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# Regional Climate Information for Risk Management

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**Abstract**

Several regions of the world have developed capability in providing services on climate information for risk management, but there are still gaps in service delivery due to inadequate information regarding the needs within the regions. This paper highlights the role of Regional Climate Outlook Forums, assesses the needs for some regions and extracts examples of how regional associations could benefit through the provision of better climate services. Problems are given for Africa, South-East Asia, South America, the Pacific and Europe. Different geographical climate features lead to different climate phenomena and in turn determine the type of climate delivery needs for risk management. Short discussions of regional socio-economic factors that shape the needs for climate information provide further context for the unique character of delivery services. Recommendations and future plans follow this assessment.

*Keywords:* Regional climates; socio-economic requirements; regional climate information; delivering information.

## 1. Introduction

Humanity at large and all socio-economic activities depend on weather, climate and water. All regions and sectors have their specificities, some being more dependent on temperature, precipitation, wind or a combination of several parameters, some being more prone to average values and others to extremes. This paper depicts problems of particular regions of the world where climate information service and use are still limited, and the of region of Europe for the case of the energy sector. The regions are the small island states of the Pacific, the maritime continental South-East Asia, the Greater Horn of Africa (GHA), Southern Africa and South America. These regions are mostly located over the tropics and they comprise developing or least developed countries.

## 2. Present status of regional climate information usage

### *2.1 Regional features and required climate information*

#### *2.1.1 Regional climate features*

The regionalization of the world climate is a rather difficult task, but certain regions do have specific characteristics that make them vulnerable to particular climate phenomena. Below are some of the regional climate features and the identification of climate information needs.

The tropics have the highest seasonal predictability region of the world, but there are low skills particularly in the developing countries. Intense convective precipitation that produces torrential rainfall is still rather difficult to simulate with state-of-the-art climate modelling, so weather forecasting over the tropics is another difficulty faced by climate scientists. The role of oceans over the tropics is still not fully understood, while climate modelling that includes ocean influences must take into account global ocean circulation. Low access to Internet data and the lack of climate data centres that provide long-range ocean data products are additional reasons why tropical ocean modelling is not well developed in most tropical countries' National Meteorological and Hydrological Services (NMHSs), especially among developing and least developed countries.

##### *2.1.1.1 The Pacific island region*

For the Pacific region, the season is divided into two – the humid and slightly hotter wet season, and the less humid, slightly cooler dry season. North of the equator (Micronesia) the more favoured dry season is between November and May. Hawaii is far

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enough north that winter and summer seasons are used as opposed to dry and wet, although here cyclones can still be a threat from August to November. South of the Equator the dry season is between May and November.

The Pacific islands are tropical in climate, and experience only small fluctuations in temperature and daylight throughout the year. Typical daytime temperatures are between 24ºC and 31ºC with a small diurnal variation. Rainfall is seasonal, generally influenced by the movement of the South Pacific Convergence Zone or the Inter-tropical Convergence Zone.

The natural environment of the Pacific region is strongly influenced by weather and climate. Tropical cyclones, prolonged heavy rain with accompanying floods, droughts and other extremes are commonplace. These extremes are in many instances attributable to the large seasonal and interannual variability related to the El-Niño–Southern Oscillation (ENSO) phenomenon, and are an integral part of the climate of the region. Ocean–atmosphere interaction processes determine these phenomena, which have a direct impact on the social and economic well-being of the widely scattered islands in the Pacific Ocean.

*2.1.1.2 The South-East Asia region*

The South-East Asian region maritime climate is strongly modulated with the presence of ENSO and the Indian Dipole mode and a certain degree of the influence of the Indonesian through flow. The region consists of countries belonging to the Southeast Asian Nations, the Democratic Republic of Timor-Leste, Papua New Guinea and the northern part of Australia. This region receives negative feedback of the warming of the equatorial Pacific during warm phases of ENSO. Other important climate variability over the region includes the Madden Julian Oscillation and the cold surge, both having regional impact and influences. The different structures of monsoons such as the Indian monsoon, the East Asian monsoon and the maritime continent monsoons also characterize the region. Most of the climate features of this region are related to the ocean phenomena that include the sea, air and land interactions. Complex and interactive climate modelling is still lacking in most NMHS climate information providers. Extensive use of ocean and climate data and the high requirement for computing facilities limit the capability of many tropical NMHSs to providing only weather forecasts and not climate predictions.

*2.1.1.3 The Greater Horn of Africa*

The African region, especially the Greater Horn of Africa (GHA) subregion, can be divided into three sectors based on periods of rainfall onsets and withdrawals. These are the southern, equatorial and the northern sectors. The southern sector which comprises central and southern United Republic of Tanzania normally experiences a unimodal type of rainfall regime, with rainfall occurring between December and April. The equatorial sector, made up of northern United Republic of Tanzania, Kenya, southern and extreme eastern Ethiopia, southern Sudan and the southern half of Somalia, generally exhibits a bimodal type of rainfall regime, with the long-rains season occurring in March to May and the short rains being experienced in October to December.

The rainfall patterns over the equatorial parts of the GHA are, however, quite complex with areas close to large water bodies receiving substantial amounts of rainfall throughout the year. The rainfall also shows strong seasonality in harmony with the latitudinal migration of the Inter-tropical Convergence Zone (ITCZ). Some of this variability is accounted for by the existence of complex topographic features including the east African lakes. Both the western and coastal areas receive much of their rainfall during the months of July and August. In the northern sector, comprising central and northern Ethiopia, Eritrea, Djibouti and the northern half of Sudan, the major rainy season occurs during the northern hemisphere summer months of June–September, but a few areas do receive a secondary peak from March to May.

The other major global and regional systems that are often associated with climate variability in the Greater Horn of Africa subregion include the ENSO phenomenon, sea-surface temperature (SST) anomalies over the Indian and Atlantic Oceans and tropical cyclone activities in the Indian Ocean, including modes of variability such as the Indian Ocean Dipole (IOD). The ENSO-related rainfall anomalies in the Greater Horn Africa vary significantly from season to season and from location to location. Strong El-Niño/La-Niña events are often associated with suppressed/enhanced rainfall over the northern sector of the GHA during the peak rainfall season of July to August. Over the equatorial sector, the onset of an El-Niño/La-Niña is associated with enhanced/suppressed rainfall during the October-December rainfall season and sometimes extending into the usually dry months of January and February of the following year.

*2.1.1.4 Southern Africa*

The Earth's climate is affected by factors that cause a change in the redistribution of energy in the atmosphere, land and ocean. The Southern African region is much influenced by the prevailing wind systems that include the south-easterlies, Congo air, the north-easterlies and the Inter-tropical Convergence Zone. The region of Southern Africa extends from the northern part of the Democratic Republic of the Congo at 5ºN to the Western Cape of South Africa at 35ºS. The availability of water in Southern Africa is determined by precipitation, which varies in the region from 25 mm to 1 500 mm per annum. Generally, regions that experience the lowest rainfall also experience the highest potential evaporation while regions that experience the highest rainfall experience the lowest potential evaporation. Rains are seasonal in nature, extremely variable and very uncertain. The high spatial variability, high seasonal variability and high interannual variability of the water balance of Southern Africa are reflected in the flow regimes of the region. Other factors like hydrogeology, vegetation cover, wetlands, etc. also introduce variability in the flow regimes. Rivers in the region flow into the Indian Ocean, Atlantic Ocean and to inland sinks such as the Etosha Pan in Namibia.

