



**WORLD METEOROLOGICAL ORGANIZATION  
(WMO)**

**World Climate Programme (WCP)  
Climate Coordination Activities (CCA)**

**CONCEPT PAPER**

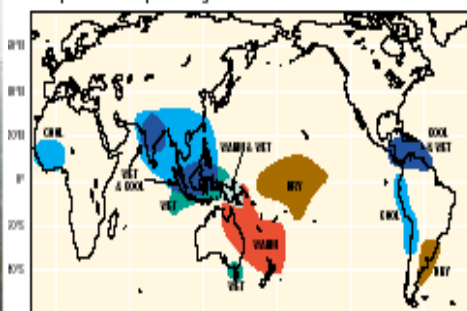
*ON THE ROLE OF  
WMO AND NMHSs IN THE IMPLEMENTATION  
OF THE NAIROBI WORK PROGRAMME*

**April 2007**

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Cold episode relationships Area–August



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**Concept Paper**  
**on the Role of WMO and NMHSs in the Implementation of the Nairobi Work Programme**

**Foreword**

This Concept Paper is the outcome of a brain storming multi-sectoral meeting which the World Climate Programme of WMO organized in Geneva, from 17 to 18 October 2006, to explore potential areas that WMO and NMHSs could play in adaptation to climate variability and change as a response to UNFCCC requirements.

The World Meteorological Organization (WMO) is the UN system's authoritative voice on the state and behavior of the Earth's atmosphere including its interaction with the oceans, the climate and water resources. It provides world leadership in expertise and international cooperation in weather, climate, hydrology and water resources, and related environmental issues, and thereby contributes to the safety and well being of people throughout the world and to the economic benefit of all nations.

WMO's strategies have been 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 global sustainable development, 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 of climate change, it is widely acknowledged that Climate change is now inevitable, and adaptation, through a range of technical, regulatory, and behavioral changes, is one of the core pathways available to society for dealing with climate change. WMO, in collaboration with its Members comprising of a global network of National Meteorological and Hydrological Services (NMHSs), plays an infrastructural role in weather and climate observation, monitoring, scientific understanding of climate processes, and 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.

WMO, through global partnership in capacity building, training, education and public awareness at all levels, contributes to mobilizing support for international action to address climate change. It provides active support to the achievement of the UN 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 Members states, Programmes, Technical Commissions, partner institutions and organizations. Regional Climate Outlook Forums initiated and supported by the WMO in different parts of the world, for example, provide an effective mechanism for capacity building at the regional level, particularly in developing countries.

It is the ambition of the WMO and the Millennium Development Goals to halve the loss of life associated with natural disasters of meteorological, hydrological and climatic origin over the next 15 years. The WMO has established a Natural Disaster Prevention and Mitigation Programme to ensure optimization of WMO's 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.

Different climatic regimes lend themselves to different trends in hydrometeorological extremes, some of which may pose considerable risks to life, infrastructure, socio-economic development and the environment. On the other hand, windows of opportunity afforded by favourable climatic conditions need to be seized in advance to enhance socio-economic development. Positioning climate information and services as effective tools to leverage opportunities as well as risk management has therefore a major thrust in WMO programmes, aimed at contributing to the well being of its Members. WMO in collaboration with its Members are the original climate networkers constantly striving to keep pace with the scientific and technological advancements and are a natural partner in dealing with climate related issues. It has a clear future goal, of reaching the benefits of rapidly advancing knowledge on climate to each and every section of the society.

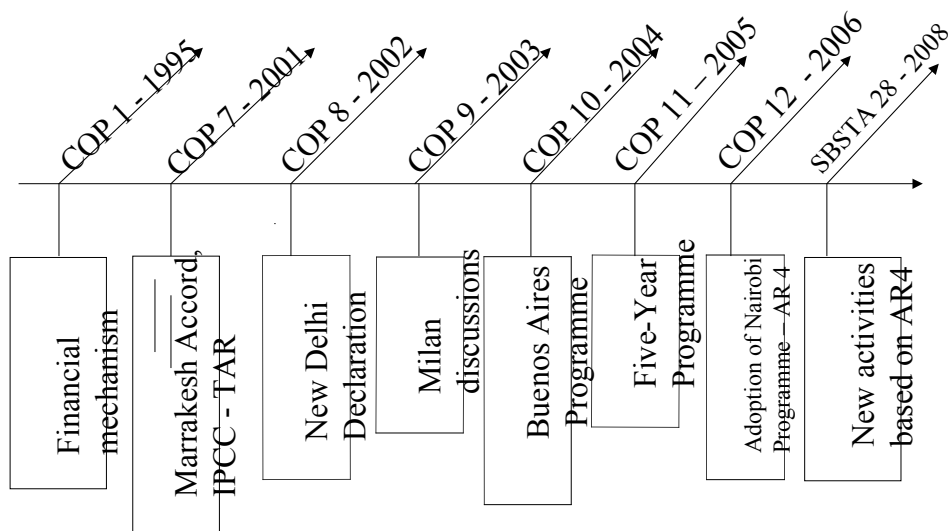
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**1. Introduction**

1.1 Climate change, one of the most serious problems facing global sustainable development, is of great concern to humanity and is being addressed by several global and regional organizations and institutions. Adaptation is one of the core pathways available to society for dealing with climate change. The IPCC Third Assessment Report (TAR) 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 and reactive adaptation, private and public adaptation, and 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.

1.2 Adaptation to climate change and its adverse effects is of high priority for all countries. Developing countries, especially the Least Developed Countries (LDCs) and Small Island Developing States (SIDS) are highly vulnerable to impacts of climate change and climate variability. Their needs for adaptation, as is the case for all countries, should be coordinated with social and economic development in an integrated manner with a view to avoiding adverse impacts. 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.

**Timeline Of Development On Adaptation In The UNFCCC Process**



### **Nairobi Work Programme**

Following Decision 2/COP11, COP-12 agreed to invite relevant organizations and other stakeholders to implement the activities of the programme of work in 9 main areas.

