Report of WMO Conference on

# Living with Climate Variability and Change: Understanding the Uncertainties and Managing the Risks

Espoo, Finland, 17 – 21 July 2006

FINNISH METEOROLOGICAL INSTITUTE

The International Research Institute for Climate and Society

World Meteorological Organization
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# WORLD CLIMATE PROGRAMME

## WORLD CLIMATE APPLICATIONS AND SERVICES PROGRAMME

# Report of the WMO Conference on Living with Climate Variability and Change:
## *Understanding the Uncertainties and Managing the Risks*

**(Espoo, Finland, 17 – 21 July 2006)**

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**World Meteorological Organization (WMO)**
**Finnish Meteorological Institute (FMI)**
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# Greetings from the President of the Republic of Finland

Climate change is a global problem that requires a global solution. The United Nations Framework Convention on Climate Change stresses differentiated responsibilities – some of us have emitted more greenhouse gases, and others have more resources to address the problems caused by those emissions. But the Convention also includes the concept of common responsibilities – all of us are part of the problem, and each of us can do something.

This conference is an excellent example of the way we can pool our scientific resources to better understand the problem, its underlying causes and its impacts. It is important to bring together professionals from various disciplines in both the private and public sectors and to bridge the communication gap between the decision-makers and researchers. Combining real-world experience with climate knowledge and information is crucial if we are to successfully manage the climate-relate risks.

Global systems are needed to create the institutional and legal framework for joint efforts. The United Nations provides us with that framework. The European Union looks forward to exploring with other countries ways and means of further enhancing action under the Climate Convention and strategies for achieving the necessary emission reductions.

I hope you have fruitful and lively discussions, and that the environment around Dipoli in Espoo inspires you in achieving your goals.

**Tarja Halonen**

**The President of the Republic of Finland**

# FOREWORD

Managing climate risks has been one of the biggest challenges of the society worldwide. Addressing this needs a global approach, to pool our capacities to better understand climate variability and change, its underlying causes and impacts, followed by development and implementation of appropriate coping strategies. Substantial efforts will be required to design risk management decision systems in a variable and changing climate. These decision systems should have the capability of using climate information along with the inherent uncertainty for risk management. With recent advances in climate science and technologies, there are many opportunities to better represent uncertainties and better manage climate risks. The emergence of globally integrated and multidisciplinary programmes involving WMO and partners worldwide has greatly facilitated the development of appropriate frameworks and facilities to support climate risk management.

The WMO Conference on "Living with Climate Variability and Change: Understanding the Uncertainties and Managing the Risks" was organized to review the opportunities and constraints in integrating climate risks and uncertainties into decision-making in the core socio-economic sectors. The Conference, co-sponsored by the WMO, the Finnish Meteorological Institute (FMI) and the International Research Institute for Climate and Society (IRI), brought together climate scientists and user communities, to collate their experiences in managing risks of climatic origin and to build a framework for future strategies. The Conference drew on experience presented by experts from both private and public organizations. It also benefited from poster presentations by participants as well as from discussions during plenary and breakout sessions. The main results of the Conference are synthesized in the "Espoo Statement", included in this report.

The Conference discussions were aimed at a synthesis of risk management across social, economic and environmental sectors. It examined how people's awareness of the need to improve risk management evolved, and the critical role of climate information in supporting these improvements. Integrating the knowledgebase within the climate and climate-sensitive sectors through active involvement of all key stakeholders will be a key step forward to support adaptation to climate variability and change. WMO's programmes and activities, aided by other closely related events such as the Madrid Conference in 2007 and World Climate Conference-3 in 2009, and in collaboration with a wide range of partners, are following up with well-coordinated initiatives to provide a global framework to promote better use of climate information in decision making. An effective interface between climate and climate-sensitive sectors to enhance coordination, stakeholder engagement and dialogue, awareness and effective partnerships is recognized to be a key requirement in this regard.

I am grateful to the many donors, participants, lecturers and organizers who made this conference possible, and especially to the FMI and its staff, for the excellent arrangements made to ensure its success. I also appreciate the efforts of Dr M. Coughlan of the Bureau of Meteorology, Australia, who chaired and actively coordinated the Scientific Organizing Committee for the conference. I hope that the summaries and syntheses of discussions and recommendations presented in this report will be a valuable source of information to the wide range of institutions, organizations and consortia of organizations engaged in supporting the society to deal with climate variability and change.

(M Jarraud)
Secretary-General

# Living with Climate Variability and Change:
# Understanding the Uncertainties and Managing the Risks

## Espoo Statement

The participants of the WMO Conference, cosponsored by FMI and IRI, on "Living with Climate Variability and Change", held in Espoo, Finland July 17-21 2006, being experts in natural disasters, public health, energy and the built environment, water resources, agriculture and food security, decision-related sciences, and policy and climate, declare as follows:

We recognise that every major social, economic and environmental sector is sensitive to climate variability and change, both of which are significant factors in each sector's sustainable development.

We agree that policy formulation and operational decision-making in climate sensitive sectors will be improved by more widespread use of climate knowledge and information in managing risks and exploiting opportunities (collectively referred to as climate-related risk management).

We recognise that the process of developing effective 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.

We note that climate-related risk management requires multidisciplinary collaborations and the cross-disciplinary exchange of information, such as can be achieved through interfacing institutes and processes.

We believe that on-going collaboration at national and regional scales between sectoral partners and climate information providers will benefit all parties. We note further 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.

We recognise the need for efforts to assemble disparate knowledge, to identify good practice, and to assess the value of and give visibility to climate-related risk management.

We recommend 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.

These mechanisms could promote:

- evaluation of current climate-related risk management in all relevant sectors
- better assessments of the value of climate-related risk management
- establishment of data sets necessary to inform decision making

- research to improve climate-related risk management
- development of decision-support tools
- capacity building in climate-related risk management
- on-going evaluation of outcomes
- the use of suitable financial mechanisms in support climate-related risk management.

We request that these recommendations be considered by WMO, other UN System organizations, and sectoral and development organizations operating at national, regional and international levels.

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Participants of the LWCVC outside Dipoli, the conference venue in Espoo, Finland.

# Conference Summary

Climate can no longer be taken for granted. Three factors are increasingly drawing attention to the need for more urgent and purposeful adaptation to changing climate conditions and the management of climate-related risks:

- The world's socio-economic structures are becoming increasingly global in scale and reach;
- The climate system is changing more rapidly; and
- Losses associated with climatic hazards are rising.

The WMO Conference on "Living with Climate Variability and Change", co-sponsored by the Finnish Meteorological Institute (FMI) and the International Research Institute for climate and society (IRI), was a result of the request made by the Fourteenth World Meteorological Congress in 2003 to the Secretary-General of WMO: to organize a multidisciplinary conference on decision processes in climate applications, designed to ensure that the outcomes and recommendations are applicable to the roles and functions of the National Meteorological and Hydrological Services (NMHSs). The conference set out to review the opportunities for, and constraints to, integrating climate risks and uncertainties into the mainstreams of decision-making for those activities where there is identifiable sensitivity to climate variability and change.

The focus of the conference was on decision-processes in real-world contexts, including agriculture, water resource management, human health and disease control, the built environment and disaster risk reduction. Particular attention was also focused on generalized decision-processes, including principles of risk assessment and management within broader institutional and policy frameworks. The conference drew on the experiences of public and private organizations, as well as individuals, engaged in managing risks including those of a climatic origin. Participants numbering 263 from 62 countries attended the conference.

With decision-making as its focus, the conference recognized that, in predicting uncertain events, one part of the human brain acts as an analytic system while another part acts as an experiential system. The discrepancy in output of these two systems often accounts for controversies and debates about the magnitude and acceptability of risks. In effect, the weighting given to the output from each system becomes an issue.

It is inevitable that many decisions lead to dilemmas over how best to distribute resources from a 'common pool'. Interactive cooperation and mutual trust are of fundamental importance in resolving deadlocks that arise over paths and priorities, and can be facilitated by appealing to the social identity of people.

The conference agreed that communicating and managing climate related risks can be aided in a constructive way by calling on both experiential and affective processing, as well as on the general aversion to uncertainty that exists in most communities. Suitable approaches may even involve appeals on more emotional levels.

The conference further agreed that the inherently uncertain nature of information on climate patterns in the future implies both liabilities and opportunities. Further, information needs to be presented in ways that take into consideration how humans process information, and aim to minimize the liabilities and maximize the opportunities. Ignoring this 'human' factor can cause many problems to seem more intractable than they really are.

The conference encouraged increased interactions between the climate information suppliers and users to exploit opportunities through the application of risk management methods. Recognizing that there are commonalities between the various sectors represented at the conference, these interactions will work best when:

- A common decision making typology is created and used;

- The needs for data and information, climate data included, are explored through multi-purpose programs on all planning horizons and at all spatial scales relevant to the targeted societies;
- Institutes and policies direct attention to the interfaces between climatic and social processes;
- Capacity building needs are identified and augmented;
- Interdisciplinary communication is encouraged and fostered, for instance, by highlighting particularly difficult cases as well as successes;
- The needs of users are met through outcome-oriented approaches; and
- The cross-cutting natures of water, health and energy issues in particular are recognized.

Specific outcomes achieved and summarised in the Final Report include:

- A review and synthesis of efforts to date in the management of risk across social, environmental and economic planning, encompassing all planning horizons;
- An examination of how people become aware of the need to incorporate or improve on their management of the risks associated with climate variability and change (in the context of capacity constraints and competing priorities), and a critical assessment the role of climate information in supporting overall risk management; and
- A review of the theory, practical techniques and challenges associated with the integration and blending of possibly disparate cross-disciplinary data and information for planning, making decisions and managing risks;

## General Recommendations

The conference agreed that government and non-government organizations should work individually and cooperatively in:

- The development of more systematic approaches to data and information requirements to enable societies to assess and manage climate and climate related risks across multiple planning horizons and spatial scales;
- Research and operational activities for reducing risks, for example through the establishment of public and sector specific early warning systems;
- The preparation and implementation of plans for enhancing the exchange of knowledge on methods and benefits of integrating climate information into policy and decision making; and
- Establishing processes that promote the systematic integration of climate information into development planning at regional and national scales.

The conference agreed in particular that, while considerable progress has been made within specific sectors, these common issues should form the basis of an on-going process to be taken up as a joint challenge by all the sponsoring organizations of the conference in consultation with other relevant institutions, recognizing that interdisciplinary interaction will be the primary element in taking up this challenge.

## Sector Conclusions and Recommendations

The principal conclusions and recommendations arising from the discussions within each of the conference sector working groups are as follows:

### *Decision Making*

Experiential and analytic processing systems often compete, and personal experience and vivid descriptions are often favoured over statistical information. Such 'realities' have research and policy implications.

(i) Communications that are designed to create, recall and highlight relevant personal experience and to elicit affective responses can lead to more attention being given by decision makers to the processing of forecasts of climate variability and climate change as well as to a greater public engagement.

(ii) Likewise, the translation of statistical information into concrete experience with simulated forecasts, decision making and its outcomes can greatly facilitate an intuitive understanding of both probabilities and the consequences of incremental change and extreme events, and also motivate contingency planning.

(iii) While the engagement of experience-based, affective decision making can make risk communications more salient and motivate behaviour, experiential processing is also subject to its own biases, limitations and distortions, which need to be recognized and corrected.

(iv) Ideally, climate forecasts and communications should encourage the interactive engagement of both analytic and experiential processing systems in the course of making concrete decisions about how to mitigate or adapt to global climate change.

(v) One way to facilitate this engagement is through group and participatory decision making, which will allow individuals with a range of knowledge, skills and personal experience to share diverse information and perspectives and work together on a problem.

(vi) Those communicating to groups should try to translate statistical information into formats readily understood in the language, personal and cultural experience of the group members.

### *Natural Disasters and Early Warning Systems*

There is a need for:

(i) A more rigorous process of scoping of the climate risk management client base and a segmentation of it with respect to needs and requirements;

(ii) Identification of decision-processes and relevance of climate information input within each target segment;

(iii) Development of products and services based on what science can deliver, along with systematic operational and reliable channels to provide appropriate products and services;

For more productive research and development, and to fill gaps in existing disaster mitigation and management systems:

(iv) Collection, archiving and distribution of disaster related data needs to be improved across all relevant sectors. In particular:

- increased resources should be devoted to basic data collection infrastructure, particularly in developing countries;
- effective, complete and accessible hazard databases should be developed, and made as widely accessible and frequently updated as possible, preferably through the Internet;
- data should be exchanged freely between countries and between sectors within countries;
- Suitably linked inter-institutional or intergovernmental structures should be identified or as necessary established for the collection of relevant environmental indicators and the setting of standards.

(v) Reviews should be undertaken at national and international levels to identify and forge any missing links between responsible agencies in the chains of responsibility and, that as an outcome of such reviews, all relevant agencies become fully aware of their respective responsibilities.