The subtropical nature of the Southern African climates controls the nature of the socio-economic activities in the region. The two main climatic parameters that determine the socio-economic prospects as well as problems in the region are the annual rainfall (its spatial and temporal distribution) and temperature fluctuations.

*2.1.1.5 South America*

In South America, there are a wide variety of climate regimes, ranging from very dry deserts aligned with the western coast of the continent, to the hyper-humid Amazonian basin and western Patagonia in southern Chile. Many climatic regions are divided by the Andes cordillera, which with its long north-south extension covers the entire latitudinal extend of South America. Parts of the south-eastern part of the continent are under the influence of the South America Monsoon.

In terms of climate variability and its predictability, there has been an important amount of investigation devoted to the understanding of the effects of ENSO on the circulation and precipitation variability in various parts of the continent, such as in Peru, central and southern Chile and south-eastern South America. These relationships have served as a scientific basis for the development of seasonal forecasts.

*2.1.1.6 The European energy sector*

The International Conference on Secure and Sustainable Living: Social and Economic Benefits of Weather, Climate and Water Services, organized by the World Meteorological Organization (WMO), and the national and regional workshops held during its preparation, have highlighted the nature, diversity and extent of weather- and climate-related disasters throughout the World [1][2]. The most weather-sensitive sectors of the economy include the energy sector, agriculture, retail and wholesale, transport, public health, utilities, communications, construction, tourism and the public in general.

Europe is located in the so-called mid-latitudes, where climate is known to be highly variable, dominated by atmospheric variability at short to medium terms. It is therefore a region where predictability is limited, especially at time ranges greater than a few days. Europe is also characterized by different types of climate – marine, continental, Mediterranean – which differ from each other and have their own specificities. However, despite these limitations that come both from the nature of climate at these latitudes and from the scientific and technical limitations of forecasting, many data and forecasting products exist to help decision-makers to improve their processes.

The Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report [3] gives a general overview of regional impacts of climate and of future changes on different sectors and activities. It states that, "Observational evidence from all continents and most oceans shows that many natural systems are being affected by regional climate changes, particularly temperature increases." The confidence associated with the projected patterns of warming and regional-scale features is now higher than it was in the previous assessment reports. In particular, warming is expected to be greatest over land and at most high northern latitudes, and least over the Southern Ocean (near Antarctica) and northern North Atlantic. It is very likely that hot extremes, heatwaves and heavy precipitation events will become more frequent. It is likely that future tropical cyclones (typhoons and hurricanes) will become more intense, with larger peak wind speeds and more heavy precipitation associated with ongoing increases of tropical sea-surface temperatures. There is less confidence in projections of a global decrease in numbers of tropical cyclones. Extra-tropical storm tracks are projected to move poleward, with consequent changes in wind, precipitation and temperature patterns, continuing the broad pattern of observed trends over the last half-century. Increases in the amount of precipitation are very likely in high latitudes, while decreases are likely in most subtropical land regions.

For the first time important consequences of actual climate change have been documented in Europe: retreating glaciers, decreases in crop productivity, extensive species loss and/or migration, impacts on health due to intense and long heatwaves in summer. These observed changes are relevant to those simulated for the future. Almost all European regions are projected to be negatively affected by future consequences of climate change, and these changes will represent major challenges for most economic sectors.

*2.1.2 Socio-economic requirements*

*2.1.2.1 The Pacific island region*

Pacific island states are largely dependent on the natural environment and natural resources for their socio-economic sustenance. Agriculture, fisheries, tourism, mining (and forestry in some of the larger more elevated islands) are the main economic sectors for most Pacific island countries, and subsistence lifestyles dominate the activities of many rural communities. Both subsistence economies and commercial activities are dependent on the natural resources of the land and the sea. The transport sector is important and is affected directly by climatic events. Sea and air transport are necessary to span the vast distances between producers and both their internal and export markets, and to bring tourists to the islands.

The poor and highly permeable soils in many islands and all island landscape processes are sensitive to the impacts of weather and climate. Effectively used weather services, and the information that can be provided by National Meteorological or Hydrometeorological Services (NMSs) can contribute significantly to the success of almost all Pacific island countries' national activities, including economic activities aimed at reducing poverty. Timely and accurate climate prediction services can contribute substantially to social well-being and economic development.

*2.1.2.2 The South-East Asia region*

South-East Asia has the most dense population of the world. Therefore, climate information for agriculture and related water resource management are indispensable. Timely and accurate climate prediction on the scale of two weekly is highly important for the determination of the proper crop types and plantation season onset.

Other important sectors are forestry, fisheries, water resources, health, tourism, mining and infrastructure. Moreover, the maritime continent comprises marginal seas that connect islands, and requires important climate information for transportation. Since the region is located between two large oceans where tropical cyclones are frequent, the seasonal information related to the phenomena are needed in many countries of the region. However, most activities are related to agriculture and fisheries, thus climate-related information for those two sectors is essential. For health, tourism and infrastructure, the utilization of climate information is still rare, although people already accept the role of climate on those sectoral issues. For those sectors an understanding of the benefit of climate information in reducing risks and losses and the proper tools for analyses are still needed.

Most of catchments of the region are small mountains that drain the discharge into the ocean in a short period of time. Proper climate information for water resources is highly needed to optimize the water resource utilization for agriculture, energy sectors and city water industry. The long drought, which is usually associated with El Niño normally brings problems with forest fire and smoke haze dispersion over the region, a transboundary problem. Better seasonal climate information in advance will help the region prepare for common air pollution during long droughts. On the other hand, climatic change that leads to excessive water runoff is sometimes related to certain climate extremes. Thus it is highly desirable to deliver accurate climate prediction related to monsoon intensity over the region.

*2.1.2.3 The Greater Horn of Africa region*

Weather and climate induced extremes such as droughts and floods represent a major challenge to the efforts of the countries within the GHA to achieve sustainable socio-economic development. These events cause severe economic disruption through the loss of life, and the destruction of property, infrastructure, the environment and other social amenities.

The economies of most of the GHA countries rely heavily on rainfed agriculture, which is highly vulnerable to extreme weather and climate events such as floods and droughts. Agriculture, livestock, fisheries, tourism and mining are some of the dominant economic sectors of most countries within the GHA subregion. Energy is the key driver to the socio-economic growth for all nations, and the GHA region is endowed with abundant renewable energy resources such as biomass, solar, wind and hydroelectricity. Biomass in the form of fuelwood, charcoal and agricultural residues is the most dominant source of energy in the region. However, the cutting down of trees and shrubs, the burning of charcoal and the clearing of land for cultivation have led to serious fuelwood shortages, deforestation, land degradation and desertification.

