capacity-building services that help ensure nations can better meet national needs for hazard information.

CHARLES V. BARBER

El Niño impacts include prolonged droughts, which can lead to forest fires.

Authoritative statements on climate

With the help of leading experts across the world, WMO regularly prepares and issues El Niño/La Niña Update Statements as a product of global consensus. These are of important value for anticipating regional impacts associated with major anomalies of this global scale phenomenon. Annual climate statements issued by WMO, prepared on the basis of inputs received from across the world, serve to document notable features including extreme events with a regional perspective. Furthermore, WMO has formulated a project plan to develop a global atlas of El Niño/La Niña impacts, to help in identifying regions affected by these global-scale climatic anomalies and assess the associated risks.

Living with climate variability and change

Recognizing the value of engaging the user sectors in a proactive manner, an International WMO Conference, on Living with Climate Variability and Change: Understanding the Uncertainties and Managing the Risks was held in Espoo, Finland, from 17 to 21 July 2006. This conference, with a strong involvement of the user sectors, took the lead in reviewing opportunities and constraints of integrating climate risks and uncertainties into the mainstream of decision-making where sensitivity to climate variability and change is but one of many factors to consider. Indeed, climate-related risk management works best if it is:

- Driven by the needs and requirements expressed by relevant decision sectors;
- Developed within real-world decision contexts;
- Enabled through facilitating institutions and policies;
- Based on environmental, sectoral and socio-economic data;
- Based on tailored climate information;
- Supported by local capacity;
- Included in planning strategies that incorporate incentives; and
- Supported by sector-specific services from the NMHSs and related institutions.

SOCIO-ECONOMIC ASPECTS

The Earth System Science Partnership

The WCRP, in concert with three science programmes of the International Council for Science (ICSU), have formed the Earth System Science Partnership (ESSP) with the specific aim of delivering research outputs of value to users seeking information regarding likely future climate change and its interactions with

bio-geochemical and socio-economic systems. The ESSP programmes and projects mandate that the ESSP has a geographical distribution of members on its governing boards, enabling developing countries to be engaged in its activities. One of the central activities of the ESSP programmes and projects is to build capacity for understanding and acting on climate change and its impacts through improving the understanding of radiative forcing and coupling including that of greenhouse gas (GHG) concentration changes; improving the understanding of feedbacks between climate and major biogeochemical cycles, especially carbon; and improving the descriptions of human activities in climate models so that they begin to represent true earth system models.

The ESSP believes that the delivery of climate information at a regional scale underpins all efforts in understanding impacts and vulnerability and developing adaptational strategies, and highlights the integrated regional study approach. Assessment of impacts, vulnerabilities and adaptation to climate change is so complex that it is difficult to prioritize research needs. However, the ESSP identifies issues of great importance as being:

- Multiscale analysis of climate change impacts and mitigation responses including economic costing of climate change;
- Assessment of climate impacts at different greenhouse gas stabilization levels;
- Assessment of impacts from abrupt and/or irreversible climate changes;
- Study and analysis of adaptation strategies and their links to sustainable development; and
- Assessment of the second-order impacts of adaptation strategies.

ADAPTATION PLANNING AND PRACTICES

A global observation network

WMO programmes related to monitoring the atmosphere, oceans and rivers provide the crucial time-sequenced information that underpins the forecasts and warnings of hydro-meteorological hazards. The WMO global network of Regional Specialized Meteorological Centres (RSMCs) and World Meteorological Centres (WMCs) provides critical data, analysis and forecasts that enable the NMHSs to provide early warning systems and guidelines for various natural hazards such as tornadoes, winter storms, tropical cyclones, cold and heat waves, floods and droughts. WMO is also facilitating the establishment of Regional Climate Centres (RCCs), as complementary and supportive entities of the NMHSs, to handle operational regional climate services, coordination, capacity-building, data services as well as research and development. The functions and responsibilities of the RCCs are determined by the relevant NMHSs and are expected to address issues of particular regional significance by appropriate interpretations of global climate products.