(vi) A comprehensive assessment should be made of the implications of climate change projections for identified risks of natural disasters and whether climate change will serve to increase or decrease those risks.

(vii) Tools in support of decision-making should be developed and placed on a systematic basis within institutions, to render them more robust to changes in key personnel.

(viii) National assessments should take place, guided by information provided by the outcomes of recommendation (iii) above, of how hazard risks are likely to change with changes in the climate and what strategies are available for adaptation in particular locations.

***Agriculture and Food Security***

To address the various interfaces between institutional arrangements in the usage of climate information and for greater effectiveness of planning processes within agriculture and its associated industries, especially for great food security:

(i) Climate information relevant to food production and distribution should become freely available through networking and collaboration between institutions that share overlapping objectives. This accessibility would enlarge the end-user-base and would allow achieving multiple objectives from a common pool of information

(ii) Inter-institutional capacities in the use, interpretation and application of climate information should be strengthened;

(iii) National agricultural and food chain policies, long-term strategies, development plans and programmes should factor in risks from climate variability and change;

(iv) Lack of legislation to support community should be overcome through better governance at national and local levels; and

(v) Information systems should be appropriately packaged:

   a. to explain why particular groups are vulnerable to climate shocks, and

   b. to guide the choice of intervention to reduce vulnerability.

***Human Health and Disease Control***

*With respect to improving decision-making in the health sector, it is important to:*

(i) Recognize the wide range of decisions that can help to protect health in a changing climate.

(ii) Give priority to "no regrets" interventions and place greater emphasis on assessing economic implications.

(iii) Pay greater attention to prioritizing interventions, and make best use of scarce resources.

(iv) Recognize that reliable and high quality surveillance systems are a pre-condition for disease prevention.

(v) Support climate-based early warning systems with effective action plans, and carry out continuous and iterative evaluation of their effectiveness.

(vi) Analyse, refine and replicate successful models of interdisciplinary decision-making.

With respect to research and development, there is a need to:

(vii) Generate support for evidence-based decisions through high quality studies that describe the links between climate and health, and that address how this can be taken through to changes in operational practice.

(viii) Place greater emphasis on understanding climate effects on health in the context of other influences.

(ix) Promote interdisciplinary collaboration in research between the health and climate sectors.

(x) Develop more stable and systematic interactions between the health and climate communities, including access by each community to the other's data.

(xi) Support international training in climate-health interactions and also national and community level capacity building.

***Water Resources***

Decision making in the water resources area could be improved through:

(i) Planning systems that are more long-term, in order to appropriately balance immediate needs with longer term issues such as adaptation to climate and other changes.

(ii) More effective translation of research knowledge and information to policy making processes, which in turn requires more effective communication of information from researchers to policy makers.

There are clear indications of a gap between the climate community and water resources practitioners. Relevant research and development areas that may facilitate the uptake of climate information by practitioners in water resources include:

(iii) A major effort to create global datasets of hydrologic variables that allow comparable analyses of climate impacts on hydrology and water resources. Such an effort should be built on the strengthening of local and regional streamflow data networks. Ultimately streamflow data is most useful to decisions in the local basin.

(iv) Exploitation of the links between water and, *inter alia*, economic development and health, to show the impact of variability and change and the benefit of data for designing measures for reducing those impacts.

(v) The need for a holistic approach to studying and managing river basins as human-hydrologic systems, which will have ramifications that reach far beyond the river banks.

(vi) Close collaboration between fields of climate and hydrology to explore the links between climate, water and aspects of development – a collaboration that requires accessing expertise in development.

(vii) Research, aligned with the needs of practitioners, into the use and value of forecasts and projections in water management, along with further research on early warning systems of floods and droughts.

(viii) Efforts to express the uncertainty of forecasts so as not to oversell their possible value in practical situations.

***Energy and the Built Environment***

In many countries, the infrastructure and built environment that exists today has been designed using climatic design values calculated from historical climate data on the assumption that past extremes will represent future conditions. Changes in climate will require changes to these climatic design values, as well as to larger societal changes.

Several factors motivate decision making processes in the energy and built environment sectors to respond to the challenges of living with climate change and variability. These factors and recommendations for attention in the context of climate variability and change can be summarised as follows.

- Risk management considerations that provide:
- Operational savings & efficiencies that support:
- Public/consumer needs and requirements
- Regulations and codes
- Business opportunity/new markets
- Peer and community pressure

The effective incorporation of climatic information to support energy generation and decisions about the built environment will require that:

(i) The designs of resilient infrastructures are underpinned by accurate estimates of return values of weather and climate related extremes.

(ii) Data coverage, networks and databases are improved, particularly in developing countries, and that partnership arrangements are encouraged to provide opportunities for the building of research and development capacity;

(iii) Data sharing approaches encouraging knowledge and technology transfer be instituted – especially in areas where long data records may not be available to meet the needs of the built environment investments;

(iv) Critical regulatory thresholds in existing structures and construction design codes are identified, especially where there are likely to be sensitivities to variations in the intensity and frequency of extreme event resulting from climate change;

(v) It be recognized that the efficient operations of infrastructure, energy systems and industrial facilities and processes have unique needs for climate information, and that close collaboration between climatologists and industry decision-makers will ensure that optimal climate information can be developed to meet short and long-term needs for energy generation, together with the planning and management needs of the built environment.

# Opening Addresses

## Mr Michel Jarraud
**Secretary-General, World Meteorological Organization (WMO)**

It is a pleasure for me to address this opening plenary of the WMO Conference on Living with Climate Variability and Change: Understanding the uncertainties and managing the risks, which is being organized by the World Meteorological Organization (WMO) and co-sponsored by the Finnish Meteorological Institute (FMI) and the International Research Institute for Climate and Society (IRI). On behalf of the World Meteorological Organization and my own, I wish to express my appreciation to Finland for hosting this Conference in Espoo, a city renown for its promotion of development through the preservation of nature.

As one of the original signatories of the WMO Convention in 1949, Finland is a founding Member of WMO and the FMI has a long tradition of actively supporting WMO's Programmes and activities. In 1969, Professor E.H. Palmén was one of the first recipients of the prestigious International Meteorological Organization (IMO) Prize. Furthermore, I wish to indicate my special gratitude to Mr Pekka Plathan, Director-General of the FMI and Permanent Representative of Finland with WMO, as well as all his staff, for the excellent arrangements made to ensure the success of the Conference.

Moreover, I wish to thank our co-sponsors in this endeavour and to recognize the efforts in terms of fundraising that the two organizations have made, in collaboration with WMO, which have resulted in important contributions to the event by, among others, Australia, the European Commission, France, the United Kingdom, the United States of America, and by many national organizations of Finland, namely the Ministry of Environment, the Ministry of Foreign Affairs, the Ministry of Trade and Industry, the Academy of Finland and the Finnish Meteorological Institute. I therefore take this opportunity to thank all the contributors for their assistance, which has made this Conference a reality.

Climate is a splendid resource but, while benefiting from its rewards, we are nevertheless quite vulnerable through its variability. Our presence here is, therefore, a reminder of the high priority that we assign to it, and of our resolve to optimize societal response to climate variability and change. It also shows that we are prepared to work together in promoting safety and enhancing the quality of life for all societies.

Today, climate can no longer be taken for granted, since three factors are increasingly drawing attention to the need for more urgent and purposeful adaptation to climate conditions and management of climate-related risks:

- Societies are becoming increasingly interdependent;
- The climate system is changing;
- Losses associated with climatic hazards are rising.

To quote some examples of very recent events, I could recall that the year 2005 was one of the two warmest years on record globally since the mid-1800s; that prolonged drought continued in parts of the Greater Horn of Africa, placing millions of people at risk of starvation; that persistent drought conditions caused some of the worst wild fires registered in South-Western Europe; that during 2005 an unusually wet monsoon caused massive flooding in parts of India; or that the 2005 Atlantic hurricane season was the most active season on record, with an unprecedented 27 named tropical storms, as opposed to a long-term average of only 10 such storms.

Indeed, every year we observe similar climate anomalies. Much of the time, these are natural features of our climate system, so individuals, communities, and nations must constantly adapt to its slow changes and find ways to develop in harmony with nature. As scientists, however, we also recognize many uncertainties in climate, and it is precisely because of these uncertainties that the present Conference has been organized, in order to highlight the main issues in integrating climate information with the mainstream of decision-making and to formulate recommendations on possible solutions for dealing with the uncertainties and the associated risks.

In the present context, the Conference shall specifically address several climate issues related to agriculture, water resources management, disease control, power generation and disaster mitigation, amongst others. In organizing this event, care has been taken to select highly qualified experts drawn from many disciplines who can truly contribute, in their respective fields of specialization, to meeting the Conference goal of achieving substantial progress in the establishment of an agenda for climate-related risk management.

A number of factors are closely related to the vulnerability of a society, such as:

- Physical aspects of vulnerability, like those dependent on the geographical location;
- Social vulnerability, often linked to population growth and sectoral conflicts;
- Economic vulnerability, which is linked to the development, infrastructure and food security,
- Environmental vulnerability, which is often linked to water availability, soil degradation and air pollution.

In addition, poverty can become a crosscutting factor, linked to all of the above.

Why is climate-related risk management imperative? Essentially all human societal activities are in peril, since climate risks threaten our assets, procedures and financial viability. These issues are even more critical in the developing countries and the Least-Developed Countries, since the concept of climate risk might not even be considered, for example, in their standard insurance portfolios of options for companies and sectors, and so a climate-related disaster might signify a catastrophic failure of the entire national economy. Accordingly, clear geo-referencing at the regional, national and even sub-national levels becomes a question of prime importance.

It is also to be stressed that, in the developing and the Least-Developed Countries, there is often no established or an insufficient mechanism for data collection and reporting and, accordingly, insufficient reliable data on which to base a rational attempt at risk assessment. Furthermore, even in those cases where applicable methods for evaluating climate-related economic losses have indeed been developed, perhaps by some international Organizations, there are still very few globally accepted procedures to measure direct and indirect climatic disaster-related costs across the different disaster-types.

In addition, this Conference brings together representatives from the private and public sectors, including multilateral organizations, government, industry, research institutes and development agencies, in order to share widely their knowledge and experiences in mitigating climate variability in terms of policy and implementation. Therefore, a particular focus of the conference will be to highlight the most up-to-date and state-of-the-art research on complex decision-making theory and practice in all sectors sensitive to climate variability and change.

The WMO Conference on Living with Climate Variability and Change is part of a series of WMO activities dealing with Climate Variability and Change. In November 2005, WMO organized in Beijing the Technical Conference on Climate as a Resource, which resulted in proactive recommendations for the enhancement of climate services in support of sustainable development. In March 2007, WMO will hold in Madrid the International Conference on Secure and Sustainable Living: Social and Economic Benefits of Weather, Climate and Water Services. The Madrid Conference, organized under the Gracious Patronage of Her Majesty Queen Sofia of Spain, will provide an important occasion for representatives of various sectors of society to describe how the environment impacts them, how weather, climate and water information helps them to make decisions and reduce risks, and to outline what changes would be needed to improve decision-making.

These are some of the activities that WMO is implementing within its role of providing world-class expertise and leadership in international cooperation, as the United Nations Agency with mandate in weather, climate and water. They are actions that contribute positively to human safety and well-being and to the economic benefits of all nations, bringing us closer to realizing a major WMO objective: that of halving by 2019 the 1994-2003 ten-year average of deaths caused by disasters of meteorological and hydrological origin. In addition, these actions are also supportive to the achievement of the UN Millennium Development goals of eradicating extreme poverty and hunger and of ensuring environmental sustainability.

Faced with the disturbing prospect of having to live with climate variability and change, the achievement of a clear understanding of all the uncertainties and risks involved becomes a fundamental requisite. In 1979 WMO organized the First World Climate Conference and launched its World Climate Programme in response to growing concern being expressed with increasing emphasis by climatologists and to observational results indicating possible changes in the global climate. Since then, and for more than a quarter of a century, WMO has been working proactively in response to the challenges being posed by this problem.

However, climate issues are very complex and their management often demands a multidisciplinary approach and the development of innovative partnerships with other organizations and their respective programmes. WMO has therefore cosponsored, with its partner Organizations, a number of important initiatives like the Global Climate Observing System (GCOS), the World Climate Research Programme (WCRP) and the Intergovernmental Panel on Climate Change (IPCC), among others. I am pleased to note that some of these organizations are represented in this Conference, along with many end-users of climate information, whose collaboration WMO values very highly.

This Conference shall therefore provide an optimal opportunity to mutually exchange information on stakeholders' capabilities, limitations and needs. I urge all participants to mix freely, to build collaborative partnerships and to develop mutually supportive networks. I am looking forward to the conclusions and recommendations of the WMO Conference on Living with Climate Variability and Change.