The GHA subregion is also endowed with hydropower resources. These resources are, however, highly vulnerable to fluctuations in rainfall: not enough rainfall leads to low water levels in the dams for electrical power generation resulting to huge economic losses and negative economic development for a nation. On the other hand, too much rainfall can lead to floods that pose threats of dam breakages and siltation.

Weather and climate forecasts, especially seasonal forecasts, are extremely important for water resource management in terms of flood management, agricultural and urban water use management and reservoir management for power generation, recreation, navigation and endangered or threatened species. Early, accurate and timely weather and climate forecasts allow managers to predict streamflows that are necessary for efficient management of water systems.

The GHA coastal zones and wetlands support a diversity of habitats and resources encompassing mangroves; rocky shores; sandy beaches; deltas, estuaries and coastal wetlands; coral reefs; and lagoons. Coral reefs and mangroves are especially important features because they protect the coastline by moderating storm and wave impacts and because mangroves stabilize sand and soils, cycle nutrients, absorb and break down waste products, provide wildlife habitat and maintain biodiversity. Reefs and mangroves also contribute significantly to the economies of coastal countries by providing opportunities for tourism and for harvesting of resources. However, coastal zones and marine and wetland areas are vulnerable to climate-related hazards such as storms including tropical cyclones/ hurricanes, waves and storm surges, tsunamis, river flooding, shoreline erosion and influx of biohazards such as algal blooms and pollutants. Furthermore, climate variability substantially alters the distribution and abundance of major fish stocks, and has implications for marine populations and ecosystems.

*2.1.2.4 Southern Africa*

Over the whole globe about 90 per cent of the natural disasters derive from extremes of climatic conditions. Due to direct impacts, tropical cyclones rank as the highest cause of fatalities. The fatalities due to droughts, because their effects are indirect and slowly evolving, are more difficult to quantify. In the Southern Africa Development Community (SADC) comprising 15 conterminous and three island states, with over 220 million inhabitants, the percentage of climate-related disasters is even higher than 90 per cent as there are no major earthquakes or volcanic eruptions that could contribute to the catastrophes as in other parts of the globe. The mainstay of the economies of the region is agriculture and thus this exposes the subregion to the vagaries of climate systems. Other downstream sectors such as health, power utilities, water resource management and the environment are equally susceptible to climatic extremes. This has been amply demonstrated since the 1980s.

*2.1.2.5 The European energy sector*

For the energy sector, major socio-economic concerns are related to the means, variability and extremes of weather and climate. There is also a need for dimensioning/investments, planning, real-time operations, safety/security of people and goods. For a review, see WMO [1] and Rogers et al.[4].

*2.2 Present status of use of regional climate information*

*2.2.1 Types, contents and quality of regional climate information*

*2.2.1.1 The Pacific island region*

There are several sources for regional climate information for the Pacific, and the key providers are the National Oceanic and Atmospheric Administration (NOAA), the Australian Bureau of Meteorology (BOM) and New Zealand's National Institute of Water & Atmospheric Research (NIWA).

The Pacific Island Climate Prediction Project, funded by the Australian Agency for International Development (AusAID) and managed by the Australian Bureau of Meteorology, aims to develop a framework for incorporating climate prediction information into decision-making processes across a broad range of agencies and industries whose interests are affected by seasonal climate variability. Over the last five years, the project has trained NMS personnel in the use of the climate prediction software and has facilitated the establishment of a climate prediction service in nine Pacific island countries. Currently the main focus of the project is to train clients in the effective use of prediction information through implementation of pilot projects in various climate-sensitive sectors such as agriculture, water, health and renewable energy.

The publication of the monthly Island Climate Update (ICU) began in 2000 and is financially supported by New Zealand's International Aid & Development Agency. This project is focused on providing a monthly climate development summary and climate forecast information for the South Pacific region. It also provides a wider regional perspective and global context for the individual in-country forecasts made by each Pacific island country NMS. The backbone of the ICU is the monthly teleconference, which focuses on relationship-building between South Pacific NMHSs representatives, Australia (BOM), New Zealand (NIWA), and the United States (NOAA and the International Research Institute for Climate and Society [IRI]). The goal of the teleconference discussion is to reach a conclusion about the current state of South Pacific climate and a consensus on the outlook for the coming three-month period. Rainfall and SST forecasts made through the ICU both utilize a multi-ensemble approach, which incorporates 10 available climate model ensembles from European, American and Australian agencies, as well as individual Pacific Island NMS statistical outlooks produced using SCOPIC.

With NOAA/Office of Global Programs (OGP) funding, the Pacific ENSO Applications Center (PEAC) pilot project began in 1994 as a partnership of the University of Hawaii, the University of Guam, NOAA (National Weather Service and OGP) and the Pacific Basin Development Council (the governors of the four American Flag Pacific Islands). The mission of the Pacific ENSO Applications Climate Center is to conduct research and develop information products specific to the United States Pacific Islands on the ENSO climate cycle, its historical impacts and the latest long-term forecasts of ENSO conditions in support of planning and management activities in such climate-sensitive sectors as water resource management, fisheries, agriculture, civil defence, public utilities, coastal zone management and other economic and environmental sectors of importance to the communities of the United States Pacific Islands.

*2.2.1.2 The South-East Asia region*

In South-East Asia, based on the technical paper of the Asian Disaster Preparedness Center, a Regional Climate Outlook Forum was held in February 1998 in Bangkok in conjunction with the Asian Regional Meeting on El Niño Related Crises. This was followed by a forum organized by the Association of South-East Asian Nations (ASEAN) Specialized Meteorological Centre (ASMC) in Singapore in February 1998. Since then, ASMC has been producing Regional Climate Outlooks using electronic communication with international agencies and with national meteorological agencies in the region.

These Regional Climate Outlooks are used by the member countries to generate their own seasonal forecasts. In general, the national meteorological agencies use the regional forecasts in conjunction with past statistical information on local climate conditions and inputs from other meteorological agencies (for example, BOM, IRI, NOAA, United Kingdom Weather Service) to generate national seasonal forecasts. The regional forecasts issued by ASMC indicate rainfall probabilities in five categories (below normal, slightly below normal, normal, slightly above normal and above normal). However, the national forecast products indicate rainfall probabilities in the traditional three categories. This may be attributed to the low level of confidence in using the five closely spaced rainfall categories. It may also be attributed to the fact that at the national level, accountability to users with regards to the accuracy of the forecasts is much higher than at the regional level. However, it is expected that as more experience is gained and confidence levels are raised in the application of forecasts, the national forecasts will become more detailed.

*2.2.1.3 The Greater Horn of Africa region*

The Intergovernmental Authority on Development (IGAD) Climate Prediction and Applications Centre (ICPAC), a specialized regional centre of IGAD, is charged with the responsibility of climate monitoring, prediction, early warning and applications within the GHA subregion for the reduction of climate-related risks including those associated with climate variability and change in support of national/regional poverty alleviation and sustainable development strategies.