Global early warning systems

WMO/NMHSs are providing early warnings of extreme weather, climate or hydrological events, which are dispatched immediately to newspapers, radio and television stations, emergency services, decision makers and other users. In response to this information, many lives are saved through timely evacuations.

A lot more could be achieved by deploying resources to further strengthen early warning systems. The challenge is to ensure that all countries, particularly LDCs and SIDS, have the systems, infrastructure, human capacity and organizational structures to develop and utilize early warning systems to reduce the risks and impacts of natural disasters.

Proactive strategies for prevention and preparedness

WMO has established its DRR Programme to develop an organization-wide coordinating framework to further enhance its contributions to natural disaster risk reduction activities at the international, regional and national level. WMO puts great emphasis on proactive strategies for prevention and preparedness on the basis of a multi-hazard framework. It works toward raising awareness, at the ministerial level, of the relation between preventive, proactive risk management strategies and economic development, and among the public and decision makers of the causes and consequences of natural hazards.

WMO is putting in place a comprehensive set of best practices, related to the utilization of scientific and technical information in disaster risk reduction. Activities such as sharing of best practices, technology transfer, training and capacity-building help the NMHSs deliver products and services in an effective and timely manner to meet national needs for hazard information. In carrying out such activities, greater emphasis is laid on partnerships with UN partner organizations, international and regional

MALAGA-WEATHER.COM

River Guadalhorce flood prevention levee, Spain, soon after completion in 2003. A double levee construction was made to avoid a repeat of the devastating 1989 floods.

MALAWI WEATHER RISK TRANSFER INSURANCE MARKET FOR LIVELIHOODS AND FOOD SECURITY

Malawi is dominated by smallholder agriculture, with farmers cultivating mostly maize, the staple food. Maize is very weather sensitive and requires a series of inputs. The economy and farm livelihoods are affected by rainfall risk (and resulting food insecurity), soil depletion, lack of credit, and limited access to weather data. Malawi suffers serious capacity constraints because it is ravaged by poverty and AIDS.

In Malawi, the role of the state in agricultural marketing (mainly tobacco but also maize) is still strong. The price system is regulated, and smallholder incentives are influenced by food aid and sales of subsidized maize by the state marketing board. The state and donors respond to recurrent drought-induced food crises by ad hoc disaster relief programmes.

At farm level, weather-based index insurance allows for more stable income streams and could thus protect peoples' livelihoods and improve their access to finance. An insurance product can be based on a crop production index constructed from weather data recorded at the airport weather station in Lilongwe (Malawi's capital). Analyses and simulations conducted for the Lilongwe area indicate that the match between potential insurance payouts and farm-yield losses would be adequate. What is needed is for demand to be aggregated at product distribution channels such as the National Smallholders Farmers' Association of Malawi (NASFAM). Rural financial institutions could finance the insurance premiums and lower interest rates to borrowers, since the financial institutions stand to benefit from reduced default risk. At provincial level, banks can package loans and weather insurance into a single product, a weather-indexed crop production loan. Farmers would enter into higher interest rate loan agreements incorporating weather insurance premiums that the bank would then pay to the insurer. In case of a severe drought impacting crop yields, the borrower would pay only a fraction of the usual loan due and would thus be less likely to default, strengthening the bank's portfolio and risk profile. In Malawi, historical simulations of such products for maize demonstrated that the years of reduced loan payments coincided with the drought years in which farmers suffered from much lower yields, mainly 1992 and 1994. Recently, the Commodity Risk Management Group (CRMG) at the World Bank partnered with Opportunity International (OI) to develop weather insurance products to secure credit for groundnut farmers. Nearly 1 000 policies were sold in October 2005 for the 2005/2006 groundnut growing season. Almost 3 000 policies were sold by OI and a rural bank for the 2006/2007 season. At the country-wide level, a specific nationwide maize production index for the entire country could form the basis of an index-based insurance policy or operate as an objective trigger to a contingent credit line for the government in the event of food emergencies that put pressure on government budgets. Applying the Lilongwe maize farmer index approach to the macro-level situation, a Malawi Maize Production Index (MMPI) can be defined as the weighted average of farmer maize indexes measured at weather stations located throughout the country, with each station's contribution weighted by the corresponding average or expected maize production in that location. Given the objective nature of the MMPI and the quality of weather data from the Malawi Meteorological Office, such a structure could be placed in the weather risk reinsurance market. Analysis shows that Malawi could need up to US$ 70 million per year to financially compensate the government in case of an extreme food emergency. Given the size of this figure, such a transaction would be treated on a stand-alone basis, with an estimated premium of approximately three times the expected loss for the reinsurer. Other country examples show that in 2006, the Government of Ethiopia successfully established contingency funding for emergency drought response in the form of weather index insurance. Thailand has a pilot for flood index insurance, Nicaragua launched a pilot in 2005, and Viet Nam is setting up a large scale weather index insurance programme.