## Dr Stephen Zebiak

**Director General, International Research Institute for Climate and Society (IRI)**

We are all increasingly aware of the importance, and urgency, of coming to grips with our environment. Population increase, urbanization, ecosystem stresses, the growing toll being taken by environment-related disasters, and the threat of escalating risks associated with climate change are all confronting us. Can we meet the challenge? If so, how? Human well-being depends on the answer. The challenges amount to this: can we become better stewards of our environment? And, can we better manage our own activity *in harmony with our environment?*

What is the role of science in this endeavour? I would argue that it is crucial. Science provides us with the means to monitor, analyze, and to a growing degree, predict, our environment. It provides us the means to explore our decision options, to weigh the risks and benefits associated with our actions, thus helping us make the right choices rather than suffer the consequences of wrong ones. It also provides us the means to quantify our assessments, including their uncertainty. Uncertainty is an unavoidable fact in any climate projection, prediction, or assessment. But uncertainty is very different from no information. The form our climate information and products naturally take, indeed must take, is probabilistic. We say, for example, that there is a certain percentage chance of drought in a given season, a certain chance of surpassing X degree days, a certain likelihood of a region being impacted by severe storms or hurricanes. These assessments have uncertainty, explicit in their probabilistic form. Does this make them useless? The answer is problem-dependent, but in many cases, certainly not. *Uncertainty is not the enemy, provided we have the right framework to handle it.* Risk management provides just such a framework. In a risk management approach, decisions are never based on a single scenario. Rather, risks and benefits are assessed over the range of possible scenarios, in such a way that catastrophic loss is minimized, and over time, the best outcomes are realized. Our challenge is to find the decisions and policies that are amenable to such an approach, and to seize upon them.

I would next like to assert that *climate change is not an issue of the future, it is an issue of the present.* We are facing droughts and floods *today.* We are facing landslides, dust storms, locust outbreaks, *today.* We are facing the effects of hurricanes and typhoons *today.* The extreme events that are playing out year by year are exacting a heavy toll on all societies, but a devastating and debilitating toll on the most vulnerable, impoverished societies. If we can build the knowledge, tools, institutions and practices to cope better with the climate now, we will also be helping ourselves prepare for the future, and helping to protect our path toward sustainable development.

So what can we do? How can we benefit from the knowledge in hand now, even as it evolves through the work of science? To address this, I'd like to tell you a bit about the history of our institute. The IRI was founded, almost exactly 10 years ago, on the belief that climate knowledge could be brought to bear on decision making in societies toward their decided benefit. The research achievements of the preceding decade had not only demonstrated an increased understanding of climatic phenomena such as El Niño, but successfully put that understanding to the test in demonstrating a capability to forecast the phenomenon as much as several seasons in advance. Thus from the *climate community* came the impetus to create a new, international institute that would have a mandate to continually improve upon the ability to monitor and predict seasonal climate, but also to confront directly the myriad issues at the interface of climate and decision making that would allow, *in practice,* the uptake of climate information in climate sensitive sectors. The institute was launched under the primary sponsorship of NOAA, and it began to take up its mission in earnest. We built a highly interdisciplinary staff, and began undertaking research across the many relevant sectors, as well as place and problem based demonstration projects, where in principle, the knowledge could be brought together to address practical problems.

Ten years later, I have the following experience to share with you. Our premise was not wrong, but it was very naïve. Our initial notions on how to approach the problem were fundamentally flawed. What we found was that the climate information and products as conceived by the climate community were essentially NEVER found to be useful by decision makers on the ground. Why? First, because they were not cast in the right terms – that is, the terms in which decisions and policies are made in practice. Second, because very often there were institutional and policy constraints that prevented being able to change normal practice in such a way to use the information.

Through this experience, we have come to recognize that an approach almost opposite to the "supply" mentality we began with is what is needed. We now see the following approach is much more effective: start with a *problem* focus. Engage in the problem, together with the stakeholders, developing an understanding of all the factors involved. Together, discover the possibilities; that is, *if and how* climate information could be useful in that decision or policy context. Inevitably, this involves then a further step of *tailoring* the information to suit the context. Then, undertake an analysis to estimate the value (or lack thereof) of proposed innovations that make use of climate information, and hopefully make the case for changing practice.

I mention this experience to emphasize the point that the work at the *interface* of climate science, sectoral decision making, and policy is not peripheral, but central to making progress. This poses cultural and institutional challenges to us all. We are accustomed to working within our disciplinary "boxes", yet we must somehow break through the traditional boundaries in order to make real progress.

There are examples of progress and success to motivate us. Some will be presented in this conference: prototype early warning systems for malaria epidemics and for food security crises; new schemes to optimize performance of multipurpose reservoirs using climate information; risk management strategies for agricultural management and agrarian livelihoods; weather/climate related financial instruments, such as index-based insurance. All of these, and other examples, testify to the fact that we stand at the dawn of an age where climate and society can be brought into much greater harmony.

Yet, the fact is, at present, the possibilities are not even known, let alone realized, throughout the vast majority of any of the communities that could benefit from such knowledge. What is needed is not a set of isolated demonstrations, but rather widespread uptake of the knowledge and information the science provides us. Collectively we must identify the means by which we can *facilitate* the promotion of climate risk management in practice, at scale, throughout society. Such a process will need institutional, scientific, and political support. We need to educate, to build capacity, to find the means to promote and disseminate good practice. So much is at stake: let us rise to the challenge.

**Ms Elisabeth Lipiatou**
**Environment and Climate System Unit, European Commission**

It is a pleasure for me to participate in the opening ceremony of this Conference on Living with Climate.

The timing for this Conference is excellent: awareness of our changing climate is probably the highest it has ever been. Climate change is at the centre of these discussions. Everybody can observe changes in temperature and ice-cover; we are seeing more frequent natural disasters, causing ever greater human, physical and economic damage of natural hazards. Discussions have also started on Post-Kyoto measures and associated costs and benefits.

Let me now enter into the questions and public concerns about climate change. There is no doubt that human-induced climate change is a reality, and that society is facing enormous challenges. But are we prepared for these challenges? What do we know about the future impacts on atmospheric composition, on land ecosystems, on ocean life, on water resources? What are the implications for society?

Latest figures show that the year 2005 was the warmest on record; and there also seems to be increased frequency of extreme events in Europe and elsewhere.

The public is alarmed and requesting answers: is there a link between a record hurricane season last year and climate change? What are the causes of the severe flooding in Central and Southern Europe these past few years and which have caused so much displacement and economic loss? How can we prevent and mitigate these disasters and what is the link with climate change?

In the year 2003 Europe underwent a heat wave never experienced before and which caused thousands of casualties. Was this just a single incident or was it a sign of what the average European summer will be? Even if we only look from an economic point of view, which we should not, recent research suggests that a temperature increase of 3°C might cause a decline in global income. But the same research studies suggest that at lower costs we can avoid dangerous climate change.

The question is then: what steps do we need to take? How can we take responsible decisions and assess the consequences of climate change? Research will play a crucial role in addressing these questions. Public expectations are high and rightly so; answers are expected.

The global dimension of climate change and natural hazards has initiated a number of international research efforts and collaborations, in which Europe has played and continues to play a key role.

The international dimension and collaboration in climate research in the 6th Research Framework programme is certainly one of the highlights. Just to give you a few examples: a European research consortium including African partners studies the change and impact of the West African monsoon on global climate as well as the social and economic impacts on this region; an international consortium with strong European contribution observes the shrinking Artic Ocean sea-ice cover in order to understand past climate and forecast changes; tropical experiments over Australia are carried out to increase our understanding of the changes in the atmospheric composition. These are just examples but they show that European research is present and has established an excellent reputation.

Let me now briefly comment on the close relationship between environmental research and policies including the environment. I believe that environmental policies need to be built on sound scientific knowledge. Indeed it should be noted that policy actions such as the Montreal and the Kyoto Protocols arose from the work of scientists.

We see with great satisfaction that the Montreal Protocol (a ban on ozone depleting substances) is functioning. The atmospheric load of chlorine components should further decrease in coming years. We can therefore expect that the ozone hole will slowly recover within the coming decades, although climate change may delay the recovery process.

The Kyoto Protocol is based on the scientific consensus that there is a balance of evidence for human-induced climate change. This has been formulated by the Intergovernmental Panel on Climate Change, established by the United Nations Environmental Programme as an independent body for scientific advice. I know that many of you here today have contributed to its work.

However we all know that the Kyoto Protocol is only a first step to stabilising our climate, and greater efforts are necessary to achieve the ambitious goals. I will even go one step further - climate change is unavoidable. Society needs to be prepared for the coming changes in order to minimise their socio-economic impact.

This leads me now to the 7th Research Framework Programme, where we have taken the necessary steps to include climate change research to make Europe fit for the expected challenges. I can assure you that we will further promote scientific excellence and cooperation in these fields at European and international levels.

The programme will address major unanswered scientific questions and advance our understanding of the earth system functioning and changes. It will tackle the problems which are most important for society such as the future climate change impacts from local to global scale and determine optimum mitigation and adaptation strategies. Certainly, the commitments on research and systematic observation as formulated in the Treaties and international initiatives like the Group on Earth Observations are taken seriously by the European Commission.

This is one of the many reasons why earth observations will continue to be an integral part of the FP7 allowing early detection of changes and the development of response options. The combined use of observation and models should help us to detect thresholds and eventually points of no return, which our society should know about.

I would not like to end this speech without thanking the representatives of for their noble support making these nice facilities available.

But I would also like to thank you for your personal support to the European research and the European Commission in the different panels and advisory groups. It is indeed my hope and wish that the successful work you have done so far will continue and that Europe will keep its leading position in Climate Change research. It is something we can be truly proud of.

# Conference Address

**Prof Jeffrey Sachs**
**Director**
**The Earth Institute at Columbia University**
**New York, USA**

### Extended Summary

It is significant that this Conference is taking place at a time when the world is experiencing more intense climate shocks more frequently, and yet there is no proper interface, even at the intellectual level, where societal knowledge in policy, finances, economy or demography and the knowledge of climatology is considered. There is therefore an intellectual task to understand how best to incorporate the scientific aspects of climate variability and change into societal decision making, recognizing that both will continue to change throughout the world, and then to agree on what we can do about building the necessary interfaces.

The roles of climatic processes are often not recognized in human crises. Yet the underlying or major contributing causes of many recent and historical human crises, such as the violence in Darfur, Sudan and the collapse of governments in Ecuador and Indonesia, can in large measure be triggered by a single episode or sequence of weather related events that in turn give rise to massive ecological and demographic challenges for the country or region affected. The conflict in Darfur, for example, is in fact a consequence of a reduction in rainfall and the doubling of the population of the region in the last 25 years, in an area that is already semi-arid, i.e. with an existing baseline of water stress. The roots of the violence relate to the ecological disasters of the 1980s when shortfalls of water led to conflict between pastoralist and farming communities. These root causes are neither understood nor appreciated, and so the solutions proposed to resolve the crisis are often a mix of military and humanitarian relief; such solutions clearly do not address the baseline water issue, which is the fundamental problem. Another example is the strong El Niño-episode of 1997-98, which caused massive floods in the coastal areas of Ecuador and a severe drought and wide forest fires in Indonesia. These events, combined with poverty and a highly vulnerable economic situation in both countries, led to the collapse of the governments when the financial crises amplified out of control as a consequence of bad political decisions.

These examples from real life show clearly that ill-considered decisions made in situations where there is a strong interaction between climate and social processes can have catastrophic outcomes. To reduce the chances of such interactions leading to undesirable consequences a more systematic approach is required. Within a society, each community, national government, climate service and emergency response organization needs to make a checklist of the typologies of risks they face, the baseline exposures, and the potential for responding, so that vulnerabilities of the society can be analyzed and mapped. This process is very complicated and therefore, there is no single agency, department or intellectual discipline that can sufficiently capture the plots of interacting forces at play. There is a lot of data needed to establish the baselines. There is therefore, the need for more openness and flexibility in the sharing of data.

At a minimum a typology of climate related risks includes: hydrological risks (droughts, floods, mudslides, depleted or polluted freshwater aquifers), heat stress risks (affecting human health and crop yield), diseases, pests, storms and sea level rise (Figure). It is important to develop this list further within particular societies in order to model their specific vulnerabilities.