These activities are achieved through capacity-building of both meteorologists and users, and include mapping of climate hazards; climate monitoring, prediction and early warning; downscaling of climate products; and the development and application of the climate tools required by various climate-sensitive sectors in order to reduce sector-specific climate risks.

The IGAD Climate Prediction and Applications Centre provides regular regional climate advisories including ten-day, monthly and seasonal climate bulletins as well as timely early warning information on evolving climate extremes and the associated impacts. These advisories assist in disaster management for sustainable development. These products are required by IGAD, the NMHSs, and other national, regional and international partners.

The Centre uses two empirical techniques to provide climate outlooks, namely dynamical and statistical approaches. The statistical prediction methods are based on empirical relationships between rainfall over specific parts of the GHA and some global/regional/local climate system indices. The major climate system indices that are used at ICPAC include evolution of monsoons, medium and upper level winds, Madden-Julian Oscillation (MJO), Quasi Biennial Oscillation (QBO), El Niño–Southern Oscillation, Indian Ocean dipole, tropical cyclones and sea-surface temperature gradients among many others that have been derived from general circulation.

The products generated at ICPAC include the following:

(a) Decadal rainfall distribution;

(b) Decadal drought severity;

(c) Decadal agrometeorological conditions;

(d) Decadal general impacts;

(e) Decadal weather outlook;

(f) Decadal cumulative time series graphs.

The monthly products include:

(a) Climatological summaries;

(b) Drought severity;

(c) Agrometeorological conditions;

(d) Dominant synoptic systems;

(e) Climate outlook;

(f) General impacts;

(g) Preseason consensus outlooks;

(h) Climate Watch.

*2.2.1.4 Southern Africa*

Climate scientists worldwide are working tirelessly to improve techniques of climate monitoring and predictability in order to better serve communities. The contribution of climate system monitoring and prediction to the economic and social development of mankind is now widely recognized. Thus many sectors will benefit from more accurate predictions on multiple timescales. One area in which climate monitoring and prediction plays an important role is flood or drought mitigation. Floods are more spatially constrained and have more dramatic, instant effects as has been amply demonstrated recently (1998–2001) over mainly the eastern sections of Southern Africa. On the other hand, droughts often cover very large areas. The severe droughts that recurred between 1974 and 1984 caused widespread starvation and economic hardship.

The underlying principles for early warning systems are that warnings should be based on best scientific knowledge and be timely, accurate and reliable. Effective communication is also crucial for dissemination of warning information to reach the communities at risk on time. These will need to be addressed more adequately in future programmes.

At the national level there has been increased demand for warning information for all the layers of the communities, for the man in the street up to the decision-maker level. The national decision-making units report to high authorities in government. For instance, in Zimbabwe it is the Vice President's Office that has overall responsibility for disaster management.

Public education with regard to natural disasters is also receiving wide attention in most SADC countries. Dissemination of the information to the affected communities relies on existing communication technologies. The most challenging task facing the countries is to disseminate the early warning information to communities in the remote areas where infrastructural facilities are poor or nonexistent. There is a need for an improvement of the accuracy and dissemination of forecasts and early warning information.

Enhanced coordination and collaboration among the various sectors participating in natural disaster preparedness and management is a fundamental requirement. Suitable projects and programmes should also be developed and implemented to enhance the capacities of the concerned institutions/sectors.

*2.2.1.5 The European energy sector*

The data requirements for the climate information delivery in the energy sector include the following:

(a) Climate data;

(b) Short- to medium-term weather forecasts (from D+1 to D+15);

(c) Long-range weather forecasts (from D+15 to 1 year, including monthly and seasonal forecasts);

(d) Climate forecasts including decadal prediction;

(e) Seamless predictions, to ensure rationality of decisions at different timescales.

*2.2.2 Information sources*

*2.2.2.1 The South-East Asia region*

Before 1997, the Bureau of Meteorology and Geophysics (BMG) issued weather forecasts with meteorological parameters in view. Since 1997, BMG has taken the initiative to establish a broad-based National Seasonal Forecasting Working Group drawing upon expertise from various sectors. The Working Group comprises BMG, the Bureau of Assessment and Application of Technology (BPPT), the National Space Center (LAPAN), the Agriculture Research Institute and the Water Resources Management Research Institute.

The Working Group draws upon forecast information from ASMC, IRI, BOM and the United Kingdom Met Office to prepare seasonal forecast guidance for 102 meteorological regions across the entire region, including: seasonal monsoon onset forecasts indicating the dates of monsoon onset at ten-day intervals; monthly rainfall forecasts; and seasonal cumulative rainfall status for the entire season.

Since August 2008, BMG changed the institutional name to include the terminology of “Climate” into BMKG. The inclusion of the climate division highlights the new role to focus on climate information services to advise the agriculture ministry on the plantation season and the water sector for energy production. The newly established climate information services utilize regional data products provided by some global climate data centres.

*2.2.2.2 The Greater Horn of Africa region*

For the GHA region, ICPAC collaborates with a number of other partners such as IRI, the National Centers for Environmental Prediction/Climate Prediction Center, United Kingdom Met Office and FSU, among others, to address climate prediction and early warning challenges in the region

*2.2.2.3 The European energy sector*

Most of the data for climate analyses and policy planning come from NMSs and NMHSs, private companies and free services (European and United States Websites). Raw or partially analysed data from those data providers are welcome in this regard.

*2.3 Present status of communication between users and providers of climate information*

*2.3.1 The Pacific island region*

Over last few years, many users have started to become more aware of what types of climate information are available either from their local NMHS or other national or regional centres but in many cases the value of such information is still not fully understood or appreciated. The misconception that products produced by regional centres are of better quality than those produced by local NMHSs quite often creates confusion and mistrust of their local NMHSs. Users tend to take regional products on face value without questioning their relevance to one’s locality. Probabilistic forecasts are still not well understood by many end-users because some decision systems are not yet opened to probabilistic inputs and local languages are lacking proper terminology for probabilities.

The NMHSs have started to work closely with the users and have a better understanding of what their needs are, but often due to limited resources are unable to meet those needs. Through regional initiatives such as the Pacific Islands Climate Prediction Project (PI-CPP), PEAC and ICU, NMHSs have become more aware of information made available by regional and global centres. A lot of work has been done in this area under PI-CCP and PEAC projects through implementation of pilot studies. In most cases, users know what their requirements are and in what format the information and the products should be, but this varies from one country to another.

In most Pacific island countries, NMHSs are the key contact for local climate information and services but occasionally the NMHSs find themselves competing with other more renowned national or regional centres. Many Pacific island countries’ NMHSs now have a very constructive working relationship with some users. The NMHS and user network has been established in many countries. Regular contacts via phone, e-mail, meetings, etc. are now common means of communication. Regular users of climate information provide regular feedbacks to NMHSs.