development banks, relevant non-governmental organizations and other international, regional and national organizations. WMO, as a major partner in the International Strategy for Disaster Reduction (ISDR), is addressing the weather, climate and water issues at the core of the strategy of prevention with all the organizations within the ISDR. WMO has also cemented partnerships with other organizations within and in addition to the United Nations system, in specific sectors such as health, transportation, energy, agriculture and forestry, water resource management and tourism.

RESEARCH AND DELIVERY OF IMPROVED CLIMATE PRODUCTS AND PROJECTIONS

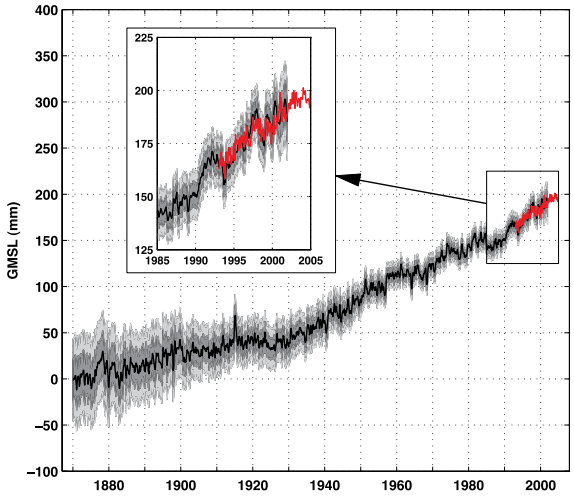
Research on the development of adaptive capacity, particularly to climatic factors, is a multidisciplinary activity and needs a close collaboration between the climate information providers and the user sectors. WMO actively pursues partnerships with the user sectors such as WHO, UNWTO and other relevant organizations.

Commission for Climatology

Within Climate Applications and Services, Open Area Programme Group (OPAG), the CCl includes expert teams dealing with application sectors such as health, energy, tourism, and urban and building climatology to provide valuable insights into the nature of climatic impacts. The Commission is in the advanced stages of developing a WMO-WHO guidance for heat-health warning systems, and a Technical Note on urban climatology and its relevance to urban design, which are of considerable relevance to the development of adaptive capacity. Such cross-cutting initiatives need to be adequately demonstrated by means of showcase projects in collaboration with the concerned user sectors and regional partners.

Climate research of direct end-user value

Climate research of direct end-user value is coordinated worldwide by the WCRP. For example, the 2006 Workshop on Understanding Sea-level Rise and Variability concluded that since 1992 the global mean sea level has been rising at a rate of 3.2 ± 0.4 mm a year, based on a combination of tide gauge and altimetry data compared with 1.7 ± 0.3 mm a year from tide gauges over the previous century (see the statement at http://wcrp.wmo.int/pdf/Sea_Level_Rise_Workshop_Summary_Statement.pdf). This is faster than the rate of 0.1 to 0.2 mm per year that characterized the previous several millennia. Sea-level rise is a result of thermal expansion of the ocean, melting of ice sheets and glaciers, changes in water storage on land, alterations in gravity and geometry of the ocean basin and coasts. Early warning of changing risks and of specific ocean inundation, especially during intense storms, is vital for national infrastructure planning.