- *Methods and tools*
- *Data and observations*
- *Climate modeling, scenarios and downscaling*
- *Climate related risks and extreme events*
- *Socio-economic information*
- *Adaptation planning and practices*
- *Research*
- *Technologies for adaptation*
- *Economic diversification*

### **Expected Outcome 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 Conference of the Parties (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/CP.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;*
- (e) *Enhanced integration of actions to adapt to climate change with sustainable development.*

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**2. General Modalities - The role of WMO and NMHSs**

2.1 WMO, the specialized UN Agency on weather, climate and water, in collaboration with its Members comprising a global network of National Meteorological Hydrological Services (NMHSs), have the potential to play an important role in the implementation of the Nairobi Work Programme. It has a vast reservoir of expertise, knowledge, data and tools among its Members, Programmes, Technical Commissions, Expert Teams and partner organizations, capable of bringing strong scientific and technical capability along with local, regional and global knowledge that offers authoritative and targeted analyses for consideration by Parties and the SBSTA and can contribute actively to the Nairobi Work Programme, using a range of modalities. Contributions could include providing expert advice, guidelines, technical inputs to workshops and seminars and also taking on operational responsibilities for the implementation of some components of specific activities.

2.2 The WMO Convention reaffirms the vital importance of the mission of NMHSs in observing and understanding weather, climate and water resources as well as providing related services to support national needs in areas such as:

- Protection of life and property,
- Safeguarding the environment,
- Contributing to national security and sustainable development and
- Promotion of endogenous capacity building.

2.3 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 the concerned locations. They form an integral part of the Global Observing System (GOS), which consists of a global network of observations over land, sea and in the atmosphere. Archived data by NMHS 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. NMHSs are national services that have been assigned specific duties for the collection, processing archiving of systematic climate data, including providing 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.

2.4 The NMHS and WMO have a long lasting commitment to satisfy the needs of their users concerning weather and climate information. They maintain permanent relation with sectors such as marine, aviation, agriculture, health and water. They are committed to understand the needs of all economic sectors, regarding their interactions with weather, climate and water, and to maintain a regular dialogue with them.

2.5 WMO, with the support of NMHSs, could contribute to the Nairobi Work Programme in the following two thematic areas:

- (a) Impacts and vulnerability:
- (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;

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- (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) Adaptation planning, measures and actions:
- (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.

2.6 Both WMO and NMHSs have been involved with the activities of the UNFCCC since its very inception. Their participation in the Nairobi Work Programme may be enhanced through their involvement at national and international levels.

2.7 WMO assists Member States, in particular the developing countries including LDCs and SIDS, 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.

2.8 The Intergovernmental Panel on Climate Change (IPCC) has been significantly contributing to the advancement of science climate change; vulnerability, impacts and adaptation assessment; technology for mitigation of greenhouse gases. The IPCC was created under the auspices of the WMO after the Second World Climate Conference held in 1988. So far, the IPCC has completed three assessments; one special regional report and many other reports. Over the years, IPCC's focus has advanced from simple assessment to the advancement of vulnerability and adaptation science and sustainable development. The IPCC's assessments are contributing to the policy changes towards climate change and adaptation. In the Data Distribution Centre (DDC) portal of the IPCC, climate scenarios are available for vulnerability and adaptation assessment. The TGCI provides with technical support to scenario users through advice and development of guidelines. Many NMHSs are the focal points of the IPCC and scientists who contribute for the IPCC assessments are being nominated through the NMHSs. In this mechanism, knowledge and technology transfer are being occurred. This also facilitates capacity building of the NMHSs.



### **HIGHLIGHTS OF WMO CLIMATE ACTIVITIES**

*Spearheaded world efforts to monitor the environment and address potential hazards such as global warming, climate change and sea-level rise. It co-established the Intergovernmental Panel on Climate Change (IPCC) and played its part in paving the way for the adoption of the United Nations Framework Convention on Climate Change (UNFCCC).*

*WCRP-CLIVAR 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.*

*In addition, WCRP's 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, 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 – 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 like floods and droughts. This network also supports various technical requirements of the United Nations Convention to Combat Desertification (UNCCD).*

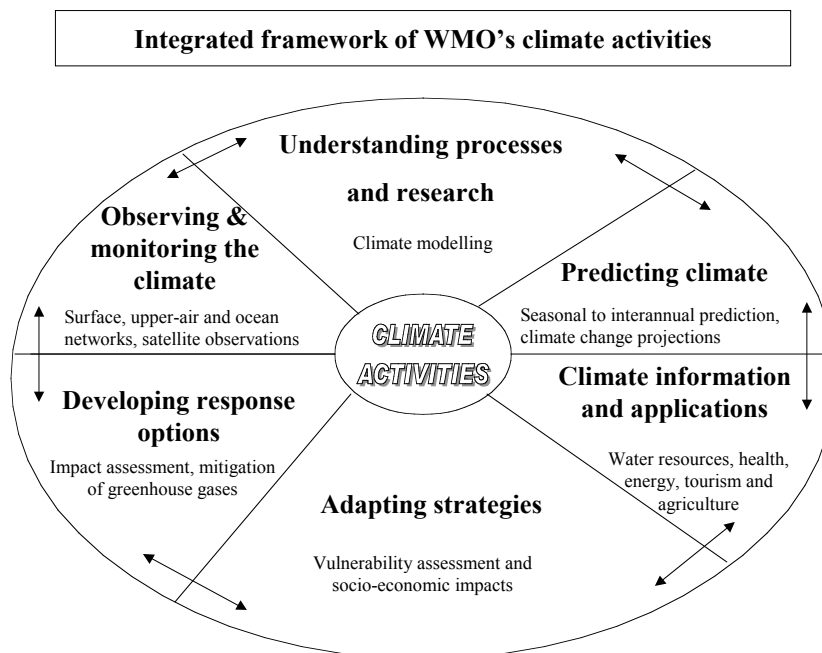
*Issues annual global statements on the state of the Earth's Climate with particular attention to regional aspects, based on the regional information provided by the NMHSs and a worldwide network of experts.*

*Actively promoted a consensus approach and regional networking for development of regional climate information and products, in particular through its CLIPS project (Climate Information and Prediction Services): e.g. Regional Climate Outlook Forums (RCOF); El Niño and La Niña Updates; Regional showcase projects, etc.*

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

*WMO provides capacity building process through Climate information and Prediction Services to help countries effectively incorporate climate issues into national sustainable development agendas.*

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*As a response to the requirements stated in Agenda 21 and the UNFCCC, a number of organizations carrying out significant climate-related activities jointly developed the Climate Agenda. Among them WMO implements a comprehensive integrating framework of all aspects of international climate-related programmes, including data collection and application, climate system research which helps for studies of socio-economic impacts of climate variability and change and adapting strategies*

2.9 The Nairobi Work Programme comprises two thematic areas, namely 'Impacts and vulnerability' and 'Adaptation planning, measures and actions', each with several sub-theme activities. Common threads in these activities are 'Methodologies, data and modeling' and 'Integration into sustainable development'.