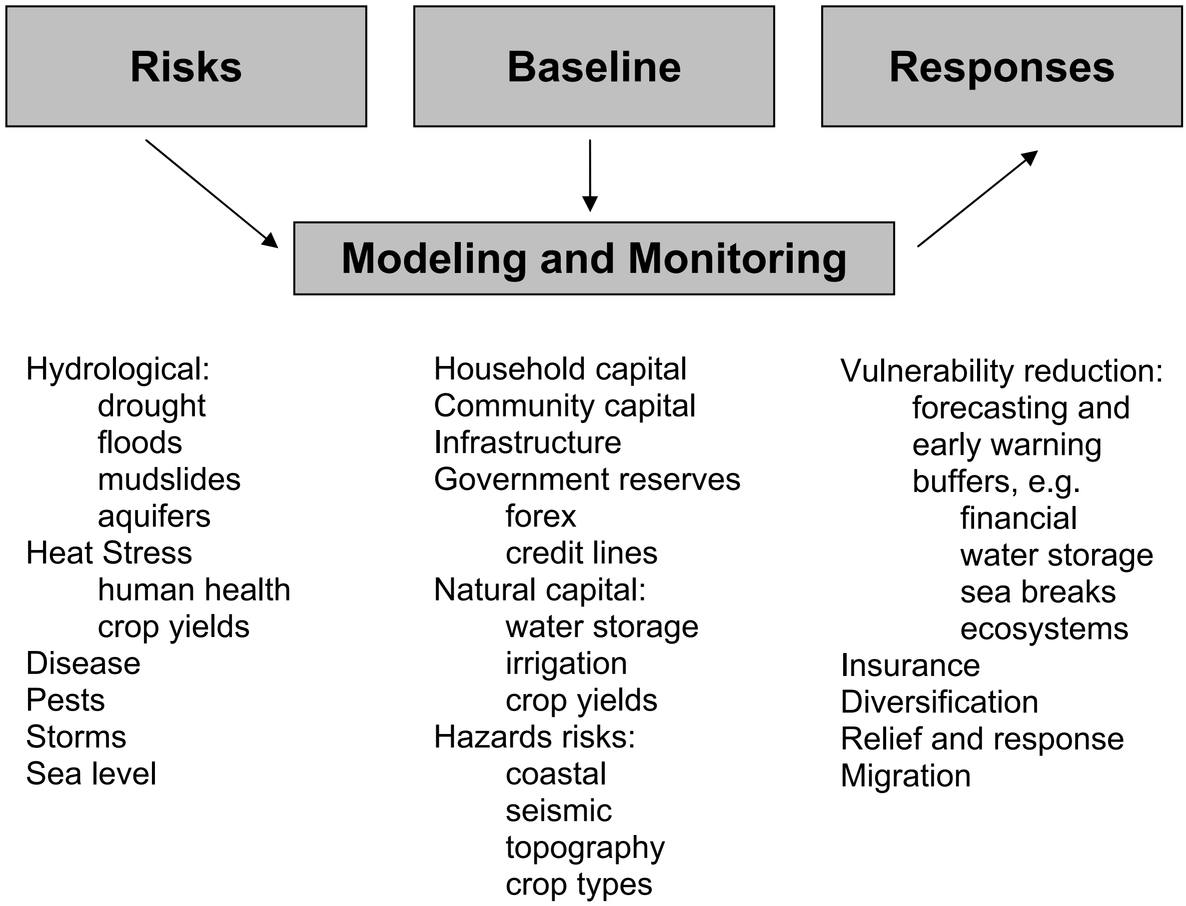


**Figure 1.** A scheme on typology of risks, baselines, and responses of climate related risks

In the baseline column we have already a mix of natural and social factors. By household capital we mean the preparedness of individual households to resist various shocks. Community capital to bolster resilience to a natural hazard consists of effective early warning systems, availability of telephones and the connection to emergency services, electricity supply, road network and transport services both private and public. Examples of government reserves to buffer the losses and to bring about 'rescue and recovery' include sufficient credit lines, in cooperation for example with the International Monetary Fund, if needed, and well-established, functioning national rescue service networks. Water storage capacity, irrigation systems and adequate storage of crop yields carried over from the more productive years represent natural capital. To avoid unnecessary risks of hazards the survey services could be used in the planning of coastal area developments as well as areas with seismic risks and/or difficult topography that might be prone to landslides. Plant breeding services could help proactively to meet the anticipated changes in climate as well as its variability. In short, the baseline column consists of many social aspects that interact with climate and hence need to be included in modelling considerations.

Both historical and current data are needed to assess the risks, to establish the necessary baselines, and for systematic modelling and monitoring. So far the systematically constructed data sets exist mostly only in the domain of climatology and, more broadly, meteorology and even there, sometimes with restricted availability. Even national security can be compromised if these existing data are not made freely available; hence it is vital that all nations resolve this problem where it exists. Parallel to this need for an open approach to the distribution of climate related data is the need for a similarly systematic and open approach to data collection in all other risk and baseline fields. Only then will we realize the possibility of a seamless interactive flow of data and information between the disciplines and organizations involved. The most urgent attention should be given to Africa where every risk seems imminent, especially in agriculture, which is 96% rain-fed.

With systematic and interactive modelling and monitoring efforts, we can support the decision making required for the responses listed in the right-hand column of the typology scheme. One way of reducing vulnerability is to develop appropriate forecasting and early warning systems. Another way would be to build buffers for the various types of capital described above, e.g. financial reserves, water reservoirs, erection of sea walls, and the improvement of ecosystems through reforestation and the establishment of national parks and nature reserves. Besides reducing vulnerability and physical exposure, efforts should be made to develop effective insurance, reinsurance and other instruments in cooperation with the World Bank and other institutions supporting development, as appropriate. Diversification is another option for alleviating vulnerability, notably in agriculture. The necessary relief and response actions should start with a minimum lag and preferably proactively to the extent possible.

It is likely that the viability of societies in some parts of the world will become so weakened, that potential for “eco-migration” will increase. To establish a globally accepted, rational and humane system for eco-migration, with due consideration for both the dignity of the migrants and the ongoing well-being of the receiving countries, is one of the more difficult challenges facing the international community.

Within the Millennium Development Goals initiative there is a global structure called the Poverty Reduction Strategic Process (PRSP) through which developing countries relate to their donors. In the PRSP, however, climate considerations are not well integrated, if at all. Furthermore, environmental considerations in general are not well considered. This challenge is one that is central to this conference.

To a large extent, international discussions about climate in a policy context have focused so far on the mitigation of the climate change, and with little consideration of adaptation. However, the focus in many forums is expanding to include adaptation in the context of current climate. This is the case, for example, in the Global Roundtable on Climate Change, organized by the Earth Institute at Columbia University. This conference has the opportunity to formulate and propose a range of practical project proposals to the companies represented at the GROCC meeting.

# Sector Lead Presentation Abstracts

## Natural Disasters and Early Warnings in Developing and Least Developed Countries

***Filipe Domingos Freires Lúcio***

National Director, National Institute of Meteorology, Maputo, Mozambique

Over the last decades there have been many international, regional and national initiatives on disaster risk management coupled with advances in scientific knowledge and applications. Despite these, the social and economic impacts of disasters are growing, particularly in developing and least developed countries, due to the fact that these countries have economies that are unable to absorb the shocks caused by disasters, have inabilities to effectively implement multi-hazard early warning systems for integrated risk reduction, but also due to increasing vulnerability of exposed populations aggravated by poverty, illiteracy, environmental degradation, population growth and displacement, urban growth, conflict, poor governance and weak institutional capacities. A good example was that of the floods of the year 2000 in Mozambique that caused damage estimated at US $ 450 million, which led to a reduction from 10% to 2% in annual GDP growth, a demonstration of the fact that the poor suffer most the impact of disasters.

In the context of climate variability and change, developing and least developed countries have increased vulnerabilities due to their limited coping or adaptation capacities that are determined by a range of factors including wealth, technology, education, infrastructure, among others. Expected impacts could affect food production, human health, water resources, energy, the frequency and magnitude of natural disasters and the environment, thus reducing the livelihood potential, particularly of the poor. The net negative impacts of climate change would exacerbate the existing vulnerabilities in these countries.

To enhance coping and adaptation capacities, developing and least developed countries need to adopt appropriate policies, informed by science, incorporating management of risk to climate variability and change into development plans and programmes. This should be twinned with effective early warning systems that must be people-cantered and must integrate the following four inter-related elements underpinned by effective governance and institutional arrangements, involvement of all stakeholders including local communities, consideration of people's interests, needs and values in a multi-hazard approach: (a) risk knowledge; (b) technical monitoring and warning services; (c) communication and dissemination of information and warnings and; (d) community response. As widely recognized, failure in one of the elements can result in failure of the whole early warning system.

In developing and least developed countries there remain many constraints on legislative, policy, financial, organizational, technical, operational, training and capacity building aspects to be overcome with a view to enhance the status of knowledge on risks to climate variability and change and thus, stimulate decision makers to implement disaster risk reduction strategies, within a multi-hazard framework that include effective early warning systems. Enhancing coping or adaptation capacity to climate variability and change should not be viewed as additional demand on already burdened economies, but viable options that should support development processes in these countries.

This paper discusses the above considerations in the context of developing and least developed countries.

## Agriculture and Food Security


***Ramesh Jain***

Former Secretary of Agriculture, Government of India and Former FAO Representative to the Philippines


The impact of climate variability and change on food and agriculture in different socio-economic systems as also the transformation in the attitude towards risk management has shaped the mitigation and the response strategies of farmers and societies over millennia.

Hydro-meteorological risks such as droughts, cyclones and floods not only endanger human lives and property but also have devastating impact on food production and farmers' livelihood systems sometimes across countries and continents. Economies that do not have inbuilt buffering mechanisms as in resource poor rain-fed agriculture production systems in developing countries also marked with absence of financial and insurance services are disproportionately vulnerable to the severity of extreme climate events. Climate change further compounds the problem as it threatens to alter the frequency, severity and complexity of climate events as also the vulnerability of high risk regions in different parts of the world.

In recent years, there has been a dramatic technological progress in the understanding of climate systems as well as in monitoring and forecasting weather events on the scale of seasons and beyond. The advent of more reliable forecasts goes hand-in-hand with emerging trends in disaster management, in which reactive strategies are gradually replaced with more anticipatory, proactive and forward looking approaches. These technologies provide a unique opportunity for developing countries to mitigate and reduce their vulnerability to adverse weather and climate phenomena, as also to take advantage of the knowledge of anticipated events to improve the quality of life of their peoples and economic growth. Widespread concerns on the likely impact of emerging climate risks including due to human induced actions on the climate system provides opportunities to translate climate change adaptation concepts into locally actionable practices. Potential opportunities also exist to understand and make use of the patterns of climate variability through skilful use of past observed climate data source in different countries though with a caveat that in climate science future is not always a mirror of the past.

There are, however, formidable challenges in making use of climate forecast technologies and information for societal benefits. Some of the major barriers are:

1. Most of the climate information products and tools scientists have developed for risk management are not fully utilized as they might be. This is partly because we still need to develop institutional, economic and cultural frameworks within which decisions are made in any society. It is also partly because decision makers frequently do not actively seek new technologies and sources of information or initiate contacts with experts who could be helpful in making more informed decisions.
2. While capacities to generate most of the climate information products rest with advanced global climate research centres, the need and demand for these products lies within local at-risk communities in developing countries of different regions.
3. The uncertainties associated with climate change as well as socio-economic scenarios in the next 50-100 years do not lend urgency to efforts in mainstreaming climate change adaptation options into the immediate development planning process.
4. The financial and managerial constraints in developing appropriate interventions in developing countries to spread, share and master the climate and other risks in agriculture seriously undermines the benefits of technological breakthroughs in climate forecasting.

Like all knowledge intensive processes the use of climate information requires national and local institutions with a capacity to interpret and with well functioning procedures for information dissemination of probabilistic climate information products to match.

Some recent experiences of making use of usable climate information, in Asia and elsewhere to anticipate and manage risks in agriculture provide useful insights. Learning from these experiences and replicating them would pave way for mainstreaming climate information into achieving food security through agriculture development planning processes in developing countries.

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## Climate Variability and Change: Risks to Health – and Adaptation Options

***Anthony J McMichael***

The Australian National University, Canberra, Australia

Climatic fluctuations, both acute and longer-term, have caused hardship to many societies: economic disruption, physical hazards, disease, death and “collapse”. The demise of the Mayans and the West-Greenland Vikings was substantially due to climatic adversity that evolved over 1-2 centuries of time. The 1840s Irish Famine followed unusually cold and wet conditions. Acute health effects of weather extremes are well known – hospitalisations and deaths during heat/cold waves; deaths and injuries from floods, storms, cyclones and fires. In many countries with endemic malaria, disease outbreaks are clearly related to inter-annual climatic variations, especially cyclical phenomena such as the El Niño Southern Oscillation.