The PI-CPP has demonstrated that in order to implement successful climate information and services, a partnership between the NMHS and the relevant user group should be established, and the benefits should be demonstrated through pilot schemes. Information and products should be sector-specific and practical. In addition, NMHSs should be in a position to sustain this service for the long term. In the Pacific island region NMHSs quite frequently struggle to demonstrate benefits of using climate information.

*2.3.2 The South-East Asia region*

The regional climate information providers of South-East Asia are associated with the ASEAN forum on Science Committee on Meteorology and Geophysics. There is an annual meeting to discuss the regional issues related to weather and climate service delivery. At the national level there are, for example, user and provider forums for climate information services for the water sector. In this monthly forum, the climate outlook related to water and energy sources is discussed and preparations for action taken for the next projected outlook. The agriculture sector uses the national forum to discuss possible climate for the next plantation season. Major decisions include the need for a national rice import policy. For the regional forums on disasters such as smoke haze, the well established specialized meteorological centre for South-East Asia monitors smoke haze distribution to minimize risks from dispersion due to long drought, and anticipates better regional climate outlooks in this matter.

*2.3.3 The Greater Horn of Africa region*

The IGAD Climate Prediction and Applications Centre disseminates/communicates the seasonal climate outlook at the beginning of each rainy season through an innovative process that was initiated by a WMO Climate Information and Prediction Services project, in collaboration with NMHSs and regional/international climate centres, among many other partners. This process is known as the Regional Climate Outlook Forum (RCOF). This process includes a pre-RCOF capacity-building component for climate scientists to improve the understanding of the regional climate processes, among others. The RCOF process is usually followed by regular releases of 10-day and monthly climate updates.

The Climate Outlook Forums have made enormous contributions to the improvement of the quality of the seasonal rainfall outlook and dissemination of climate information and prediction products in the region. The forums bring together climate scientists, policymakers and the general user community. The forums have proved beyond doubt that pre-disaster mitigation strategies through optimum use of climate information and products can contribute enormously to sustainable development in the GHA subregion

### *2.3.4 Southern Africa*

Regional Climate Outlook Forums have completed ten years of successful operation in different subregions of Africa. Three RCOFs, namely the Greater Horn of Africa Climate Outlook Forum (GHACOF), Southern Africa Regional Climate Outlook Forum (SARCOF) and Prévision Saisonnière en Afrique de l'Ouest (PRESAO) have successfully sustained regular real-time operations throughout this ten-year period. Despite the challenges of resources and human and infrastructural capacities, African RCOFs have achieved remarkable progress in regional networking and user liaison, and have substantially contributed to capacity-building and user awareness, particularly in developing and least developed countries. The RCOFs in various forms and sizes are now in operation serving more than 10 subregions around the world, and concerted efforts are being made to extend the concept to several other regions. The long African experience, coupled with the varied strategies adopted by the other RCOFs suiting their own local needs, will be of immense value to guide and develop such initiatives. A proposal to organize a suitable event to commemorate the completion of ten years of RCOFs in Africa has been enthusiastically embraced by all the RCOF leaders in Africa, and also their various partner agencies.

Recognizing that climate information including predictions/outlooks could be of substantial benefit to many parts of the world in adapting to and mitigating the impacts of climate variability and change, WMO has helped establish RCOFs across the world with an overarching responsibility to produce and disseminate a regional assessment (using a predominantly consensus-based approach) of the state of the regional climate for the upcoming season. Built into the RCOF process is a regional networking of the climate service providers and stakeholders including user sector representatives. Participating countries recognize the potential of climate prediction and seasonal forecasting as a powerful development tool to help populations and decision-makers face the challenges posed by climatic variability and change. National and regional capacities are varied but certainly inadequate to face the task alone. In parallel, NMHSs and some decision-makers have come to realize the potential benefits to be gained and have played larger roles in the processes. Ownership now lies largely with national and regional players, but there is a continuing need for support at all levels to ensure that the momentum gained to date is maintained.

The RCOFs bring together national, regional and international climate experts, on an operational basis, to produce regional climate outlooks based on input from NMHSs, regional institutions, Regional Climate Centres (RCCs) and Global Producing Centres of long-range forecasts and other climate prediction centres. Through interaction with sectoral users, extension agencies and policymakers, RCOFs assess the likely implications of the outlooks on the most pertinent socio-economic sectors in the given region and explore the ways in which these outlooks could be used. The RCOFs also review impediments to the use of climate information, experiences and successful lessons regarding applications of the past RCOF products, and enhance sector-specific applications. These RCOFs then lead to national forums to develop detailed national-scale climate outlooks and risk information including warnings for communication to decision-makers and the public at large.

### *2.3.5 South America*

Since the publication of the IPCC Fourth Assessment Report, the subject of climate change has been notoriously installed in the public agenda, and many countries, with or without regional climate change assessments are on the path to evaluating the possible impacts that different sectors will face in the climate change context. Many nations, such as Chile and Argentina, are doing this as input to their national communications. However, the two communities – climate modellers and climate impact researchers – have only recently started to communicate, and there is a clear need to bridge the gap of temporal scale that these communities are accustomed to working with.

Up until recently (with the possible exception of the European project ENSEMBLES) the climate modelling community has worked with projections for the end of century, when the climate change signal is expected to become large. On the other hand the climate impact community is more worried about the coming decades, relevant for planning adaptation strategies.

Although regional climate change simulations are planned to be carried out, the current generation of climate models that will be used as lateral boundary conditions do not account for the decadal-scale variability ultimately needed for robust or even meaningful climate change simulation for the coming decades. In technical terms, as Giorgi [5] explains, the first community sees the problem as a boundary condition problem, whereas the second community is actually trying to resolve an initial boundary condition. This timescale gap will be partially overcome by the next generation of atmosphere-ocean general circulation model simulations, the Coupled Model Intercomparison Project (CMIP5) in preparation for the IPCC 5th Assessment Report as those simulations will be set up to provide decadal predictions.

With respect to climate variability, in South America there has been a long-standing effort to further understand and exploit the predictability at intra-seasonal to interannual timescales related to ENSO. The IRI and Regional Climate Outlook Forums have played an important and active role in this area.

Much less investigation has been carried out on climate variability on the decadal scale, but there is also a general acknowledgement that the Pacific Decadal Oscillation or PDO has a relevant role in modulating the climate in various parts of the region (south-eastern South America, central Chile, Patagonia, etc).

*2.3.6 The European energy sector*

The degree to which users know what types, quality and value of climate information and services already are available depends on the regions and the application sectors. This regional and sector dependency can be illustrated for instance in the energy sector, which is one of the most important users of weather, climate and water data and forecasts in developed countries, but not in developing countries, where energy infrastructures themselves are hardly existent. The NMHSs and NMSs are clearly in the best position to provide users – national authorities, private companies and the public in general – with information about the types and quality of climate information and services. As for the value of data and services, the problem is more complex, as its evaluation needs collaborative work with the users, a complex task that is often not obvious.