2.10 The modalities for implementation of the Nairobi Work Programme, depending on the nature of the specific activities and availability of resources may include, among others, reports and technical papers, assessment prepared by the Secretariat Convention expert groups or experts from other organizations.

2.11 WMO enjoys competency, experience and resources, among other things, to contribute to the Nairobi Work Programme at international and regional levels and closely fits into such an expected role in the present context, to the subject areas addressed by the specific activities undertaken in the context of the Nairobi Work Programme.

**3. WMO Programmes**

**WMO's activities are carried out under ten major programmes**

WORLD WEATHER WATCH PROGRAMME			
WMO SPACE PROGRAMME			
NATURAL DISASTER PREVENTION AND MITIGATION PROGRAMME			
WORLD CLIMATE PROGRAMME	ATMOSPHERIC RESEARCH AND ENVIRONMENT PROGRAMME	APPLICATIONS OF METEOROLOGY PROGRAMME	HYDROLOGY AND WATER RESOURCES PROGRAMME
EDUCATION AND TRAINING PROGRAMME			
TECHNICAL COOPERATION PROGRAMME			
REGIONAL PROGRAMME			

*WMO's ten major scientific and technical programmes continue to provide assistance and guidance to NMHSs in their contribution to curb the impacts of adverse weather situations on sustainable socio-economic development and help in the implementation of the Millennium Development Goals (MDGs) - that is improving the well being 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 the implementation in a coordinated way.

**4. Contribution of WMO Programmes to the nine areas of activities in the Nairobi Work Programme**

In the following paragraphs (4.1 to 4.9), some notable activities of WMO relevant to nine areas of activities for the implementation of the Nairobi Work Programme are highlighted, with indications of the potential contributions of the WMO and the NMHSs. The nine areas of activities are as follows:

- ✓ Methods and Tools,
- ✓ Climate Data and Observations,
- ✓ Climate Modeling, Scenarios and Downscaling,
- ✓ Climate Related Risks And Extreme Events,
- ✓ Socio-economic information,
- ✓ Adaptation Planning And Practices,
- ✓ Research And Delivery Of Improved Climate Products And Projections,
- ✓ Technologies for Adaptation,
- ✓ Economic Diversification.

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#### **4.1 Methods and Tools**

##### **4.1.1 Climate Watches**

Weather extreme events such as hurricanes, thunderstorms, tornadoes, etc. require weather watches for which most NMHSs issue early warnings and undertake special monitoring. In a similar manner, 'climate watches' deal with climatic extremes like heavy monsoons, flooding, cold waves, heat waves, droughts, etc., which require long-term monitoring with historical observations and its 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, therefore enable continuous and timely climate related risk assessment and management to avoid damages to life and property. The necessary mechanisms have already been put in place in some parts of the world to issue climate watches (e.g., the North American Drought Monitor, the ICPAC and Drought Monitoring Harare Centers in Africa). WMO works with NMHSs and many institutions in the world to issue regional climate watch bulletins. Through its programs World Climate Data Management Programme (WCDMP) and Disaster Prevention and Mitigation (DPM) in collaboration with the Commission for Climatology (CCI) and NMHSs, WMO has planned for the coming four years period 2008-2011 to establish and implement climate watch systems at national levels. The main focus for these efforts is to improve preparedness and reduce socio-economic vulnerability to climate hazards in developing and least developed countries. Through DPM Program, other agencies are expected to be part of the implementation process of climate watches including resource mobilization, partnership for an integrated early warning system as well as the outreach of the decision makers at regional and national levels.

##### **4.1.2 Climate Information and Prediction Services Project (CLIPS)**

The 12th World Meteorological Congress (1995) considered that the provision of climate information and predictions would improve economic and social decision making, and that this would support sustainable development, and established a Climate Information and Prediction Services (CLIPS) project within the World Climate Applications and Services Programme (WCASP). WCASP and CLIPS build on the rapidly developing atmospheric and oceanographic research as well as the wealth of data, experience and expertise within the NMHSs and related entities and provide a framework to deliver operational user-targeted climate services. This programme has successfully demonstrated the immense potential of the concept in several regions across the globe, and a global network of CLIPS Focal Points has been established to ensure national and regional coordination of climate products and services. Capacity building and training are integral components of WCASP/CLIPS. 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, which are key components of CLIPS, need substantial resource mobilization to cater to the growing needs of climate information providers as well as user sectors, particularly in the Developing Countries and the Least Developed Countries.

##### **4.1.3 Regional Climate Outlook Forums (RCOFs)**

Specific institutional frameworks can be established, with appropriate stakeholders taking the lead, to address relevant climate change issues at the local and sector levels. In this context, the Regional Climate Outlook Forums (RCOFs), a concept conceived and supported by WMO as part of Climate and Prediction Services (CLIPS) activities, need special mention. RCOFs constitute an important vehicle in developing countries for providing advanced information on the future climate information for the next season and beyond, and for developing a consensus product from amongst the multiple available individual predictions. 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 a great potential for the regional climate activities that currently take place under RCOFs and through CLIPS training to expand, through the actions of

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the WMO regional associations and the NMHSs (facilitated by the Secretariat) to expand the use of currently available tools (e.g., PRECIS, MAGIC, etc.) to more countries and to include information on climate change scenarios assembled by World Climate Research Programme (WCRP) such as climate projections created for the IPCC Fourth Assessment Report (AR4). This would enable NMHSs to contribute to their national communications to the UNFCCC and to develop or enhance their dialogue with users of climate information on climate risks and vulnerability, and would also support improved regional coordination on climate matters, standardization of tools and increased evaluation (feedback) on model outputs. This evolution from the current state (ability in some sub-regions to undertake RCOFs and develop seasonal predictions) would require technology transfer (to enhance computational capability) including hardware, software, models and data storage devices; stable Internet; ability to download data through the Internet; trained climate experts; research.