Climate change will multiply, indeed amplify, many of these health impacts of climate variability. But, more, new configurations of health risk will arise as critical climatic thresholds are passed. As mean conditions change, so will the geographic transmission zones for various infectious diseases, especially the vector-borne infections such as malaria, dengue, tick-borne encephalitis, West Nile fever (?), and, perhaps, bubonic plague. Changing climate conditions will also introduce new stresses on food yields: (i) shifts in rainfall systems, (ii) emergence of new plant/livestock/fish pests and diseases, and (iii) changes in geographic range of wild food species (including fish populations). Rising seas will displace vulnerable coastal and small-island populations, leading to the familiar spectrum of health hazards faced by refugees. Meanwhile, in some regions (at least in the early stages of climate change), health gains may occur – e.g. receding mosquito populations in drying areas; enhanced crop yields in some mid-latitude regions; reduced winter-season mortality excess in some high-income countries.

These risks to population health signify that we are changing a fundamental part of the planet’s life-support system. The health risks from climate change, destined to increase over coming decades, threaten attainment of the Millennium Development Goals. This underscores why Population Health is a primary criterion of Sustainability (vs. other conventional indices which are actually the penultimate, not the bottom, line). The abatement of greenhouse gas emissions would, in population health terms, be true “primary prevention” – eliminating the hazard.

Meanwhile, climate change is already with us and will increase over coming decades despite any radical action now. The other challenge, then, is to identify vulnerable communities, understand their main health risks, and assess the feasibility and cost-effectiveness of adaptation options. These adaptive responses, like much of public health prevention, can occur at individual, local community and national levels. Operational research on adaptive strategies to lessen health risks, such as WHO is carrying out in low-income countries (funded by GEF/World Bank), is an important initiative. Often, optimal strategies will yield win-win situations, in which the health risks of both ongoing climate variability and emerging climate change will be lessened.

Amelioration of these risks requires national and provincial policy-making and resource commitment. Evidence indicates that market-based voluntarism can do no more than make a contribution to resolving this huge modern global problem. Are those with responsibility for making decisions on matters where health and climate factors intersect well-equipped to make the 'right' decisions? What constraints exist on choosing between, or balancing, longer-term structural adjustments versus shorter-term, more politically-immediate, imperatives?

## Water Resources

***Mike Muller***

School of Public and Development Management, University of the Witwatersrand, Johannesburg, South Africa

*Managing variability*

Managing variability is the day to day business of water managers, whether in planning for extremes or optimizing long term resource utilization. There are technical and institutional instruments to help achieve goals such as water supply for people, industries and farms, to protect communities and their infrastructures from flooding while sustaining ecosystems. Infrastructure can be designed to manage variability or societies designed to be resilient in different ways e.g. storing food and money rather than water, which is why sectors impacted upon by water should be integrated into its management.

However, management objectives are often not achieved because the means are lacking. Storage can address rainfall variability but its high cost means that poor countries which face great variability often have the most limited storage capacity with other infrastructure and production systems vulnerable to climatic extremes. There is often limited information to support the planning, development and management of water, aggravated by the degradation of hydrological networks with no remote systems that adequately fill the gap.

*The challenges and costs of climate change*

Given the challenges of managing today's variability, many practitioners argue that climate change is a secondary priority for water managers in developing countries. However, water investments are undertaken on a time scale comparable to a climate change forecast and it is therefore critical to understand the extent to which climate change might affect them. The present challenge is to understand the potential impacts of climate change on water management. Uncertainties multiply at each step of the hydrological cycle, from temperature predictions to estimates of rainfall, evaporation, infiltration and runoff. However, if the predicted rainfall changes, increased variability and event intensity actually occur, this will impose substantial costs on poor countries.

*Adaptation to climate change: an added burden*

There is no clear boundary between managing "normal" climatic variability and adapting to climate change. What part of a dam's cost addresses "normal" variability and what climate change? This is not a trivial question since climate change is driven by the activities of countries that should help fund the costs of adaptation in terms of the "polluter pays" principle

*Conclusions*

Building resilience into water management systems will be critical if Millennium Development Goals are to be achieved. Adapting to climate change will impose additional costs which should be supported by those whose actions have imposed them. While mitigation remains important, adaptation must also be addressed. Fortunately, water provides a structured learning cycle and is a patient teacher.

## Energy and the Built Environment

***R K Pachauri***

Director General, The Energy and Resources Institute (TERI), New Delhi, India &
Chairman, Intergovernmental Panel on Climate Change (IPCC)

Humanity's ecological footprint grew globally by about 160% from 1961-2001, to around 2.2 hectares/person, ranging from less than 1 hectare/person over much of Africa to around 9 hectares/person over North America. The world's energy footprint, dominated by fossil fuel use, grew by 700% over the same period. Per person energy footprints in 2001 show a 14-fold difference between high and low income countries. Global water use doubled from 1961-2001, with domestic use growing by more than four-fold. High income countries used about 1000 cu m water per person, twice as much as middle and low income countries, on average. While energy consumption in OECD countries is expected to grow by around 30% over the next 25 years, it is expected to more than double in non-OECD countries and in total output to begin exceeding that of the former as early as the end of this decade.

Governments around the world are beginning to recognize the need to set energy standards for buildings, with some setting mandatory requirements and others relying on voluntary standards. In 1950, New York was the only 'mega' city, but by 2006 there were 17, with 14 located in coastal regions and 11 in Asia. By 2015, it is anticipated there will be 33 mega cities, of which 27 will be in the developing world. In one major city in Asia it is estimated that 90% of primary children have unacceptable levels of lead in their bloodstream, with 50% of the population living below the poverty line. Yet that same city still has its own share of gleaming shopping malls and throughout such cities 'gated communities', which separate those who have wealth from those that do not, are beginning to permeate . One must ask then whether western 'monoculture' is an inappropriate model for development in the large urbanized centres of the developing world.

The elimination of poverty and hunger is central to the Millennium Development Goals (MDG), the attainment of which will in turn depend in large measure on improved access to efficiently and appropriately generated forms of energy for:

- Reducing share of household income spent on cooking, lighting, and space heating;
- Improving ability to cook staple foods;
- Reducing post-harvest losses through better preservation;
- Enabling irrigation to increase food production and access to nutrition;
- Enabling enterprise development, utilizing locally available resources, and
- creating jobs;
- Generating light to permit income generation and education beyond daylight; and
- Powering machinery to increase productivity.

Improved human health too is a critical MDG that will be achieved in large measure through the provision and distribution of energy for:

- Providing access to better medical facilities for maternal care;
- Allowing for medicine refrigeration, equipment sterilization, and safe disposal by incineration;
- Facilitating development, manufacture, and distribution of drugs;
- Providing access to health education media;
- Reducing exposure to indoor air pollution and improving health; and
- Enabling access to the latest medicines / expertise through renewable-energy based telemedicine systems.

The development of more alternatives that are appropriate for use in the developing world that rely on more efficient methods do not always have to be based on high levels of investment. For example, traditional methods of brick making employed widely throughout India are wasteful in terms of energy use, are highly polluting and involve much backbreaking manual labour. With the application of relatively simple science and technology the brick-making industry can be turned around such that it is more economically viable, efficient with respect to energy use, more environmentally friendly and more socially responsible towards its work force.

The suitability of architecture in the world's growing number of mega-cities and also within the traditional village setting also requires innovation that draws on relatively simple yet sound concepts, such as:

- Application of bioclimatic architectural principles;
- Incorporation of passive features, e.g. insulation;
- Learning from national as well as international experience; and
- Use of natural daylight and passive cooling.

The profiles of energy sources in both rural and urban settings within developing countries rely heavily on either the use of renewable biological material, e.g. firewood, dried cow-dung etc, or on the other hand, fossil fuels, LPG, kerosene etc. The use of solar based forms of energy generation has enormous potential for growth, yet the uptake of solar based systems is so far extremely limited in both the developed and developing world, with China adding nearly 80% of the 13Gwh added during 2005.

In conclusion, as Gandhiji said a technological society has two choices: First, it can wait until catastrophic failures expose systemic deficiencies, distortion and self-deceptions. Second, a culture can provide social checks and balances to correct for systemic distortion prior to catastrophic failures.

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## Climate Science: Who Cares What We Know?

***Ann Henderson-Sellers***

World Climate Research Programme (WCRP)

This conference's target is climate decision making and makers. In this presentation I therefore pose and try to answer the two-fold question: who are the climate decision makers and who cares if they make poor decisions? In particular, I ask "Climate science: who cares what we know?"

History teaches us that climate decision making has been ill-advised and sometimes hopelessly incorrect. Our generation is no exception. Today climate decisions are dependent upon especially tricky and immiscible factors including: politicians, the mass media and climatologists themselves. Journalists today demand: quickly consumed 'meanings'; emotion and drama; heroes, not teams; 'breakthroughs' or hot news; controversy and conflict; and clear commentary. In contrast climate scientists prefer: detail, data and method; being cool and objective; teamwork and shared credit; incremental progress; to qualify their views; and to consult their peer group. For most of today's politicians science is a low-order issue and generally, funding science mean less funds for other, vote-gaining, priorities. Politicians do not know (m)any climatologists; indeed scientists and politicians seldom meet. Even if they do come into contact they speak different languages and there is a total mismatch in their timeframes. Science has low or even negative electoral impact. Science is based on facts while politics is about leveraging our emotions.

Of course there are persistent scientists and thoughtful (about climate) politicians who have managed to create positive outcomes. For example developed nations have reduced their CFC use by 99% since 1987, but some replacements are also O3 depleting. Similarly, the

Global Environment Fund (GEF) has supported over 120 global warming mitigation projects since 1991 avoiding 1.2 billion tonnes $CO_2$. Unfortunately, economic growth in the West has more than offset this mitigation. Exports are greatly aiding Least Developed Countries' economic growth. On the other hand a 'cheap' bag of salad greens in Europe costs 50 litres of water in Kenya: a price not counted and not paid.

And then there is the elephant in the room. However we try to look away we are energy addicts and must tackle our energy dependence before we can truly come to grips with sensible environmentally and climatologically sustainable policies. The West exhibits every symptom of energy addiction: reduced effect for the same energy 'dose'; disagreeable feelings at removal; pleasure when energy returns; craving for energy; energy dependent behaviour; increased priority for energy; and rapid return to energy dependence after abstinence.

The answer to my talk's title question, "Climate science: who cares what we know?" is Us! The people, *all of us*. We are all affected every time society has to pick up the pieces of a poor climate decision. It is we who need to understand the climate questions and to insist that our politicians act to solve the problems of energy usage and global warming.

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# Sector Reports on the Keynote Presentations

## Decision Making

***Co-Chairs:*** ***Elke Weber*** *(Columbia University, New York, USA)* ***and*** ***Nigel Harvey*** *(University College London, London, UK)*

**Keynote Presentations:**

- *The Theory of Decision Making* Renate Schubert, ETH Zürich, Switzerland and WBGU, Germany
- *Psychology of Decision Making* Elke U. Weber, Department of Psychology and Graduate School of Business, Center for Research on Environmental Decisions (CRED), Columbia University, USA
- *Decision Making Cultural Issues – Developed World: A practitioner's perspective* Maarten van Aalst, Red Cross/Red Crescent on Climate Change and Disaster Preparedness
- *Trying, Failing and Succeeding? "Climate Change Decision Making Cultures"* Coleen Vogel, School of Geography, Archeology and Environmental Studies, University of Witwatersrand, South Africa
- *Institutional and Policy Framing for Living with Climate in the Developing World* Shiv Someshwar, International Research Institute for Climate and Society, USA

Normative models provide the traditional scientific approach to decision making. Uncertainties can be accommodated within the framework they provide. However, a more flexible approach is required in order to take into account expert knowledge and new evidence, by using, for example, Bayesian techniques. Nonetheless, normative decision models remain as good benchmarks for decision making. Such models offer a clear analytic starting point and are based on knowledge of quantitative probabilities, either in terms of observed frequencies or of experiential degree of belief. However, they take account of the views of only one individual decision maker. In other words, no interaction with other parties can be considered; in a highly multi-disciplinary and multi-organizational context, such as assessing the effects of climate variability and change, we know that such interactions are prerequisite to effective risk management.

In the psychology of decision making, economic analysis and the analysis of institutional constraints are important elements of risk management plans. However, economics, political science and geography are not the only useful social sciences. Risk communication needs to reach human decision makers and risk management needs to be embraced and implemented by human decision makers. One pertinent question is, "What is special about human risk perception and decision making under risk and uncertainty?" From this point of view psychology, behavioural economics and behavioural game theory add important insights to risk management process and to designing of useful decision tools.

In predicting uncertain events, humans rely on a neural multiprocessing system in which one part of the brain acts as an analytic system while another part acts as an experiential/emotional system. The latter are available to many animals whereas the former is more likely to be unique to humans. These systems operate in parallel and to some extent interact. Discrepancies in their output can account for controversies and debates about magnitude and acceptability of risks. In effect, the weighting given to the output from each system becomes an issue. Experiential processing lies at the root of a number of possibly unconscious biases, including overconfidence in the accuracy of intuitive judgments and decisions.