However, decision-makers in companies are becoming more and more aware of the influence that climate and weather variability may have on their businesses. Weather risk can be divided according to the timescales involved. Long-term risks are mostly related to climate change. In the following, we will concentrate on shorter timescales, ranging from a few hours to up to a year. On these timescales two types of climate phenomena are important: (a) extreme events (storm, flooding, heatwaves) and (b) normal climate variability.

Extreme events are mainly covered by traditional insurance contracts and by mitigation strategies to reduce or limit the damage they may cause. The impact of natural climate variability is less obvious than the impact of catastrophic events. In weather-sensitive industries like the energy sector, agriculture, retail – to name a few – weather and climate variability may have a very important impact on turnover and profit. The reasons companies manage climate exposure are various:

(a) Protection against extreme events (insurance);

(b) Hedging weather exposure (natural variability) using weather derivatives and/or insurance contracts;

(c) Legal requirements (gas and electricity supply);

(d) Shareholders and/or investors who ask for proper management of weather related risks.

For proper weather risk management, companies need actionable weather information. The information must be locally adapted, it must be relatively easy to understand and the data provided must be coherent with historical data and with predicted data.

Some large weather-sensitive companies – like large energy providers – have their own climate department, for example, Electricité De France (EDF). They are able to do the necessary transformations to obtain exploitable information, but today such companies are still the exception. The vast majority of potential users of climate and weather information need data that are prepared according to their needs. The processing of raw weather information to a decision can be split into four steps:

(1) Transformation of raw weather and climate data into coherent datasets: The data are subject to quality control. Measurement error, steps (due to change of instruments or the modifications of the environment), artificial drift, etc., are removed. Furthermore, it would be desirable to obtain coherence between historical data and predicted data.

(2) "Localization" of the data: Timescales and spatial scales are adapted to the individual needs of each user. It can be envisaged to prepare standard sets of such data for specific user groups. Downscaling methods – statistical or dynamical – are needed for this purpose.

(3) Quantifying the impact of weather and climate phenomena on the business of a specific company or a specific sector: Since weather is not the only factor that influences business it is important to include other influencing factors (macroeconomic factors, calendar data) in such studies, and to investigate interactions with the weather data.

(4) Transformation of the estimated impact and the corresponding uncertainties into a decision.

The first step is carried out by private or national and international weather services. The transformed datasets provide the raw material to manage weather exposure, and no adaptation to specific user needs is required. National and international weather services must ensure that the data types provided correspond to the needs of potential users. Those needs may evolve over time and it is important that the weather services maintain close relationships with the user community. An example for new data requirements is the wind energy sector. The size of the wind turbines has considerably increased and nowadays wind data and forecasts at an altitude of about 100 metres above ground are needed, whereas 10 years ago this altitude was more of the order of 50 metres. If such a change occurs it is important not only to update the forecasts, but also to provide coherent historical records of those new data.

Step two represents the first step of specialization. It can be envisaged as the preparation of standard datasets for groups of users. However, in most cases this is probably an on-demand service. In response to a specific request from a user, data are downscaled and adapted individually. Due to their experience with downscaling methods, weather services can offer this type of on-demand service, but private companies can equally well fulfil this task.

Step three is even more specific. The influence of weather variables interacting with other factors on the variables of interest of a user has to be quantified. This task can probably best be fulfilled by private companies that provide the link between weather and socio-economic factors.

Steps one to three are needed to provide information as a basis for a decision. The fourth step is to actually take a decision. This process is not at all trivial and appropriate methods may change from one user to another. Companies typically have developed methods for decision-making and they will apply their methods to the information supplied. In most cases companies will not apply a decision-making method they are not 100 per cent familiar with. Weather services and companies working on weather data can, of course, provide their experience gained in the field of probabilistic forecast systems and decision-making, but standard decision-making methods offered by weather services probably will not find broad acceptance.

Probably the greatest challenge facing NMSs and NMHSs is their ability to understand and answer the users' needs. Weather services have traditionally provided forecasts with little or even no input from the users of their products and services. On their side, users generally do not try to influence the information and service providers essentially because they are not experts in the field. This gap between users and providers results in an underutilization of the available information and the development of services that do not necessarily meet the users' needs. There is clearly a need to shift from weather forecasting to risk forecasting, a current limitation on effective risk forecasting being our ability to link vulnerability and weather information, and to make this product available in a timely and useful format.

## 3. Delivering regional climate information based on regional circumstances

In general the user expectation is that the climate information service provider should be able to provide timely climate information of the highest quality; should have the capacity to tailor information to specific user needs; and should be contactable. Specifically the user need could be as follows:

(a) Regional interpretation of climate change information (for example, IPCC Assessment Report terminology of probability);

(b) Establishment or strengthening of regional forums for information exchange among users and between users and providers (for example, exchange of information on best practice; types, quality and value of information; feasible relationships between users and providers);

(c) NMHSs role in delivering regional climate information, bridging the gap between the science community and the end-users, with their expertise on weather and climate and the impacts on the society in the country.

### *3.1 The South-East Asia region*

It is clear that the countries of South-East Asia are gradually working towards setting up systems for effective application of climate forecast information. However, there is a long way to go before the benefits can be realized. On the applications side, three key issues need to be addressed:

(a) Building historical databases of sectoral impacts to continually improve the understanding of impacts of climate variability on different sectors;

(b) Capacity-building of user organizations to translate climate forecast information into usable information for decision-making purposes;

(c) Setting up systems to continually evaluate the usability of forecasts and to improve methodologies to translate forecasts into actionable information.

In Indonesia, national climate-sensitive organizations, on receipt of the climate forecast information from BMG, process the outlook with reference to past impacts, and disseminate processed information to provincial sectoral organizations. At present, these forecasts are used as a general alert. Information is received by national-level user agencies from the field agencies only when disaster events occur. The processed forecast information received at the national level is useful for taking general precautionary measures but cannot be used for comprehensive development planning.

In the Philippines, the Departments of Agriculture, Water Resources and Public Health have well-defined mechanisms as end-users for receiving forecasts from the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) at the national level, and processing and disseminating it to regional and subregional levels. The Department of Agriculture, on receipt of advisories from PAGASA, analyses potential impacts on agriculture production. Based on this information, the department prepares a vulnerability map for each of the country's 12 regions. These maps are then reviewed with agriculture research institutions and other agencies such as water resources and irrigation departments and food security agencies.

After receiving inputs from these organizations, the department makes modifications to the maps as necessary. The final processed information is passed on to regional agricultural departments. The National Water Resources Board (NWRB) and the National Power Corporation (NPC) assess the potential impacts through reservoir operation simulations after receipt of forecasts from PAGASA. These simulations determine the projected available water in reservoirs and serve as the basis for water releases or allocation to various users. The Department of Health recently established a mechanism to use the forecast information from PAGASA in planning for contingency measures to deal with waterborne diseases [6].