**4.1.4 The Observing system Research and Predictability Experiment (THORPEX): A Global Atmospheric Research Programme**

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 1-day to 2-week high impact weather forecasts for the benefit of society, the economy and the environment. 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; societal, economic and environmental benefits of improved forecasts. The programme establishes an organizational framework that addresses weather research and forecast problems whose solutions will be accelerated through international collaboration among academic institutions, operational forecast centres and users of forecast products. THORPEX contributes to the development of a future global interactive multi-model ensemble forecast system, which would generate numerical probabilistic products, available to all WMO Members including developing countries. The purpose is to provide accurate, timely, specific and definite weather warnings in a form 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.

**4.1.5 WMO Natural Disaster Prevention and Mitigation (DPM) Programme**

4.1.5.1 From 1980 to 2005, natural disasters worldwide have taken the lives of nearly two million people and produced economic losses above one trillion (or one thousand billion) US dollars. During this period, weather-, water- and climate-related hazards and conditions accounted for 89% of total number of disasters, 72% of loss of life and 75% of total economic loss. However, over the last few decades, significant developments with monitoring, detecting, analyzing, forecasting and warning of weather-, water- and climate-related hazards have led to significant opportunities for reducing impacts of related disasters. For example, over the last 25 years, there has been nearly a 4-fold increase in the number of disasters and a 5-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 development of specific end-to-end early warning systems, such as those for tropical cyclones.

4.1.5.2 The international movement in disaster risk management is supported by the Hyogo Framework of Action 2005-2015, 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:

- Governance: organizational, legal and policy frameworks;
- Risk identification, assessment, monitoring and early warning;

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- Knowledge management and education;
- Reducing underlying risk factors; and
- Preparedness for effective response and recovery.

4.1.5.3 Implementation of HFA is a critical contribution to development of capacities for climate adaptation and climate-related risk management. The overall framework of DRM seeks to reduce the likelihood of undesired, negative outcomes such as disasters in the course of pursuing positive goals. This involves three types of actions and activities including, risk identification, risk reduction and risk transfer.

- Risk identification involves the identification of risk levels and the risk factors that cause losses. Risk identification creates the evidence base needed to support risk reduction and risk transfer decision and activities.
- Risk reduction involves measures to prevent losses. Examples of such measures include hazard-resistant infrastructure development, land use planning and zoning, early warning systems based on sound science but targeted at mobilizing action at the local level. Other measures include educational and preparedness programmes for a wide variety of actors such as decision makers, operational emergency planning and response staff and the development of contingency plans.
- Risk transfer involves the use of financial mechanisms to share risks and transfer them among different actors (e.g., at-risk populations, government, private sector). Examples of such tools include weather derivatives, catastrophe bonds and different types of insurance.

4.1.5.4 WMO, through its Fourteenth Congress (Cg-XIV, May 2003) has established a new cross-cutting Natural Disaster Prevention and Mitigation (DPM) Programme with the vision to strengthen further international and national collaboration in disaster risk management This Programme addresses capacity development of NMHSs and their partnerships in supporting disaster risk management (DRM) decisions at the national level in the complete cycle of disaster risk management including prevention and mitigation as well as emergency preparedness, response, recovery and reconstruction. With the threat of the climate change and its potential impacts on the trends and severity of natural hazards, WMO is deeply committed to ensure that the latest knowledge and capacities in climate are translated into operational products that would enable our Members to enhance their capacities in climate-related risk management.

4.1.5.5 WMO Disaster Prevention and Mitigation Programme addresses seven priority areas, to provide systematic support to strengthen Members' NMHSs capacities for strengthened disaster risk management. These include:

- (a) Mainstreaming technical capacities such as hydro-meteorological risk assessment and early warning systems in the national disaster risk management plans, legislations and development planning. (Adaptation Planning);
- (b) Strengthening capacities for meteorological, hydrological and climate-related hazard monitoring, databases, and methodologies for hazard analysis in support of risk identification, risk reduction and risk transfer activities. (Data and Observations, Methods and Tools);
- (c) Strengthening capacities for operational meteorological, hydrological and climate-related hazard early detection and warnings built upon strong governance, organizational and operational processes (Adaptation Planning and methods and Tools);
- (d) Strengthening capacities for provision of meteorological services in support of pre- and post-disaster emergency response and relief operations (Methods and Tools);
- (e) Facilitation of partnerships among NMHSs and other key national agencies for a more coordinated approach to disaster risk management (Adaptation Planning);

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- (f) Strengthening educational and training programmes of NMHSs and their key stakeholders in DRM such as authorities, emergency response operators and media (Adaptation Planning and Socio-economic Information);
- (g) Development of public outreach programmes and materials (Environmental and Socio-economic Information).

#### **4.2 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 the developing and least developed countries. NMHSs, through the WMO, may 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. NMHSs can contribute significantly through the development and use of Modern Climate Data Management Systems (CDMSs) and through '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. WMO requests the parties to the convention to establish a trust fund to fill gaps in the global climate monitoring network and to support capacity building of ground-based atmospheric observing systems recognized by GCOS. These included networks measuring the classical Essential Climate Variables as well as the chemical variables greenhouse gases and aerosols.

##### **4.2.1 Data Rescue**

For a comprehensive climate analysis, apart from having good observational networks, it is extremely important to preserve the collected climate records properly in 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. As matter of fact, 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 detection of observed climate change and variability with long period records of quality climate observations.

##### **4.2.2 Climate Monitoring**

Through the CCI and in cooperation with its Members, WMO has been issuing annual statements on the status of the global climate since the last 13 years. These statements document the extreme weather and climate events in the regional context, and provide a historical perspective on the variability and trends of surface temperatures that have occurred since the nineteenth century. WMO is also working with the NMHSs to develop climate change detection tools and software to compute indices that reflect the best estimate of climate trends within the countries. Through capacity building activities based on up-to-date knowledge and software, WMO assists Developing Countries and Least Developed Countries to follow quantitative and objective approaches for their contributions to the IPCC process and reporting to the UNFCCC.