It should be kept in mind that the perception of risk is subjective. The variance of outcomes does not explain how people perceive risk in risky options. When assessing risk, the upside and downside variability do not enter symmetrically. Upside variability tends to be a welcome or neutral characteristic, whereas downside variability is worrisome. In addition, our choices differ depending on whether we perceive the choice options to be in the domain of gains or of losses. For gains we tend to be risk averse whereas for losses we are willing to accept risk and losses loom larger than gains.

In the context of communication and management of climate risks, we need to consider how to best use people's experiential and affective processing, as well as their aversion to uncertainty. If analytic processing of distant and time-delayed climate risks leads to inadequate motivation to take adaptive, protective, or mitigative action, it may help to think about the design of more emotional appeals.

Many environmental decisions involve common-pool resource dilemmas. However, the situation here is not as hopeless as predicted by game theory and economic rationality. Interactive cooperation and mutual trust are of fundamental importance to resolving these dilemmas and they can be facilitated by appealing to the social identity of people.

Development of formats for climate forecasting, which take into consideration human information processing modes and constraints, should aim to minimize liabilities and maximize opportunities. Consideration of the combination of analytic and experiential/emotional processes can facilitate correct interpretation of climate forecasts and can motivate forecast usage and adaptive risk management actions. Such consideration would also help in the tailoring of forecast formats and risk management processes to different classes of users. Here the actions and choices can be influenced by the strategic use of framing to describe situations in ways that prime cross-group commonalities, social goals, and cooperation rather than differences, selfish goals, and competition. Choice of reference points can depict alternatives as involving gains or losses, depending on the desired response.

In the context of designing links between climate science and institutional design for the purpose of effective climate forecasts and their integration in policy and sectoral decision making, the social sciences are a crucial contributor and partner. In addition to economic and institutional constraints, constraints on human cognition and motivation need to be considered in order to design of effective risk communication and risk management processes. Knowledge about human capabilities and constraints helps with the design of effective tools. Ignoring social science knowledge leaves many problems appearing more intractable than they are and need to be. It is also important to be aware of human responses to risk management strategies as these can impact on the effectiveness of those strategies.

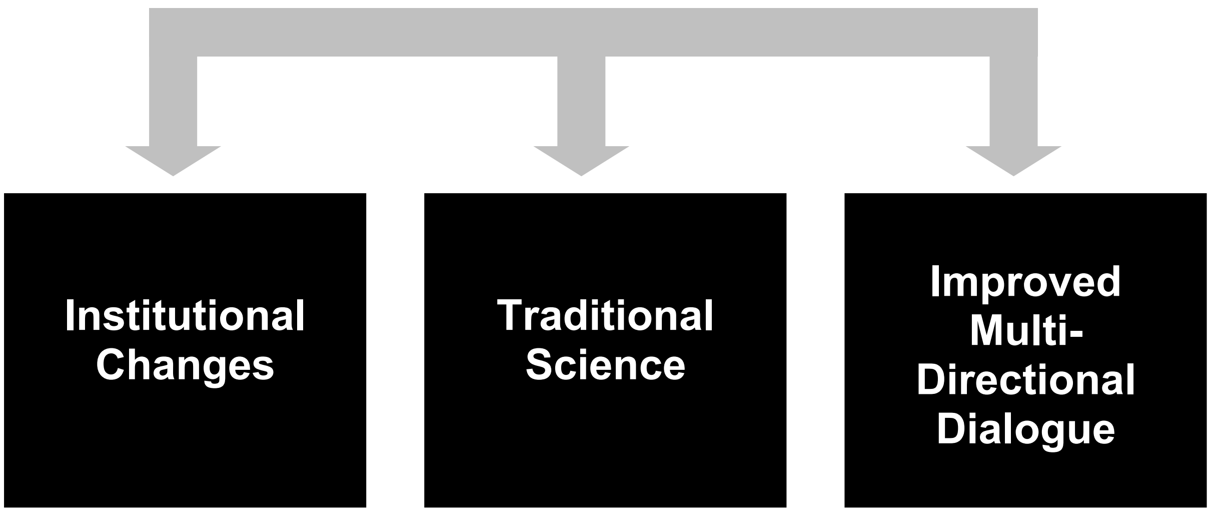


**Figure 2.** A scheme elucidating how the views of the traditional science can be broadened by the institutions in their role to improve multidirectional dialogue.

The way in which both normative and descriptive, psychological approaches have been applied to support decision making in developed and developing countries was elucidated with case studies. These case studies showed that institutions play an important role in improving multidirectional dialogue. Many institutions have multiple, overlapping, and partly contradictory roles. Such role overlap should either be minimized or coordinative responses should be developed that reduce response competition between them

## Disasters and Early Warning Systems

***Chair: Maryam Golnaraghi*** *(World Meteorological Organization, Geneva, Switzerland)*

**Keynote Presentations:**

- *Framework for Utilisation of Climate Information for Disaster Risk Reduction: Role of Risk Assessment and Early Warning Systems* Maryam Golnaraghi, WMO
- *Early Warning and Disaster Risk Reduction – Building on the Hyogo Framework for Action and Global Survey of Early Warning Systems Reduction* Reid Basher, United Nations International Strategy for Disaster Reduction
- *Risk Assessment and Early Warning Systems: Munich Re Profit and Non-profit Perspectives* Thomas Loster, Munich Re Foundation
- *Global Risk Identification Program (GRIP)* Maxx Dilley, United Nations Development Programme
- *A Proactive Approach to Humanitarian Planning and Response: Humanitarian Communities Need for Early Warning Information* Michael Meier, United Nations Office for the Coordination of Humanitarian Affairs
- *Community Based Approaches to Disaster Preparedness and Response: Need for Climate Information and Warnings to Enable Effective Community Response* Maarten van Aalst, Red Cross/Red Crescent on Climate Change and Disaster Preparedness

Disasters result from societal exposure and vulnerability to natural hazards. The importance of large-scale disasters in developing countries is illustrated by the case of the flood disaster in Mozambique in 2000. This particular disaster reduced the country's GDP growth rate from 10% down to 2%. Trough the Global Risk Identification Program (GRIP), UNDP, WMO the ProVention Consortium and other agencies within the International Strategy for Disaster Reduction (ISDR) system are promoting risk assessment as a means for identifying and reducing hazard-related vulnerabilities. Climate-related hazards are a particularly important source of risk globally. Reliable estimates of natural hazard behaviour are an important input to risk assessment and risk management decision-making.

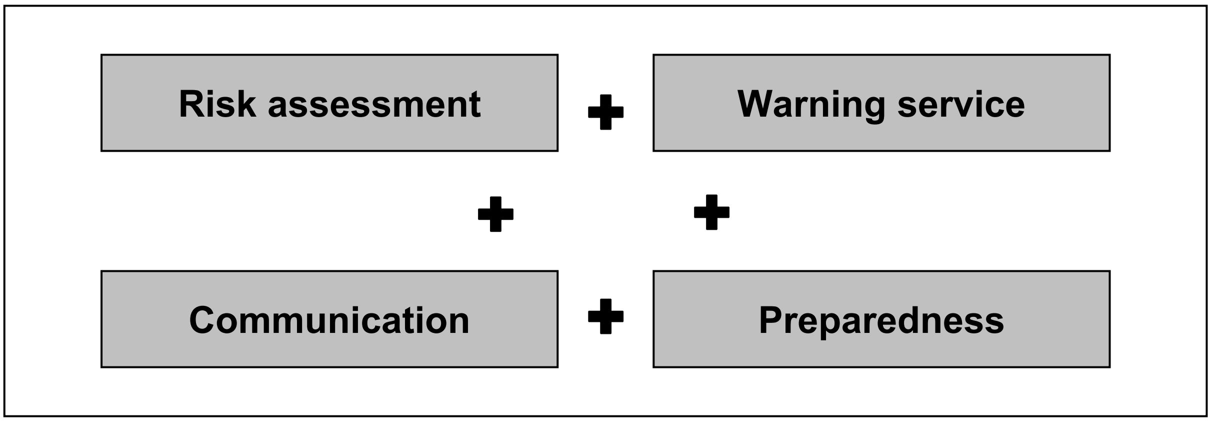


**Figure 3.** The four essential components of a functioning early warning system

For warning systems to function they must not only be technically feasible but must focus on the needs of society. Further, humanitarian aspects need to be taken into account in the context of early warning information, which involved *inter alia* meaningful dialogue in face-to-face meetings.

## Agriculture and Food Security

***Chair: Walter Baethgen*** *(IRI, Palisades, USA)*

**Keynote Presentations:**

- *Using Climate Risk Technologies to Align Best Policies with Best Practice for Agriculture* Holger Meinke, Queensland Department of Primary Industry and Forestry, Australia
- *Data Issues in Climate-Related Risk and Impact Assessments for Food Security* René Gomes, Food and Agricultural Organization
- *Climate Information to Inform Policy Decisions in Southern Africa: Efforts and Challenges* Elijah Mukhala & Sue Walker, Southern African Development Commission Regional Remote Sensing Unit
- *Weather Risk Markets Change People's Lives – A Weather Index Based Approach to Protecting Livelihoods and Saving Lives* Ulrich Hess, United Nations World Food Programme
- *Applying the Power of Climate Science to Manage Climate Risk* Rohan Nelson, Commonwealth Scientific and Industrial Research Organization Sustainable Ecosystems, Australia
- *Whose Decision is it anyway? – Farm Level Decision Making in a Semi-arid India* P.R. Sheshagiri, Chennakeshava Trust, India

Success in economic development throughout the world will perforce increase the global food demand. Hence the goal of halving the number of poor and hungry people by year 2015[1] poses a serious challenge for the international agricultural community. Projected global warming will likely reduce the yields of some currently high productive areas, like the wheat crops in Northern India. Yields are also sensitive to 'normal' swings in climate variability, and extreme events too disturb global food security.

In providing climate related information to decision making in agricultural enterprises, it is important to apply a systems analysis approach and to focus on the outcome of the support system and how it might best aid decision making. Such an approach is more likely to convince a user of the salience and relevance of the support system. The system must be also credible in terms of results that are consistent with perceived technical quality. The third essential element is 'liability', so that the acceptance of the system is fair and not simply a vehicle for pushing agendas and interests of others.

In addition to a proper engagement model the support system needs to be well integrated so that it facilitates both farm and resource management and well-informed policy development. Here, integrated systems science is of help. Unfortunately, the lack of integration and lack of pertinent data remain as entrenched problems in much of the developing world.

For many applications, a support system comprising various temporal, spatial and economical scales, and then subject to modifications arising from both mitigation and adaptation can in many applications easily become quite complicated difficult to manage.

The power of climate science to manage climate risk in agriculture can be viewed from three perspectives: adaptation, responsibility and governance. In adaptation it is important to clarify

[1] Millennium Development Goal 1

institutional and technical constraints as well as to focus on the community resilience via local community groups in order to get engaged with the community. In addition, forecasts should be tailored to the local socioeconomic and political conditions, for example by using a multi-disciplinary approach and pointing out that change and uncertainty are normal and can be managed. In adaptation the task is to transform learning from past applications into improved climate risk management.

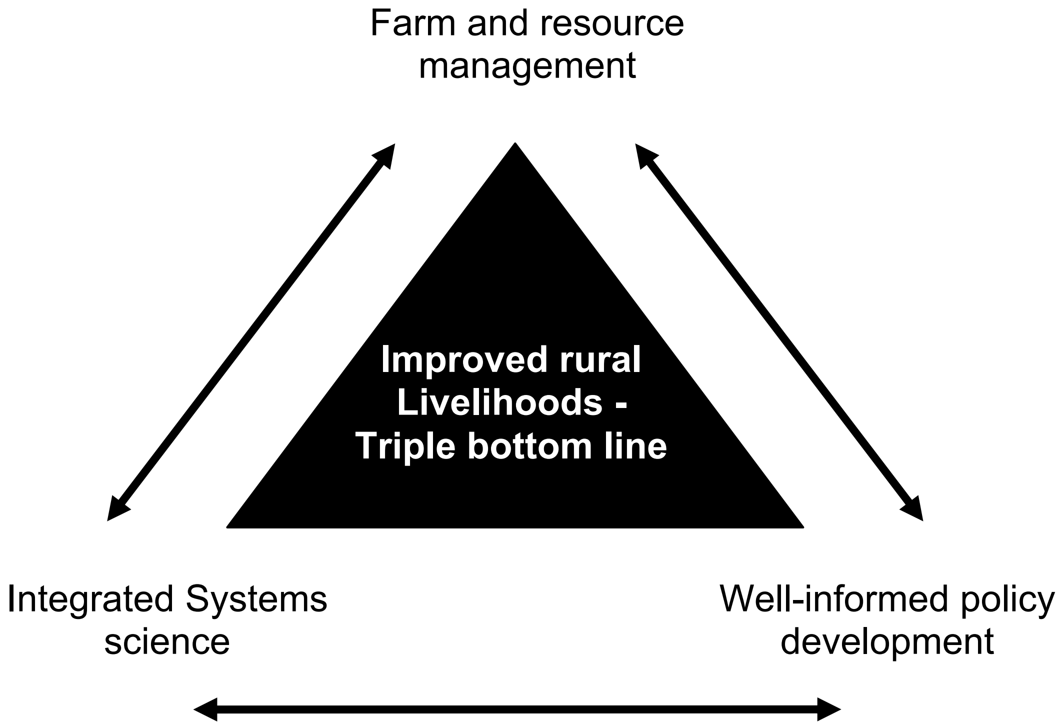


**Figure 4.** The triple bottom line of a functioning support system

Responsibility means that we need to realize that the social potential of climate science depends on how we use support systems and tools. Some of the issues can be quite contentious, but they should be brought up and discussed within the multi-disciplinary context. Notwithstanding, it is not necessary to learn everything step by step, and it is possible for learning to proceed through “leapfrogging” techniques.