Until recently in Viet Nam, ENSO global forecast information was not incorporated into national seasonal forecasts. The Hydrometeorological Services (HMS) uses antecedent parameters such as Eurasian snow cover and ITCZ to make seasonal forecasts. After the initiation of the Extreme Climate Events (ECE) Program, HMS began to incorporate long-range forecast information into seasonal forecasts. The forecasts are received from a range of agencies including ASMC and NOAA. In view of these developments, the importance of regional climate outlooks for Viet Nam has increased. The seasonal forecast information provided by HMS is used by climate-sensitive sector agencies like agriculture and water resources, and the Disaster Management Center, only as a general alert. These departments have a well-established mechanism to monitor situations created by natural hazards. However, much progress is needed to make full use of climate forecast information for development planning [6].

*3.2 The Greater Horn of Africa region*

The IGAD Climate Prediction and Applications Centre, NMHSs and partners have also undertaken a number of pilot application projects aimed at assessing and communicating examples of the successful use and impediments in the use of seasonal climate prediction products; development of new methodologies for better production, dissemination, interpretation, use and evaluation of climate information and seasonal prediction products in the reduction of climate related risks; and development of new applications tools that enable decision-makers to take advantage of seasonal forecast information. These have made enormous contributions to the improvement of the quality of the seasonal rainfall outlook, the interaction of users from various sectors and the overall awareness, education and improved dissemination of climate information and prediction products for early warning and disaster management.

Some examples are highlighted below.

*3.2.1 Agriculture and food security outlooks*

Seasonal regional agriculture and food security outlooks are now released regularly with Famine Early Warning Systems Network (FEWSNET) and other partners based on RCOF products. These products are developed through pre-RCOF capacity-building workshops by climate and agriculture/food security experts. The outlooks are being used by the regional governments that have responded to the projected food deficits through advisories for mixed cropping, shifting of planting location, changes in crop types (for example, from maize to millets) and early food imports, among many other interventions.

*3.2.2 Health outlooks*

Vector-borne diseases are sensitive to changes in meteorological parameters such as rainfall, temperature and humidity. Climate extremes such as floods and droughts are very common in the Greater Horn of Africa (GHA). This makes the GHA very vulnerable to the outbreaks of malaria, cholera, Rift Valley Fever (RVF) and many other vector-borne diseases. The NMHSs, ICPAC, World Health Organization and other regional partners now release regional malaria outlook information regularly based on RCOF products.

*3.2.3 Water resources and hydropower sector*

Some efforts have been made in the region to reduce climate risks associated with the negative impacts of extreme climate events on water and hydropower resources through good understanding of the climate patterns of the previous events and their linkages with the regional hydrology cycle; enhanced monitoring; and effective and timely early warnings. Pre-RCOF capacity-building workshops on streamflow forecasting are held regularly, and also address expectations in regional hydropower generation risks.

*3.2.4 Enhanced dissemination of climate early warning information*

Timely availability of climate information in a user-friendly language is critical to the effective application of climate products and information. Most of the users of climate information in the GHA are illiterate, and the majority live in the rural areas where tribal/clan languages are the only mode of communication. Women and children are often impacted most by the climate hazards. The NMHSs, ICPAC and the media have developed partnerships to ensure climate information is downscaled, translated into local languages, and disseminated in a timely manner to enable the communities to develop community-specific disaster risk reduction strategies, including integration of indigenous knowledge

*3.3 Southern Africa*

The RCOF process, pioneered in Africa, typically includes the following components:

(a) Meetings of the regional and international climate experts to develop a consensus for the regional climate outlook using national, regional and global information, typically in a probabilistic form;

(b) The Forum proper, which involves climate scientists, representatives from the user sectors and the media for identification of impacts and implications, and for the formulation of response strategies;

(c) A training workshop on seasonal climate prediction to strengthen the capacity of the national and regional climate scientists;

(d) Special outreach sessions involving media experts, to develop effective communication strategies.

The consensus prediction process that underlines RCOF operations consists of the following elements:

(a) Determine the critical time for development of the climate forecast for the region in question;

(b) Assemble a group of experts:

  (1) Large scale prediction specialists;

  (2) Regional and local climate applications and forecast/downscaling specialists;

(3) Stakeholder representative of climate-sensitive sectors;

(c) Review current large scale (global and regional) climate anomalies and the most recent forecasts for their evolution;

(d) Review current climate conditions and their impacts at local, national and regional levels, and national-scale forecasts;

(e) Considering all factors, produce a forecast with related output (for example, maps of temperature and precipitation anomalies) that will be applied and fine-tuned (downscaling) by NMHSs in the region to meet national needs;

(f) Discuss, with active involvement of stakeholder representatives of climate-sensitive sectors, applications of the forecast and related climate information to climate-sensitive sectors in the region;

(g) Consider practical products for development by NMHSs;

(h) Develop strategies to effectively communicate the information to decision-makers in all affected sectors.

*3.3.1 Regional Climate Outlook Forum contributions*

The Regional Climate Outlook Forums have facilitated regional cooperation and networking, and have effectively demonstrated the immense mutual benefits of sharing of climate information and experience. Close interaction between the providers and users of climate information and products of the process has enhanced feedback from the users to climate scientists, and has catalysed the development of many user-specific products.

The Regional Climate Outlook Forums have significantly contributed to adaptation to climate variability. The concept has the potential to be extended to develop our capacity to adapt to climate change. The RCOFs can be effectively expanded to cater to the needs for developing and disseminating regional climate change information products.

The RCOF process has facilitated a better understanding of the links between the climate system and socio-economic activities. An increasing demand for climate services has been recorded in many parts of the world as a result of these developments. Awareness has been created that climate information, including short-range climate predictions, is an essential element in mitigating the impacts of climate variations. The RCOFs have fostered interactions and exchange of information between the climate scientists and users of climate information especially at decision- making levels. More importantly, they have facilitated the mainstreaming of regional cooperation and networking, and have effectively demonstrated the immense mutual benefits of sharing of information and experience.

Regional Climate Outlook Forums are in operation in many parts of the world, mainly serving developing countries.

*3.3.2 Role of Regional Climate Outlook Forums in meeting sectoral needs*

In many regions, the users benefiting from the RCOFs are true stakeholders, contributing to the organization and growth of the sessions, thus ensuring their sustainability and applicability to user needs. Typically, RCOFs attract the participation of practitioners and decision-makers from sectors including:

(a) Agriculture and food security;

(b) Water resources;

(c) Energy production and distribution;

(d) Public health;

(e) Disaster risk reduction and response;

(f) Outreach and communication.

Based on the seasonal temperature and rainfall predictions, and using the present soil moisture conditions, river runoff for the season is predicted in some of the RCOFs. This information is very useful for water managers and helps them in making decisions on water allocations among various uses and for hydropower generation planning. Regional agriculture and food security outlooks are now regularly produced based on the climate outlooks after the RCOFs in some regions. This information is very important in planning food grain reserves and distribution. Based on the needs of specific sectors, specialized, sector-oriented outlook forums, such as the Malaria Outlook Forums (MALOFs) are being held in conjunction with RCOFs in Africa.