##### **4.2.3 World Weather Watch**

The network of WMO World Weather Watch, 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

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communication allow global population to be better prepared and adapt themselves to prevailing climate especially during the occurrence of extreme weather conditions. Resources are to be made available to maintain an up to date and efficient World Weather Watch System. GCOS has already established Regional Action Plans with the active participation of NMHSs, to address this gap.

#### **4.2.4 Global Climate Observing System (GCOS)**

The role of the GCOS in ensuring the availability of adequate climate observations has been and continues to be an important one. As the Parties to the UNFCCC increasingly embrace the need to develop effective adaptation policies, the need for high-quality, long-term climate observations at all scales for adaptation needs has become obvious. Healthy 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 will be required for adaptation to climate variability and change and for sustainable development generally. Over the last five years GCOS has held workshops and follow-up meetings in ten developing regions as part of its Regional Workshop Programme. Through this Programme GCOS 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 COP, facilitating implementation of these Plans by the regions is now a high priority for GCOS. The Plans contain projects that, if implemented, would eliminate gaps and deficiencies in atmospheric, oceanic, and terrestrial climate observing networks and improve related data management and telecommunications functions.

#### **4.2.5 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 World Climate Research Programme's (WCRP's) Group on Coupled Climate Models and Anthropogenic Climate Change (ACC). This incredibly rich resource has already been exploited by many countries, with over 200 papers published by mid-2006. However, to date, much of the benefit has not been realized in developed 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. The WMO can facilitate this by capacity building initiatives for climate scenario construction and supporting the exchange, archiving and user-friendly access to all climate data including the state-of-the-art climate scenarios developed during the IPCC Fourth Assessment Report (AR 4) and any future Assessments. Climate models are also used to assimilate historical climate observations and generate a "reanalysis" providing comprehensive four-dimensional data representing the observed climate system over the past few decades. These reanalysis data, the generation and evaluation of which are actively supported by the WCRP, provide valuable information in data sparse regions. However, access to such model-generated data and their analysis, either in terms of scenarios or reanalyzes, is critically dependent on computational, storage and Internet bandwidth facilities, which is a major challenge for the Developing Countries and LDCs.

#### **4.2.6 Monitoring Atmospheric Composition**

Adaptation has always been considered as a complementary to mitigation. NMHSs also have the responsibility to monitor concentration of greenhouse gases in the atmosphere. WMO, within its Atmospheric Research and Environment Programme, coordinates the WMO Global Atmosphere Watch (GAW) Programme responsible for greenhouse gas measurements. In October 2006, GCOS and WMO established the WMO-GAW Global Atmospheric CO<sub>2</sub> & CH<sub>4</sub> Monitoring Network as a Comprehensive Network of GCOS. In March 2006, WMO released the first of 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



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Meteorological Agency. The GAW Central Calibration Laboratory for Greenhouse Gases hosted by the US National Oceanographic and Atmospheric Administration (NOAA) plays a crucial role. GAW is now working to register global monitoring activities within the GCOS framework for the Essential Climate Variables, aerosols and ozone. .

#### **4.2.7 Dangerous Interference With The Climate**

Recognizing that the ultimate objective of the UNFCCC is to achieve stabilization of greenhouse gas concentrations in the atmosphere *at a level that would prevent dangerous anthropogenic interference with the climate system*, the WCRP has established a project designed to underpin definitions of 'dangerous interference with the climate'. This new venture is involving many nations in a united response to the call from the G8 science academies and those of China, India and Brazil in a statement issued in July 2005 that governments should be urged to 'launch an international study to explore scientifically informed targets for atmospheric greenhouse gas concentrations, and their associated emissions scenarios, that will enable nations to avoid impacts deemed unacceptable'.

### **4.3. Climate Modeling, Scenarios and Downscaling**

#### **4.3.1 Climate and Earth System Models**

4.3.1.1 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, absolutely, and accurately represent all the complex processes and interaction in the Earth System. One of the most significant problems comes 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. Global projections of coarse resolution (typically 100 x 100 km) are less useful for local applications. 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. Small Island States) 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. Further hampering, regional downscaling efforts in meeting the needs of least developed countries and SIDS is the lack of sufficient observed baseline data. The states, therefore, have to deal with large uncertainties in their long term planning horizons and are becoming more vulnerable to the impacts of ever increasing extreme climate events.

4.3.1.2 Concerted efforts are being made by some of the NMHSs and leading international climate modeling groups, under the coordination of the WCRP, to develop Regional Climate Models so that they become capable of providing regional scale (typically 25 x 25 km, and higher resolution with appropriate computing facilities), climate information for impact studies, and to facilitate their use within the modest computational infrastructure of the developing countries. Global efforts can be spearheaded by WMO to bridge the existing gaps between developed and developing countries in their understanding of climate change impacts through capacity building and regular updates of occurrence of extreme events and associated damages. Developing countries NMHSs may be provided with appropriate tools to respond rapidly to trends and developments of regional scenarios, changing needs, emerging issues and specific challenges. In particular, the application of the regional climate models in developing countries need adequate local observational data for model evaluation, and regional expertise to diagnose and interpret the simulated regional features. In order for the regional models to become reliable tools to generate high-resolution climate scenarios, these models need comprehensive validation for specific applications, nesting within higher resolution verified global models and the developing countries need assistance from the modeling groups to incorporate user feedback in resolving the model

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deficiencies, which can be facilitated by the WMO and WCRP. Regional climate models provide more useful local information needed by policy makers and planners on adaptation policies and to enhance the capacity of communities to cope with the future. Since fine resolution climate change information for use in impact studies can also be obtained via sophisticated statistical downscaling methods, coordinated efforts must also be undertaken to use these methods to develop and implement useful and plausible regional scale climate scenarios. These methods are computationally inexpensive with respect to regional climate models and they can be used to provide site-specific information, which can be critical for many climate change impact studies. Consequently, a coherent strategy is needed to facilitate the transfer of expertise from developed countries and to provide access to downscaling tools in developing countries with limited or modest computational resources, since all downscaling methods are complementary.