Governance should be adaptive so that institutional arrangements are designed to exploit climate science for social benefits in such a way that institutions empower the sciences.

Data issues in the context of food security assessments require a mix of climate, weather, crop and socio-economic data. As noted above, data are often unavailable where they are needed most. In particular, real-time ground weather data and data on crop distribution and stage are not easily available. Regarding pertinent methods, there is a lack of good ‘downscaling’ tools. The most serious gap is the lack of detailed geo-referenced disaster impact assessments where pre-disaster, post-disaster and extreme factor data information is needed.

Recent developments in hedging against risks for climate in food security in the insurance and finance industry have helped to transfer and alleviate risks both to protect livelihoods and to save lives. So far the access to these services has been quite limited but, by broadening the services, the service providers can diversify the risks so that the end result helps both the providers and the clients.

Research on farming in a semi-arid region such as Southern India suggests that it is possible to achieve improved farming conditions by adaptive farming, which takes into account several socioeconomic factors. By recognizing that soil moisture is the most critical parameter that drives the system, successful farming can be achieved for example by improving moisture balance in dry land horticulture tree plantations. The adoption of such science based practices can be relatively simple and can lead to significantly improved farming productivity.

## Human Health and Disease Control

***Chair: Carlos Corvalán*** *(World Health Organization, Geneva, Switzerland)*

**Keynote Presentations:**

- *Reducing Impacts from Climate Related Disasters* Bettina Menne World Health Organization, Office for Europe, Italy
- *Protecting Health Through early Warning Systems for Communicable Diseases* Zhou Xiaonong, National Institute of Parasitic Diseases, China Center for Disease Control
- *Urbanization, Climate, Energy and Health* Diarmid Campbell-Lendrum, World Health Organization
- *Climate Variability and Change, and Nutritional Security* Anthony Nyong, Centre for Environmental Resources and Hazards Research, University of Jos, Nigeria
- *Response Options for the Health Sector* Madeleine Thomson, International Research Institute for Climate and Society, USA

Population wellbeing and health is the absolute bottom line of sustainability. Throughout the 1990s – despite its fundamental significance to the society – human health was under-recognized as a potential area for climate impacts. Since then two barriers have been partially lowered: first, the preoccupation of modern epidemiology with individual level (vs. population level) determinants of health; and second, the wide-spread non-awareness of the dependence of human wellbeing/health on nature's life-support systems. The latter barrier is one example where the possible reluctance of different sciences to cooperate for the common good prevails until there is an eventual realization that they can indeed support each other. Multi-scientific discussions and interactions should therefore be encouraged at the health-climate science interface as elsewhere.

Climate variability and climate change present a wide range of challenges to preventive health, acting over shorter to longer time scales and a variety of spatial scales (See figure 5). Over short time scales, extremes associated with current climate variability also influence risks for human health. Recent examples of extreme events that seriously affected human health and well-being are the 12-day heat wave in Southwest Europe in August 2003, Hurricane Katrina in August 2005 and the current ongoing, prolonged drought in Australia. The reduction of health consequences stemming from climate related disasters requires proactive integrated risk management that identifies risks and includes those associated with climate in a wide societal context. This work should be done jointly by the health and climate sectors.

Over longer time scales, gradual climate change will affect vector-borne and other infectious diseases, such as dengue and malaria. Climate also affects "external" sectors which are among the most important determinants of health, such as food production.

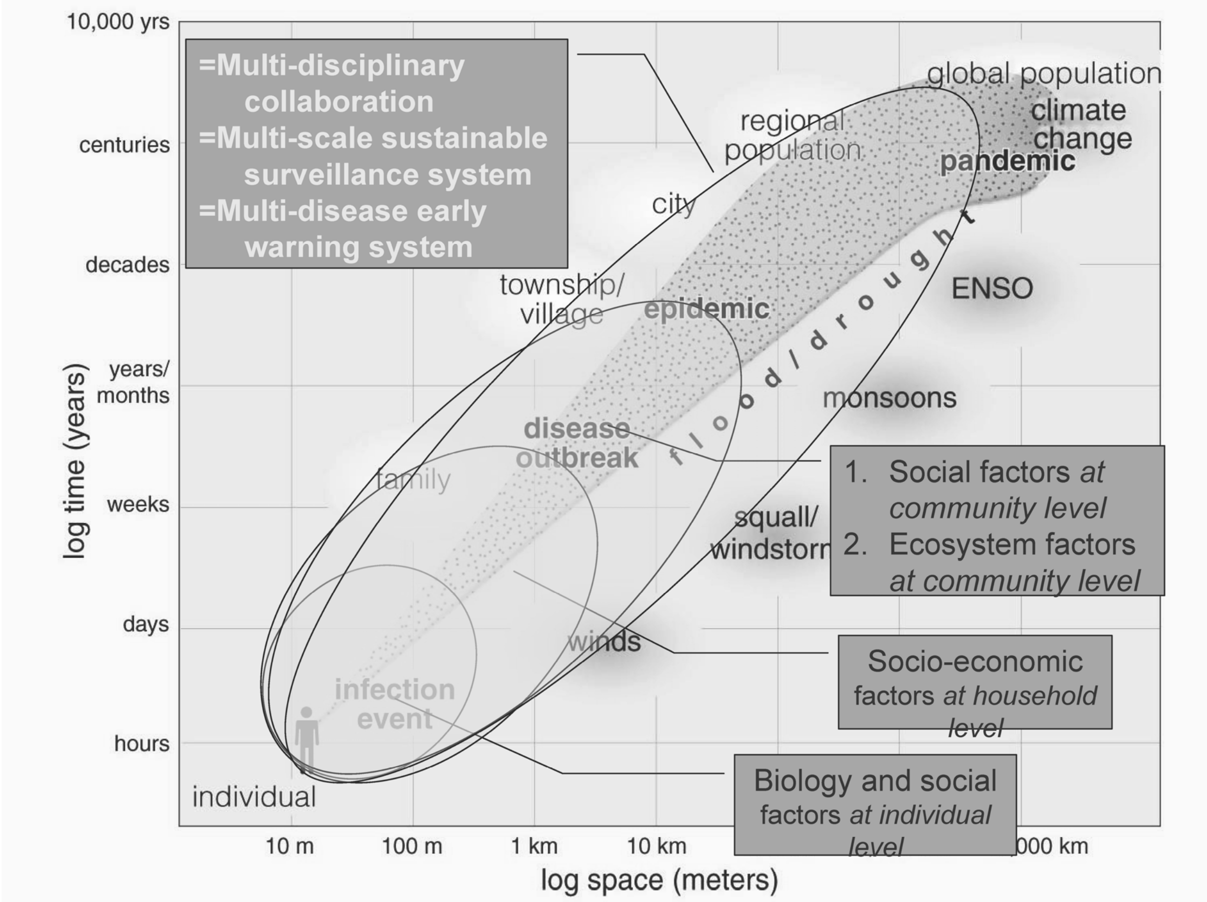


**Figure 5.** Climate-sensitive diseases vary across wide temporal and spatial scales. Non-climatic vulnerability factors are shown in boxes on the right. Interventions to reduce health impacts are shown in the box on the top left (adapted from presentation by Dr. Zhou Xiaonong).

Climate change often compounds other non-sustainable pressures on these systems. For example, ocean warming and ocean acidification, acting on top of over-fishing, threaten the future productivity of global fisheries. This will have consequences for the nutrition of affected populations, especially in coastal or island developing countries.

Climate and other threats to "health-supporting" systems need to be considered and protected in an integrated manner, through sustainable development. With respect to the effects of climate variability and change on food and nutrition security, it should be understood that it is not only about the security of food supplies but also the need for couplings to a sanitary environment, to adequate health services and to the availability of comprehensive care. At first hand this is a policy issue, i.e. where food and nutrition security is an integral part of overall economic development.

Actions by the health sector and partners can go a long way towards ameliorating harmful health effects from climate change. The control of schistosomiasis in China provides a cogent example where it has been shown that it is possible to manage the spread of a disease through properly designed and developed early warning systems for various scales. Some basic issues here are: to understand the variability of the transmission; to assess the risks and vulnerabilities at different scales; and to create and update baseline databases by appropriate surveys.

Actions to protect health from climate variability and change vary from location to location, and there are particular hotspots where actions can have particularly large effects. For example, the rapid urbanization trend means that cities, particularly in developing countries, both have specific health vulnerabilities to climate change, and are an increasing cause of the problem. City-level actions, from promoting healthy and low-carbon development to targeted health interventions using climate information, are of critical importance.

Overall, key principles for health adaptation are: to protect high-risk groups/populations; to assess feasibility and cost-effectiveness of proposed measures; to seek 'win-win' adaptations that tackle problems stemming from natural climate variability as well as from human-induced climate change; to seek a balance between long-term structural 'climate-proofing' and more immediate, lower-cost, politically expedient interventions; to enhance inter-sectoral awareness and coordination; and to encourage public-private partnership initiatives in developing appropriate financial instruments.

## Water Resources

***Chair: Roberto Lenton*** *(IRI, Palisades, USA)*

### Keynote Presentations:

- *Managing Risks: Securing the Gains of Development* Gordon Young, World Water Assessment Programme, UNESCO
- *Designing "Resilience Systems" in Water and Economic Development* Humberto Barbosa, FUNCEME, Brazil
- *Practical Experience in Integrated Flood Management: Integrating Land and Water Resource Development in a River Basin* Americo Muianga, former Director of water Affairs, Mozambique
- *Climate Information Needs for Integrated Risk Management of Water Resources – A South African Perspective* Roland Schulze, University of KwaZulu-Natal, South Africa
- *Climate and Development: Mitigating Variability in Water Resources* Casey Brown, International Research Institute for Climate and Society, USA
- *Integrated Water Resource Management is Blind without Climate* Henk van Schaik, Co-operative Programme on Water and Climate, UNESCO

The useful life of water-related infrastructure is often measured in hundreds of years. Hence there is much to be said for adopting 'leapfrogging' paradigm by aiming at choices for development that are at the leading edge of the long time scales. The Integrated Water Resources Management (IWRM) concept (Global Water Partnership, 2000 and Oki & al., 2006 ) has been developed as one response to the multitude of pathways to resilience in water resource issues. The IWRM encourages the engagement of communities and sectors especially sensitive to water availability into its management. The IWRM approach is an important tool, therefore, in the achievement of sustainable development.

A decline in stream flow data is of particular concern amongst water resource managers as a lack of data increases the planning uncertainties. Furthermore, it is very difficult to estimate the stream flow on the basis of other available data. It was also emphasized that adaptation to water uncertainties in the face of climate change was a significant issue.

Chapter 10 of the World Water Development Report II (UNESCO, World Water Assessment Programme, 2006) discusses the risks of water management from the point of view of water-related disasters. Developing countries are disproportionately affected by disasters and, even in the more developed countries, it is again the poor who are most vulnerable to disasters. Hence, water risk management has become a general priority for alleviating poverty, ensuring socio-economic progress and securing the gains of development.

While there has been considerable progress in water risk management over the past decade, both technical and organizational constraints remain high. Water-related disaster risk reduction program require a stronger integration of risk-related public policies and improved cooperation among decision-makers, risk managers and water managers. Institutional coordination and management mechanisms need to be strengthened and stakeholder involvement encouraged. In addition, indicators are needed to detect and monitor changes in the natural and social environment. Moreover societies should take steps to improve decision-making in situations of uncertainty, with plans for action underpinned by a clear legislative framework. Finally water risk management strategies need to be aware of the levels of preparedness of their societies to live and deal with risks.

The design of short-term water management in the semi-arid region of Northeastern Brazil provides a cogent example in improving water allocation using seasonal to inter-annual climate forecasts in probabilistic forms to assess upcoming reservoir inflows and their contributions to existing water storages. Water allocations can then be facilitated by the use of appropriate macroeconomic models and policy constraints.