JOHN CHURCH

Reconstructed sea levels from 1870 to 2000 indicate an increase in the rate of global mean sea-level (GMSL) rise.

TECHNOLOGIES FOR ADAPTATION

Climate data management systems

Climate change studies, policy and decision-making in particular in the development of adaptation strategies could not be undertaken without having an access to computerized climate data sets. The WMO World Climate Data and Monitoring Programme (WCDMP) provides the best platform for collaboration among the NMHSs in climate data and metadata collection, quality control and management. It ensures that climate data are readily available to and among nations. It also develops standards and guidance on best practices for the quantity, quality and timeliness of climate data required for use in modelling climate processes and, monitoring and assessing climate variability and change and their impacts. Climate data management is an area where the NMHSs contribute significantly through the development of modern Climate Data Management Systems (CDMSs) to enable prompt and adequate response to the users in their needs and requirements for climate data. WMO has planned to modernize the infrastructure in at least 40 countries during the period 2008–2011, with a particular focus on developing countries and LDCs. This will be in addition to the 50 countries in which CDMSs have been already installed during the current plan period 2004–2007.

Water resources planning and management

The impact of climate variability and change on water resources depends not only on changes in the volume, timing and quality of stream flow and recharge but also on system characteristics, changing pressures on the system, how management of the system evolves, and what adaptations to climate change are implemented. Within the framework of the WCP-Water, WMO is promoting the implementation of several demonstration projects on the impact of climate variability and change on water resources in specific regions, by providing seed funding for the creation of multidisciplinary teams that would demonstrate, practically, the application of methodologies to regionalize Global Climate Models and study the impacts of climate variability and change specifically on the scale of regional and large basins water resources. Furthermore, efforts are under way to enhance the utility of Regional Climate Outlook Forums (RCOFs) in water resources management. The National Meteorological Services are encouraged to upgrade their climate prediction capability in such a form that it can be utilized by National Hydrological Services for improved water resources management.

ECONOMIC DIVERSIFICATION

WMO Member countries are facing the need to increase food production and water resources storage capacity to satisfy the aspirations of their ever-growing populations. While weather retains its inherent variability and other environmental hazards are spreading and intensifying, people from various sectors are becoming aware of the potential economic contribution of meteorology to the efficient sustainable development of their countries.

Agricultural sector

Agriculture is typically the most important sector in the economy of many developing countries, especially in LDCs and SIDS. Farmers practise subsistence agriculture and the productivity of the agricultural systems depend heavily on prevailing rainfall and temperature patterns. Climate variability, climate change and seasonal shifts in meteorological parameters strongly impact agricultural productivity, affecting the food security of many vulnerable developing countries. The WMO Commission for Agricultural Meteorology (CAgM) has been actively addressing the key issues of adaptation to climate change in the agriculture, forestry and fisheries sectors. Most NMHSs

JOSEPH LAURE (IRD)

The productivity of agricultural systems depends heavily on prevailing rainfall and temperature patterns.

are providing climate inputs to decision-making in agricultural communities in order to alleviate food security problems. Such services are vital to the special needs of developing countries where agriculture is a critical socio-economic sector. Weather and climate products, including advance information from nowcasting to seasonal forecasts, are becoming more and more useful in crop management and yield optimization. The NMHSs continue to place emphasis on the provision of clear and precise, user-targeted information on weather and climate and on raising the awareness of farmers and other user groups to the benefits of the use of climate information in decision-making. Decadal information is also an integral element for agricultural planning, which is facilitated by the climate data archives of NMHSs.

The Agricultural Meteorology Programme (AGMP) of WMO assists the NMHSs in the provision of meteorological and related services to the agricultural community to help develop sustainable and economically viable agricultural systems and improve production and quality, reduce losses and risks, decreased costs, increase efficiency in the use of water, labour and energy, conserve natural resources and decrease pollution by agricultural chemicals and other agents that contribute to the degradation of the environment.