4.3.1.3 While downscaling using regional climate models is valuable, there is an urgent need for high resolution global simulations to capture the global teleconnections that are an integral part of weather and climate. There is an urgent need to advance from climate projection with a space resolution of approximately 100 km, insufficient for adequately resolving cyclones, to cloud system-resolving models with resolutions of several kilometres. This will require the coordination of many scientists working together to build the next generation of climate prediction models and PetaFLOPS computers to run them on.

#### **4.4 Climate Related Risks and Extreme Events**

4.4.1 It is the ambition of the WMO and the Millennium Development Goals (MDGs) to halve the loss of life associated with natural disasters of meteorological, hydrological and climatic origin over the next 15 years. As a result, the WMO is working towards the development of new products, programmes and partnerships that provide/facilitate information with longer lead-times on the state of the climate and associated natural hazards. The WMO has established a Natural Disaster Prevention and Mitigation Programme (DPM) to ensure optimization of WMO's 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. 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 of emergency response and disaster mitigation/prevention. These systems operate alongside educational and capacity-building services that help ensure nations can better meet national needs for hazard information.

4.4.2 With the help of the leading experts spread across the world, WMO regularly prepares and issues El Niño/La Niña Outlook statements as a product of global consensus, which are of immense value for anticipating regional impacts associated with major anomalies of this global scale phenomenon. Annual statements of climate issued by the WMO, also prepared on the basis of inputs received from across the world, serve to document the notable features of extreme events with a regional perspective. In collaboration with the CCI (Commission for Climatology) and Natural Disaster Prevention and Mitigation Programme (DPM), WCP has formulated a project plan to develop a global atlas of El Niño/La Niña impacts, which can help in identifying regions affected by such global-scale climatic anomalies and assess the associated risks.

4.4.3 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, during 17-21 July 2006. The conference was co-sponsored by Finnish Meteorological Institute (FMI) and International Research Institute for Climate and Society (IRI) with additional support from the Government of Finland, the European Commission and some WMO Members. This conference was unique in the sense that the user sectors took the lead to review opportunities and constraints in integrating climate risks and uncertainties into the mainstreams of decision-making where sensitivity to climate variability

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and change is but one among many factors to consider. The focus was on risk assessment and decision-processes in real-world contexts, and the conference came up with the “Espoo Statement” (<http://www.livingwithclimate.fi>).

4.4.4 The Espoo Statement noted that the practice of climate-related risk management is not widespread within many sectors and that there is a lack of awareness of climate-related risk management opportunities among numerous communities that would benefit climate-related risk management requires multidisciplinary collaborations and the cross-disciplinary exchange of information and agreed on-going collaboration at national and regional scales between sectoral partners and climate information providers will benefit all parties. 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 socioeconomic data,
- Based on tailored climate information,
- Supported by local capacity,
- Included in planning strategies that incorporate incentives,
- Supported by sector-specific services from National Meteorological and Hydrological Services and related Institutions.

4.4.5 Espoo Statement recommended that collaborative mechanisms be developed that facilitate needs and requirements driven activities in climate-related risk management, and that they be used to improve the quality of climate-related risk management to the benefit of all.

#### **4.5. Socio-economic information**

##### **4.5.1 The Earth System Science Partnership (ESSP)**

4.5.1.1 The WCRP in concert with three science programs 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. ESSP Programmes and Projects mandate that ESSP has a geographical distribution of members on its governing boards, which enables developing countries to be engaged in its activities. One of the central activities of the ESSP programmes and projects are to build capacity for understanding and acting on climate change and its impacts:

- Improving the understanding of radiative forcing and coupling including that of Greenhouse Gas (GHG) concentration changes (presumably via radiative forcing and other associated processes, e.g. CO<sub>2</sub> feedbacks on oceans and the terrestrial biosphere) because this forcing is the basis of greenhouse warming.
- Improving the understanding of feedbacks between climate and major biogeochemical cycles, especially carbon (e.g. vulnerabilities of presently stable carbon pools to release under climate change). Likewise, greater understanding is needed about feedbacks between climate and the hydrological cycle. To accomplish this, it is important to embed better descriptions of the major elemental cycles (e.g. C, N, S) and the hydrological cycle, together with their interactions, into climate models.
- Improving the descriptions of human activities in climate models so that they begin to represent true "earth system models". For this, the natural and social science communities must begin to work together more intensively. It is particularly important to understand and model trends in human energy use,

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urbanization and land use, and their interactions with climate and biogeochemical cycles. ESSP is working actively on these trans-disciplinary questions through its joint projects, including the Global Carbon Project.

4.5.1.2 ESSP believes that delivery of climate information on regional scales underpins all efforts in understanding the impacts and vulnerability and developing adaptational strategies, and highlights the ESSP Integrated Regional Study approach, and particularly the impressive success of the Global Environmental Change And Food Security (GECAFS) regional case 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:

- Multi-scale 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;
- Assessment of the second-order impacts of adaptation strategies.

#### **4.6 Adaptation Planning And Practices**

4.6.1 WMO's 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. WMO's global network of Regional Specialised Meteorological Centres (RSMCs) and World Meteorological Centres (WMCs) provide 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 concerned NMHSs and are expected, to address issues of particular regional significance by appropriate interpretations of global climate products.

4.6.2 WMO has the ability to transmit advisories through the Global Telecommunication System, facsimile and Internet at intervals of three to six hours to the NMHSs of countries at risk. The forecasters at the NMHSs used these advisories to produce their national warnings, which are dispatched immediately to newspapers, radio and television stations, emergency services and other users. In response to this information, many lives were spared through timely evacuations.

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

4.6.4 The climate-related natural disasters of the past year, including severe storms, monsoon flooding and hurricanes, have underlined the urgency of a global initiative to pool knowledge that could help minimize the damage. Scientists around the world are advancing the understanding of climate change and its implications for natural hazards. There is a great need for sector-specific weather, climate and hydrological information and early warnings. WMO has the infrastructure to generate and deliver information-based products and services to enable nations to prevent, prepare for, respond to, adapt to and recover from the impacts of weather-, water- and climate-related hazards in the most timely and effective manner.