The Drought Monitoring Centre has made a great impact in the SADC member states and many users have publicly acclaimed the services and products as being of upmost importance to their operations. One of the principal target beneficiaries of the products are the NMHSs, which are members of disaster preparedness and management committees consisting of government ministries and departments. These committees are mandated to formulate policies and at times supervise the exercises and recommend ways of providing emergency food relief to disaster-stricken areas. Other players such as the private sector, non-governmental organizations and parastatals are co-opted into the committees as the need arises.

*3.4 The European energy sector*

Reducing risks associated with weather, climate and water and their future changes will necessitate acting in three directions [4][7]: by improving weather and climate data and forecasts; by improving the communication between providers and users, and by improving the users' decision-making processes. All three of these fields are of equal importance, and any deficiency in one of them is likely to seriously affect the whole chain. If the first and the third points are to be treated mainly by providers and users respectively, the problem of communication has to be addressed in close cooperation, because it is the essential link between the communities, and will condition the development of useful products and services that will be used efficiently, for the benefit of the electricity sector, and, in consequence, of the whole society. At the regional and international levels, WMO and other international institutions (WBC-World Energy Council, or International Air Transport Association, for instance) play major roles as facilitators, notably by providing recommendations and guidance. But a crucial element is a close collaboration at the regional, national and local levels between NMSs, NMHSs or private weather companies and users.

For example, EDF has developed, in the last 30 years, national and international collaborations with both scientific institutes and operational centres, among which Meteo France, the French National Weather Service, has a central role. This partnership is based both on common research projects with the Centre National de Recherche Météorologique, Meteo France's research centre, and on commercial contracts for the provision of data and forecasts. In addition to existing catalogue products, specific needs are generally addressed in partnership from the description phase to the final product delivery. The common process is to develop ideas based on operational needs in the frame of research projects, which, if they are successful, are then tested in near-operational conditions. This phase of evaluation is then transformed into a commercial contract when the usefulness of the new product or service has been determined. Of course, new products can then benefit other users and sectors.

To ensure a good communication between EDF and Meteo France, coordination teams have been formally set in place, formal meetings with feedback and event review mechanisms take place at least twice a year and complementary technical meetings are held on demand. This organization has proven very efficient in increasing the quality of communication and mutual understanding. It relies essentially on the ability of both parties to communicate. This example could be followed by other companies and in other sectors. In developing countries in particular, upstream communication between providers and users of weather, water and climate information should be emphasized in order to rationalize the investments in observing and forecasting services, as their efficient and adapted use in different socio-economic sectors is a key component in their development.

We think such experiences could be used to emphasize their benefits to others sectors/users. A way to achieve this would be to organize regional workshops aimed at presenting best practices, and collecting needs. These workshops could use different approaches:

(a) The sectoral approach, in which people from major sectors from all over the world could share their experience and best practices;

(b) The regional approach in which users from the same region but from different sectors could discuss their specific needs, current answers and potential developments based on geographical, regional and legal requirements.

Cost-benefit analyses for climate information and service systems are useful for providers, as they can comfort the authorities in their funding decisions. They are also useful for the users in order to establish the economic value of weather, water and climate data and forecasts in their applications. However, although some case studies have been done in the past decades, the Madrid Conference preparatory regional workshops showed that only a few quantitative evaluations of the benefits of weather services have been realized at the national scale [1]. This once again calls for the organization of national and regional workshops to develop the methodologies of economic evaluation, establish partnerships and set up pilot demonstration projects.

## 4. Future plans

It is clear that some regions are gradually working towards setting up systems for effective application of climate information. However, there is a long way to go before the benefits can be realized. On the applications side, four key issues need to be addressed:

(a) Building strong historical databases of sectoral impacts to continually improve the understanding of impacts of climate variability on different sectors, especially the socio-economic benefits;

(b) Capacity-building of user organizations to translate climate forecast information into usable information for decision-making purposes;

(c) Setting up systems to continually evaluate the usability of forecasts and improve methodologies to translate forecasts into actionable information;

(d) Streamlining climate information policy and management into climate-sensitive sectors to optimize the operational and planning of the respective sectors.

The Regional Climate Outlook Forums stimulate the development of climate capacity in the NMHSs and do much to generate decisions and activities that mitigate adverse impacts of climate and to help communities adapt to climate variability.

## 5. Conclusions and recommendations

The specific needs and priority areas for climate services vary from region to region. Some regional centres are already developed and should be the models for the development of other regional centres. National Meteorological and Hydrological Services should learn how to interface with users to reshape their services to produce more effective use of climate information. Some regions face an urgent need for capacity-building to develop better climate services since the need for services is growing and the present level is inadequate for the massive service delivery required. Data and information provision should be supported by developed countries to leverage the capacity within regions in order to achieve less disparity among climate service capabilities across regions.

There is a need to develop regional climate analysis tools using basic climate information and data, and to increase knowledge of risk minimization through the utilization of climate information. Moreover, early warnings should be based on the sound analysis of risks. Risk and vulnerability assessments to identify areas and populations at risk to hazards are high needs. Further needs include: strengthening of weak links in the research on early warning systems for flood forecasting (especially for flash floods); promoting of the use of satellite technology for precipitation estimates; and encouraging information exchange to mitigate disaster risk and to reduce the impact of disasters on society. Finally, there is a need for adequate and proper links with national disaster management authorities to increase public awareness of the climate information that NMHSs have provided in order to reduce the risk of disaster due to climate and weather phenomena.

Following are the recommendations to address these needs:

a) Reconstruction of a better climate data management.

b) Capacity-building of user perception especially the sectoral user needs based on regional climate characters.

c) Regional cooperation in delivering climate information with regard to common issues especially the transboundary issue.

d) Need to increase NMHS personnel capacity by training in communicating forecasts and related uncertainties in climate prediction.

e) NMHSs to establish partnership with the user community to enhance dissemination of climate information and to acquire relevant feedback from the climate information they provide.

f) Need to have more pilot or demonstration projects on climate information applications and products as well as socio-economic benefits of the climate information.

g) Enhance capacity of climate prediction modelling in developing countries as well as better provision of climate modelling input from global data products, reanalyses and integrated observing systems.

h) Education of more intermediaries to translate NMHS product languages into user perceivable language in all climate-sensitive sectors.

i) Regular and updated meetings among regional NMHSs and with users in sectoral institutions.

j) Need to include active participation of private companies in evaluating risk management and calculation of financial risk benefit.

k) A key area is the design and delivery of climate information and prediction products that satisfy the needs of end-users.

l) Need to include disaster management authority to assess the climate impact, vulnerability and risks at national and regional levels.

m) Need for internationally agreed means of communications to disseminate warnings to specific authorities in the region such as the regional disaster association.

n) There is need for adequate funding in order for the region to make realistic programmes for effective disaster preparedness and management.

o) Warnings to be disseminated must be based on best available technical and scientific knowledge.

p) Exchange of warning information must be timely and access unrestricted between countries, particularly regarding cross-border hazards.

q) Warnings must be accurate and reliable in line with international standards, protocols and reporting procedures.

r) Collaboration with other specialized regional centres.

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