Energy sector

Weather and climate impacts on energy supply, demand and price are multi-faceted. Climate and weather data and products are being increasingly used by energy-related agencies in planning, design and operations. Tailored climate information can help enhanced exploitation of sustainable natural sources such as wind and solar energy, biomass and hydraulic energy, which are also environment-friendly. Weather extremes generally are much more frequent than seasonal extremes. Therefore, it is important to devise coping strategies to incorporate climate information on weather extremes in planning the transmission and distribution systems. Additionally, forecasting of the extremes can help in managing demand and price fluctuations, and also to minimize disruptions. Development of new financial instruments for hedging weather risk, as well as advances in forecasting (so-called climate derivative products), are expected to minimize economic losses to both energy producers and consumers. It is most important to generate and sustain an effective partnership between the energy sector and the meteorological community. In the context of sustainable development, climate information is of crucial importance in the expansion of hydropower, wind and solar energy generation capacities. There is a clear need to improve the forecasting skills (including communication of uncertainty) of extreme weather events which have significant operational and societal impacts, particularly with a regional/local focus. Innovative strategies like wind energy prediction based on climate inputs can be of great value in the grid-control of electricity.

Tourism sector

Tourism is currently one of the largest and fastest growing industries, and for a majority of nations it is one of the top sources of export or foreign exchange revenue. Climate change will not only impact on tourism directly by changes in temperature, extreme weather events and other climatic factors, but also indirectly as it will transform the natural environment that attracts tourists. WMO, in partnership with the NMHSs and the international meteorological community, is making an important contribution by providing relevant information to the tourism sector in order to reduce the adverse consequences of weather and climate extremes for tourism operators. At the same time WMO is joining with the World Tourism Organization (UNWTO) and the tourism sector to maximize the benefits of favourable weather conditions and changes in climate. Both organizations are raising awareness levels about the sensitivity of tourism to weather and climate variability and change, including extremes. They are also providing guidance on how key actors in the tourism sector might best respond to reduce risks and maximize benefits.

Strengthening national institutional frameworks

In many developing countries, climate is considered a lower priority than other pressing needs and as a result fewer resources are allocated to climate activities at the national level. The sixth UNFCCC compilation and synthesis report highlighted the gaps in institutional and human capacity. In some developing countries, the NMHSs are taking the lead in the establishment of national climate change committees and monitoring of UNFCCC activities, including advising policy- and decision makers on matters relating to adaptation to impacts of future adverse climate conditions. Their detailed scientific knowledge, under the guidance of WMO programmes on climate issues, enhances their role, with the collaboration of other stakeholders, in preparing national greenhouse gas inventories and addressing the impacts of climate change on vulnerable sectors of the economy such as agriculture, water resources, energy and coastal zones.

CLIMATE IMPLICATIONS FOR THE US TRANSPORTATION SYSTEM

Transportation planning operates on several different time scales: road planners typically consider 25 years and railroad planners 50 years, while bridges and underpasses are generally designed with 100 years in mind. In all cases, planning should take likely changes into consideration. The US Department for Transportation (DOT) supports research that examines the potential impacts of climate variability and change on transportation infrastructure and services and fosters strategies that avoid, mitigate, or adapt to the potential impacts of climate change on the transportation system.

The US National Research Council and the National Academy of Science recently commissioned a study on climate variability and change with implications for transportation. The study was conducted in 2006 by NOAA scientists Drs Thomas Peterson and Andrew Horvitz, and Dr Michael Wehner from the Lawrence Berkeley National Laboratory.

The US transportation system was built for the typical weather and climate experienced locally, but climate model projections see changes in weather and climate extremes ahead of us which may have considerable impact on transportation. As the global climate warms, cold temperature extremes are projected to continue to decrease. Milder winter conditions would likely improve the safety record for rail, air and ships. Warm extremes, on the other hand, are projected to increase. This change would likely increase the number of roadbed and railroad track bucklings and adversely impact maintenance work. As the cold season decreases and the warm season increases, northern transportation dependent upon ice roads and permanently frozen soil would be adversely affected while the projected commercial opening of the Northwest Passage would result in clear benefits to marine transportation. Changes in precipitation might cause local flooding or drying in inland waterways.