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4.6.5 WMO was designated to co-chair with OCHA, an advisory group to contribute to former and oversee the implementation of the Global Early Warning System Survey requested by the UN Secretary-General Kofi Annan, and the development of the International Early Warning Programme (IEWP). WMO has provided a preliminary overview of the current capabilities and gaps for Early systems.

4.6.6 WMO has established its Natural Disaster Prevention and Mitigation (DPM) Programme to develop an organization-wide coordinating framework to further enhance its contributions to the natural disaster risk reduction activities at the international, regional and national levels.

4.6.7 WMO puts greater 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.

4.6.8 WMO is putting in place a comprehensive set of best practices, related to 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 partnership with major economic development commissions, insurance and re-insurance companies, UN organizations, international and regional 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.

4.6.9 WMO will work to ensure access to increasingly accurate forecasts and warnings with longer lead-time, and will help countries adapt themselves to local conditions and to the needs of local populations. WMO will work with its partners to develop the much-needed sector-specific early-warnings for applications in health, agriculture, transportation, energy, water management, etc. It mainstreams technical capacities such as hydro-meteorological risk assessment and early warning systems in the national disaster risk management plans, legislations and development planning and strengthens capacities for operational meteorological, hydrological and climate-related hazard early detection and warnings built upon strong governance, organizational and operational processes. Furthermore, WMO facilitates partnerships among NMHSs and other key national agencies for a more coordinated approach to disaster risk management.

#### **4.7 Research And Delivery Of Improved Climate Products And Projections**

4.7.1 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.

4.7.2 WMO's Technical Commission for Climatology (CCI) includes expert teams dealing with application sectors such as health, energy, tourism, urban and building climatology provide valuable insights into the nature of climatic impacts. The Commission is in advanced stages of developing guidelines 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

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regional partners. In collaboration with the CCI and DPM, World Climate Programme has developed a project on the implementation of heat-health warning systems, and is pursuing resource mobilization for the purpose.

4.7.3 Climate research of direct end-user value is co-coordinated worldwide including WMO member nations by the WCRP. For example the 2006 WCRP Workshop on Understanding Sea-level Rise and Variability concluded that since 1992 the global mean sea level has been rising at a rate of  $3.2 \pm 0.4$  mm a year, based on combination of tide gauge and altimetry data compared to  $1.7 \pm 0.3$  mm a year from tide gauges over the previous century (see Statement at [http://wcrp.wmo.int/pdf/Sea\\_Level\\_Rise\\_Workshop\\_Summary\\_Statement.pdf](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 has characterised 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.

#### **4.8 Technologies for Adaptation**

##### **4.8.1 Climate Data Management Systems (CDMS)**

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's World Climate Data and Monitoring Program (WCDMP) provides the best platform for collaboration among 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 modeling climate processes and, monitoring and assessing climate variability and change and their impacts. Based on the WMO/WCDMP leading role in the capacity building, climate data management is an area where 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 DCs and LDCs. This will be in addition to the 50 countries in which the CDMS have been already installed during the current plan period 2004-2007.

##### **4.8.2 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 streamflow 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. In 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 in practical terms 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 Climate Outlook Forums (RCOFs) in water resources management. National Meteorological Services are encouraged to upgrade their climate prediction capability in such a form that it can be utilized by National Hydrological Services in providing climate-oriented predictions for improved water resources management including providing information that allows to dealing in an adaptive way with extreme hydrometeorological events outside the range already experienced by countries/regions. One of the major reasons why predictive climate information is at present not fully utilized by water managers is the lack of a generally agreed conceptual framework for the use of climate predictions/scenarios. Milestones to address these issues are the conclusions of an expert meeting between climate specialists and

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water managers held in December 2006. There is a general recognition that both the climate information providers and the water managers essentially work side by side to solve common issues, that is: The improved planning for and management of water resources in a context of Integrated Water Resources Management. In this approach, focus will be predominantly on the scale of climate outlook information as this type of information is easier for water managers to assimilate at present. Furthermore, climate information needs improvement both in accuracy, and resolution in time and space with a view to activities based on strategic, tactical and operational considerations. Despite existing uncertainties, information on climate variability as well as climate change scenarios is sufficient for developing adaptation strategies and measures. Validating predictive skills of climate models and their utility for water management should be one focus of the conceptual framework for follow-up activities proposed at the meeting.

#### **4.9 Economic Diversification**

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

##### **4.9.1 Agriculture**

4.9.1.1 Agriculture is typically the most important sector in the economy of developing countries, especially in the LDCs and SIDs. Farmers practice 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) established an Open Programme Area Group (OPAG) on Climate Change/Variability and Natural Disasters in Agriculture in 2002 and the Expert Teams of this OPAG have been actively addressing the key issues of adaptation to climate change in the agriculture, forestry and fisheries sectors. Most NMHSs are providing climate inputs to decision making in agricultural communities in order to alleviate the 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. NMHSs continue to place emphasis on 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 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.

4.9.1.2 The Agricultural Meteorology Programme 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 or other agents that contribute to the degradation of the environment. NMHSs, through their agrometeorology activities, foster a better understanding by farmers and other end users of the value of climatological information and weather forecasts in their planning and operational activities. Users are made aware of the economic benefits and practical possibilities of the use of meteorological products and information.

4.9.1.3 The Agricultural Meteorology Programme of WMO places emphasis on developing appropriate adaptation strategies, mainly in the vulnerable crops and cropping systems in the developing countries and assists the NMHSs in their dissemination to appropriate stakeholders at the national level. The science of agrometeorology and its applications contributes to the development of operational knowledge to cope with new hazards such as increased effects of

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climate change and climate variability and their consequences. Information on recent past weather coupled with local knowledge, can now be more widely used thereby allowing better planning of farming operations and of national agricultural policies.

4.9.1.4 Meteorological inputs must be made available to define and help manage new farming systems that permit a new equilibrium between increased population and natural resources, including climate with all its inherent variability.

#### **4.9.2 Energy**

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, hydraulic, 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. Weather and climate information should be better integrated into the development of energy policies at various levels. Capacity building of both the climate and energy communities is of fundamental importance to improve communication of each other's needs and capabilities, so that well-planned analyses of the meteorological impacts on energy sector can be made which can feed the development of effective tools to better manage risk in the energy sector. Climate information should be used more comprehensively in the development of energy requirement scenarios, which can help planning appropriate investments. In the context of sustainable development, climate information is of crucial importance in the expansion of hydropower and wind and solar energy generation capacities. There is a clear need for improving the forecasting skills (including communication of uncertainty) of extreme weather events having 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 grid-control of electricity.

#### **4.9.3 Tourism**

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 UNWTO and the tourism sector to maximize the benefits of favourable weather conditions and changes in climate. In this way 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 system might best respond in order to reduce risks and maximize benefits.

#### **4.9.4 Strengthening National Institutional Frameworks**

4.9.4.1 In most developing countries, climate is seen as a lesser priority compared to other current needs and relatively few resources may be allocated to climate activities at national levels. The sixth UNFCCC compilation and synthesis report highlighted the gaps in institutional and human capacity, as identified from the submission of national communication. In some developing



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countries, 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 from WMO programmes on climate issues enhanced their role, with the collaboration of other stakeholders, to prepare national greenhouse gas inventories and address impacts of climate change on vulnerable sectors of the economy such as agriculture, water resources, energy and coastal zones. WMO, with assistance from international and regional organizations, may guide and improve the capabilities of these national institutions frameworks for implementation of adaptation activities. They can be provided with appropriate tools to take on work on developing GCMs at smaller scales to suit national needs. Research activities and systematic observations can be promoted to overcome constraints on data needs and to build capacity related to vulnerability and adaptation components of national communications.

4.9.4.2 The climate system is so complex and the scientific and computational requirements for providing societally-beneficial regional climate forecasts are so enormous that the nations of the world should create international research and computational facilities dedicated to the 'grand challenge' of climate prediction.

4.9.4.3 The scientific expertise to revolutionize climate prediction of the physical-biogeochemical Earth system and its interactions with the global socio-economic systems resides in no one nation or scientific discipline. An international joint effort is required to make very necessary advances in the 21st century. Immediate beneficiaries of such a multi-national joint effort focussed on the 'grand challenge' of climate prediction will include Parties to the UNFCCC and others to 'environmental' UN Conventions wishing to develop vulnerability assessments and adaptation policies.

## **5. Future Development and strategies**

5.1 WMO, 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 important role of governments and UN agencies for implementation of programmes for adaptation to climate variability and change as well as mitigation. WMO, NMHSs 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, NMHSs and their partners will continue to work within the United Nations system to ensure that climate variability and change decision-making continues to be based on sound scientific knowledge for the benefit of society.

5.2 One important contribution to the further development of activities under the Nairobi Work Programme can be expected from the IPCC 4<sup>th</sup> Assessment Report (AR4). It needs to be recalled that COP-11 asked SBSTA to consider further activities at its 28<sup>th</sup> Session based on information contained in the IPCC AR4 and other activities and information. The AR4 will provide new information relevant to all areas covered by the programme of work, in particular observations of climate and its impacts, climate modeling and projections, possible future impacts for different scenarios, planning and technologies for adaptation and interrelationship between adaptation and mitigation. The three working group contributions will be released in early February, April and May 2007. A presentation to SBSTA-26 is planned. The AR4 Synthesis Report will come out in November 2007 and delivered to COP-13.

5.3 In this context, following the Conference on "Living with Climate Variability and Change: Understanding the Uncertainties and Managing the Risks", held in Espoo, Finland, during 17-21 July 2006 which reviewed opportunities and constraints in integrating climate risks and uncertainties into the mainstreams of decision-making WMO is organizing an international Conference in Madrid, Spain (19-22 March 2007), on the social and economic benefits to society of

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the products and services provided by the meteorological and hydrological community, especially the National Meteorological and Hydrological Services (NMHSs) and WMO Members states. The Conference will stock take socio-economic information including available approaches and will explore requirements to be accomplished to ensure better integration of such information into adaptation process. The Conference will also consider socio-economic scenarios and assessments of vulnerability, adaptive capacity and adaptation options with a view to identify needs and gaps as well as improving availability and access to relevant information. By bringing together decision-makers, users and service providers, WMO aims to increase further, in view of their growing value and impact, the utility of weather, climate and water knowledge for social and economic benefit.

**6. Conclusions**

6.1 From the above it is clear that WMO through its programmes and its Members (NMHSs) have a major role to contribute in the implementation of the Nairobi Work Programme. In order for this to succeed, the relevant programmes of WMO need to be involved in the activities of the UNFCCC, especially SBSTA WMO and its Members States can contribute through active participation in the discussions at the SBSTA sessions and through active participation at the national level on those activities that are aimed at implementing the Nairobi Work Programme. Resource mobilization for regional capacity building, particularly in the case of Developing Countries and Least Developed Countries, and implementation of demonstration projects as well as mainstreaming of climate activities into national development planning is a major challenge that needs to be addressed.

6.2 WMO commits itself to facilitate 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's 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 ably.

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**LIST OF ACRONYMS**

ACC	Anthropogenic Climate Change
CAgM	Commission for Agricultural Meteorology
CCI	Commission for Climatology
CDMSs	Modern Climate Data Management Systems
DRM	Disaster Risk Management
ESSP	Earth System Science Partnership
GPC	Global Processing Centre
IPCC	Intergovernmental Panel on Climate Change
LDCs	Least Developed Countries
MDGs	Millennium Development Goals
NMHSs	National Meteorological and Hydrometeorological Services
OPAG	Open Programme Area Group
Petaflops computers	Ability of a computer to do one quadrillion floating point operations per second
RAPs	Regional Action Plans
RCCs	WMO Regional Climate Centres
RCOF	Regional Climate Outlook Forum
RSMCs	Regional Specialized Meteorological Centres
SBSTA	Subsidiary Body for Scientific and Technological Advice
SIDS	Small Island Developing States
THORPEX	THE Observing System Research and Predictability EXperiment
TOGA	WCRP's Tropical Ocean and Global Atmosphere
UNFCCC	United Nations Framework Convention on Climate Change
WCDMP	World Climate Data and Monitoring Program
WMCs	World Meteorological Centres
WWRP	World Weather Research Programme