Another project commissioned by the National Academy of Science and still under way draws heavily upon the above study and in addition provides federal, state and local transportation officials in the United States with an overview of possible climate-related consequences for transportation and adaptation strategies to meet climate hazards. US transportation options for adapting to impacts will be analyzed, including possible needs to alter assumptions about infrastructure design and operations and the institutions' capability to plan and act on mitigation and adaptation strategies at the state and regional levels (see National Academies' website http://www8.nationalacademies.org/cp/projectview.aspx?key=186 for details).

USCG

FUTURE DEVELOPMENT AND STRATEGIES

The cooperative and collaborative efforts of WMO have developed institutions; trained thousands of meteorologists, climatologists, hydrologists, and atmospheric chemists; contributed to the establishment of the IPCC and UN Framework Conventions; produced the World Climate Programme, a Global Observing System of earth-based and satellite-based observation; implemented a Global Telecommunications System to share critical information quickly and efficiently; and developed a Global Data Processing and Forecasting System to monitor, assess and predict weather, climate, water and other environmental conditions that affect society. These combined capabilities have allowed nations of the world to exploit scientific advances with a view to improving severe weather warnings, accuracy of forecasts, and climate and hydrological assessments. WMO is focused on taking the next essential steps to address society's critical environmental and development needs.

The social and economic impacts of weather, climate, water and environmental conditions are great – and they are growing. At the same time, there are new opportunities for the application of weather, climate and water information to help governments improve the safety and well-being of their peoples, reduce poverty, increase prosperity and improve public health and security. There are also new opportunities to use this information to take decisions that protect the environment for future generations. In fact, scientific and technological advances are providing tools and opportunities to enable more effective actions for adaptation to climate variability and change.

The IPCC Fourth Assessment Report (AR4) provides an important contribution to the further development of activities under the Nairobi Work Programme. It provides new information relevant to all areas covered by the programme of work, in particular observations of climate and its impacts, climate modelling and projections, possible future impacts for different scenarios, planning and technologies for adaptation and interrelationship between adaptation and mitigation. Scientific progress since the Third Assessment Report is based upon large amounts of new and more expanded range of observations, longer data records, more sophisticated analyses of data, improvements in understanding of processes and their simulation models, and more extensive exploration of uncertainty ranges. Today, we have high confidence that recent regional and global changes in temperature have had discernible impacts on many physical and biological systems.

Climate change is projected to impinge on sustainable development of most developing countries, as it compounds the pressures on natural resources and the environment associated with rapid urbanisation, industrialisation, and economic development pathway. Sustainable development can reduce vulnerability to climate change, and climate change could impede nations' abilities to achieve sustainable development pathways. WMO is taking initiatives to increase the capacity of NMHSs in developing and Least Developed Countries (LDCs) to align their services with the particular needs of development in their countries. The expectation is that countries will be able to sustain their own institutional capacity development, enabling them to increase their capabilities to address Millennium Development Goals, Hyogo Framework for Action, national development priorities, and community information requirements.

WMO, the NMHSs and their partners recognize the key role that UN agencies have played in raising public awareness of climate matters, in particular concerns about human induced climate change. They also recognize the importance of governments and United Nation agencies in the implementation of programmes for adaptation to climate variability and change as well as mitigation. WMO and the NMHSs of its Member States and their partners place high priority on climate and societal issues such as sustainable development, energy use, trade

and security and believe that future climate change policies, especially adaptation, will require integration of climate change activities toward sustainable development. Through a number of new sets of strategic scientific frameworks, WMO, the NMHSs of its Members and their partners will continue to work within the United Nations system to ensure that climate variability and change related decision-making continues to be based on sound scientific knowledge for the benefit of society.

The WMO Strategic Plan provides a blueprint for WMO's 188 Members to meet the changing needs of their communities for weather, climate, water and related environmental information. Successful implementation of the plan will contribute to the desired societal outcomes such as; improved protection of life, livelihoods and property; improved health and well-being of citizens; increased safety on land, at sea and in the air; sustained economic growth in both developed and developing countries; and protection of other natural resources and improved environmental quality.

WMO will continue to assist governments and the people all over the world to understand better and assess both the effects of day-to-day weather, climate and water conditions and the impacts of extreme events on their societies, and to exploit weather, climate and water information more effectively with a view to maximizing its societal benefits. In this sense the vulnerability of communities everywhere will be reduced by introducing authoritative and scientifically sound information into sustainable development policies and into the global partnership strategies for development, especially for Least Developed Countries.

ACRONYMS

AgMP	Agricultural Meteorology Programme
AREP	Atmospheric Research and Environment Programme
AR4	IPCC Fourth Assessment Report
CAgM	Commission for Agricultural Meteorology
CCl	Commission for Climatology
CDMS	Climate Data Management System
CLIPS	Climate Information and Prediction Services [of WCASP]
CLIVAR	Climate Variability and Predictability [of WCRP]
CMACC	Coupled Climate Models and Anthropogenic Climate Change
COP	Conference of the Parties [of UNFCCC]
DDC	Data Distribution Centre
DRR	Disaster Risk Reduction Programme
DRM	Disaster Risk Management
ESSP	Earth System Science Partnership
GAW	Global Atmosphere Watch Programme
GCOS	Global Climate Observing System
GECAFS	Global Environmental Change and Food Security
GHGs	Greenhouse gases
GOS	Global Observing System
HFA	Hyogo Framework for Action 2005–2015: Building the Resilience of Nations and Communities to Disasters
ICPAC	IGAD Climate Predictions and Applications Centre
ICSU	International Council for Science
IEWP	International Early Warning Programme
IGAD	Intergovernmental Authority on Development
IOC	Intergovernmental Oceanographic Commission [of UNESCO]
IPCC	Intergovernmental Panel on Climate Change
IRI	International Research Institute for Climate and Society
ISDR	International Strategy for Disaster Reduction
LDC	Least Developed Country
MDG	Millennium Development Goal
NMHSs	National Meteorological and Hydrological Services
OPAG	Open Programme Area Group [of WMO technical commissions]
OCHA	United Nations Office for the Coordination of Humanitarian Affairs
RAP	Regional Action Plan
RCC	Regional Climate Centre
RCOF	Regional Climate Outlook Forum
RSMC	Regional Specialized Meteorological Centre [of WMO]
SBSTA	Subsidiary Body for Science and Technological Advice [of UNFCCC]
SIDS	Small Island Developing States

TAR	IPCC Third Assessment Report
THORPEX	The Observing System Research and Predictability Experiment
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
UNWTO	World Tourism Organization
WCASP	World Climate Applications and Services Programme
WCDMP	World Climate Data Management Programme
WCP	World Climate Programme
WCRP	World Climate Research Programme
WMO	World Meteorological Organization
WWRP	World Weather Research Programme
WWW	World Weather Watch

The World Meteorological Organization, through its programmes including the WMO/ICSU/UNESCO-IOC joint World Climate Research Programme, and the National Meteorological and Hydrological Services of its Members have a major role to contribute in the implementation of the Nairobi Work Programme. In order for this to succeed, the WMO needs to be involved in the activities of the United Nations Framework Convention on Climate Change, especially its Subsidiary Body for Scientific and Technological Advice (SBSTA). WMO and NMHSs of its Members can contribute through active participation in discussions at the SBSTA sessions and through national level activities aimed at implementing the Nairobi work programme. Resource mobilization for regional capacity-building and implementation of demonstration projects, particularly for developing countries and Least Developed Countries, as well as mainstreaming climate knowledge into national development planning are major challenges that need to be addressed.

The World Meteorological Organization commits itself to facilitate the dissemination and use of knowledge on applications of climate science for adaptation purposes and will make every effort to enhance partnership among stakeholders in this activity. WMO priorities in the face of such challenges are clear. They are to strengthen scientific and technical programmes, to address crosscutting issues such as adaptation, to pursue strategic alliances and partnership in all sectors and to redouble efforts to upgrade the capacity of networks and mobilize resources which are needed to operate efficiently.

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