Timely access to hydro-meteorological data as well as to forecasts is critical for integrated flood management. The system in Mozambique, for example, has been facilitated by the regional SADC-HYCOS network project. Mozambique is a country prone to floods where it is essential to have accurate flood risk maps as a sound basis for land use planning.

From a practical perspective, climate issues need to be considered in a broad context of different hydro-climatic regimes and different socio-developmental stages, as well as in pertinent local problems. Again, careful attention must be given to the maintenance and design of the climate and hydrological data networks.

The elements to build resilience in a water supply comprise: an understanding of the local water resources risks and decision constraints; engagement with stakeholders; the incorporation of inflow forecasts for water allocation; and the judicious use of inflow insurance to fund dry year buyouts. The objective is to get better outcomes, to maximize the good years and to reduce the risk exposure in dry years.

With respect to institutional mechanisms and partnerships, there is still a divide between the scientific climate community and some political leaders on the one hand and operational practices on the other. There are examples, however, of developing mechanisms and partnerships. The IWRM processes mentioned above, for example, need to be integrated with broader national processes for development planning. “Climate proofing” in long term sector planning and large investments, like dams and reservoirs, may be a lofty goal but one that is nevertheless worth pursuing, recognizing that the process from planning to implementation and operation is long and complicated.

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## Energy and the Built Environment

***Chair: Michael Coughlan*** *(Bureau of Meteorology, Melbourne, Australia)*

**Keynote Presentations:**

- *Motivating Business and Government on Climate Change* James Walker, The Climate Group, United Kingdom
- *Energy Options and the Climatic Constraints* Geoffrey Levermore,
- *A Climate Friendly Built Environment* Gerald Mills, University College Dublin, Ireland
- *Observation Solutions for Minimizing Weather and Climate Risks* Irma Ylikangas, Vaisala Corporation, Finland
- *London: Planning for Climate Change* Tatiana Bosteels, London Climate Change Agency

- *Climate Variability and Change – Threat or Opportunity for the Tourism Industry* Tagnar Cegnar, Meteorological Office, Environmental Agency, Republic of Slovenia

The business-as-usual course of energy production should not be taken for granted in the future since there are now many technically feasible options for intervention, e.g. through devising new ways to supply renewable energy. There are also some stimulating challenges in devising suitable policies and measures to get a globally desirable outcome in energy allocations. Choosing the right energy options become critical in achieving the Millennium Development Goals that relate to the reduction of extreme poverty and hunger, and to the provision of necessary basic health services.

In the built environment the turnover of the capital is not rapid and can be ~50-100 years. Accordingly, adequate attention must be given to energy efficiency in the design of such long-lived infrastructure. Further, the built environment should not be viewed too narrowly. It consists not only of houses and buildings, but also of the myriad of linkages between them. Besides mitigation measures, one also needs to consider adaptation. Aiming for a lifestyle should be considered not only in terms of its comfort but also in terms of its sustainability. Social and cultural well-being and cohesiveness are also important.

The expected emergence of more mega-cities through the coming decades, especially in developing countries, need not lead to highly divided societies. Further, rural areas should also be kept viable through proper infrastructure and access to the basic needs of living, including the availability of adequate energy.

The six principal drivers that motivate industry to action on climate change are: risk management; operational savings; public/consumer demand; regulation; business opportunities and new markets; and peer pressure. The political and business landscape on climate is already changing rapidly. It should be emphasized that confidence is critical to leadership. Scientific understanding is important when long-term targets are set up. Sharing best practices in terms of what works can be facilitated through better reporting. 'Smart' policy development is also stimulated by cross-sector dialogue.

Buildings are significant emitters of CO2 and the emission trends continue upwards. Appropriate refurbishment and better designed new buildings could help reverse this trend especially when there is encouragement through regulation, along with the development of more efficient equipment and effective controls.

We are reaching the point where most of the humanity lives in urban areas, which have been significantly modified to the detriment of the immediate and surrounding environment. In addition, urbanized areas and activities are directly or indirectly responsible for localized climate changes and weather modification. As human artefacts these areas are amenable to purposeful change. However, such changes would have to be mutually beneficial at all urban scales to achieve real success. There is a substantial body of literature on the relationship between urban form, function and climate effects. Much of this work, however, is disconnected. Moreover, the political impetus to bring about change at this level has not existed hitherto.

When attempting to detect and document climate change, climatologists will typically remove the effects of the urban environment from climatological records.

**Figure 6.** An example of the modern building design to help to reverse the trend towards sustainable development

Notwithstanding, documenting the spatial and temporal variations in the climate across an urban landscape is important in its own right. A few cities, such as Helsinki, are developing relatively dense networks (~10km) of automatic observation stations for this purpose. Although the practical experience with such networks is still very limited they have great potential for improving the urban environment when developed in cooperation with experts from both the climate information supplier and user side.

Moving about in the mega-cities of the future will require effective approaches that balance private and public modes of transport, with a likely emphasis on the latter. London, England provides an example of a large city that is already planning for climate change. The key parameters influencing London climate change strategy are: the assessed impacts and risk analysis; the potential for climate change mitigation by using renewable energy sources as much as possible; adaptation for economic development, and a keen desire by the public authorities to see London as an exemplary sustainable world city.

Tourism is an integral, firmly established industry in many countries and indeed is the largest export earner in the world. Any major changes in the market patterns of tourism brought about by climate variability and change could lead to wider impacts on many economic and social policies. Climate related risks for tourism that can be assessed include: increased likelihood of traffic accidents due to bad weather conditions; disaster related threats to the health, property and lives of tourists; and exposure to different kinds of communicable diseases.

Tourism is a continuously adapting industry and can respond fairly quickly to changing demographic and economic conditions as well as to new demands and technologies, although at some cost with respect to the addition of new infrastructure and the writing down of infrastructure in tourist areas no longer in favour.

# Cross-Cutting Issues Presentation Abstracts

## Long Term Planning and Development: Public and Private Sector Perspectives

***John W Zillman***

President Australian Academy of Technological Sciences and Engineering (ATSE)
Immediate Past President of the International Council of Academies of Engineering and Technological Sciences (CAETS)

There are many features of planning for living with climate variability and change which are common to all or most sectors of society and to both developed and developing countries.

The key steps in planning for climate which are common to most social and economic sectors include research, risk assessment, evaluation of response options, strategy development, identification of implementation agents, action planning and budgeting and performance evaluation.

It is essential in the planning process to recognise the important distinction between natural and human-induced change and to treat the challenge of living with climate variability and change in its broadest sense i.e. managing the issue (e.g. through development of greenhouse gas mitigation policies) as well as managing the impacts of climate (e.g. through planned adaptation to the natural fluctuations of climate).

The respective roles and perspectives of government and business in planning to live with climate variability and change vary from sector to sector and country to country but can be usefully assessed in respect of their motives, their expertise, their influence, their attitude to science, their attitude to risk and their attitude to planning.

Planning at the national level is usually led from the Public Sector and involves such well-established climate-focussed organisations as National Meteorological Services, agriculture, energy and infrastructure agencies and environmental policy departments. Increasingly, however, in the development of national strategies for living with human-induced climate change, governments are substantially involving private sector consultants and the various business organisations and other private sector bodies on whom they must rely for most of the implementation action through technological innovation, market development and the like.

At the international level, governments carry the lead role in planning and policy formulation but, again, in recent years, it has become normal practice fore government negotiators to engage the private sector in the development of national input and often, also, in national delegations and post-session follow-up at the national level.

It is informative to review, and to compare and contrast, the role of the public and private sectors in a range of countries and especially to identify the similarities and differences in the experience of developed and developing countries. Many of the generic features emerge from a review of long-term planning for climate in Australia (a developed country) and Africa (a wide spectrum of developing countries). An especially promising initiative, which brings out many of the common issues, is the so-called “Climate Development for Africa” program which emerged from a recent user-driven planning meeting in Addis Ababa.

## Assessment and Management of Climate-Related Risks

***Maxx Dilley***

Policy Advisor, Disaster Reduction

UNDP Bureau for Crisis Prevention and Recovery

Risk management provides an overall framework for informing decisions under conditions of climate variability and change. Risk management is a conscious effort to reduce the probabilities of negative outcomes in pursuit of positive goals. Decision-makers manage risks in order to achieve desired outcomes while avoiding undesirable ones.

Risk management is achieved by identifying, reducing and/or transferring risks. Risk identification is the process of identifying who or what is at risk, of which outcome, and why. Risk reduction involves measures to reduce the probability or severity of particular negative outcomes to particular entities. Risk transfer is the use of financial mechanisms to share risks so that the costs of adverse outcomes are not borne entirely by the entities at risk.

Applying risk management in particular decision contexts requires understanding who the decision-makers are, their goals, the causal factors that lead towards success or failure as defined by these goals, and the available decision options for managing risks. Decision contexts affected by climate variability and change are numerous and can be found across many socio-economic sectors including health, energy, water, agriculture, infrastructure and environmental management. The complexity of actors and decision-making processes within these sectors requires that risk management decision-support efforts be precisely targeted towards specific audiences.

Large areas of the developing world are at high risk of negative outcomes such as mortality and economic loss due to climate variability and extremes. Current risk patterns may change significantly in the future due to socio-economic and environmental changes, including climatic changes associated with global warming. International development efforts, therefore, must take into account not only climate-related risks based on current patterns of climate variability but also risks associated with potentially significant climatic shifts in coming decades. Successful risk management strategies in light of current climate conditions could become unviable under future conditions.

The prospect of potentially significant climatic changes introduces greater uncertainty into decision-making processes. Consequently, decision-makers have two challenges. The first is how to best manage short-term risks associated with current climate variability on seasonal-to-interannual timescales. At the same time they must also begin to factor in long term climatic trends and changing baselines, generally based on less certain information, in an effort to ensure that the short-term solutions of today do not lead to increased risks in the future.

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## Interdisciplinary Applied Research

***Gordon A. McBean***

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In their Joint science academies' statement, the Presidents of academies of science of all G8 countries plus those of China, India and Brazil, stated that "*climate change is real"* and that there must be actions to "*reduce the causes of climate change*" and to "*prepare for the consequences of climate change*". This dual nature of the climate change issue means that there must be a fully interdisciplinary approach, involving natural, engineering, health and social (including political and economic) sciences. Recalling that the UN Framework Convention on Climate Change set its objective as "… *stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic* *interference with the climate system*" leads to the questions of what is *dangerous* to whom, to what and at what rate of change and stabilization at what level and the relationships between all these questions. Future climate change will depend on as yet unknown human choices related to emissions, adaptations and uncertainties in a wide range of sciences. Since much of the greatest impact will come from extreme events, the uncertainty is further compounded. When or if a target is set for stabilization, what are the socio-economic and environmental consequences of options to attaining it? What are the international and intergenerational equity issues of these approaches? How to mobilise the world community on an appropriate time scale?

All governments need to deal with a broad range of policy issues; particularly relevant in this case are: climate change; environmental protection; disaster management and international development. Today these are largely unconnected and they need to be. Climate change is also a particularly long-term issue which creates difficulties in dealing with it in a typical 4-year election cycle. Possible frameworks for dealing with these issues need to include considerations of global security, sustainable development, economic efficiency, and poverty eradication using science-based information.

Dealing with these broad ranging issues is a problem for the traditional scientific approach. Climate variability and change and the weather associated with it are pervasive in their effects on society and the natural environment and an interdisciplinary approach is essential. The Earth System Science Partnership (WCRP, IGBP, DIVERSITAS and IHDP and their capacity-building program START) was created in an attempt to address this issue. This presentation will discuss how bringing science and scientist together, from across the globe, is needed to address the climate change issue in this broader context.

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## Promoting Change through Innovation

***Mr Esko Aho***

President of the Finnish National Fund for Research and Development (Sitra)

Innovation and technology are the key elements of European competitiveness, as highlighted in a recent report, "Creating an Innovative Europe", which was submitted to the European Commission in January 2006. The mission of the expert group was to investigate the concrete actions how to hasten the implementation of the Lisbon strategy. In Lisbon in 2000 EU Member States set an ambiguous objective to make Europe the most competitive market area in the world by 2010.

As four main recommendations, the report highlighted the importance of the establishment of an innovation-friendly market for new products and services, the guarantee of sufficient public and private funding for research and development and the need for mobility of human resources, and risk taking and entrepreneurship. Not only within economic and competitiveness questions, all these elements also have an intimate link to environmental and energy policies.

First, critical developments in climate change clearly speak for supporting new innovations and technologies to enter the market. We need new products and services to help us to take into account environmental protection. Second, this task requires that sufficient funding for research and development is secured and that it is allocated to those areas that can provide new information about and understanding of how to more effectively preserve the wild nature.

Third, innovation and technology also require mobility. This means that we need close cooperation between academia, business and administration and that the knowledge of scientists is properly utilised in decision-making processes. It is already known that we have a lot of information about climate change but we should do more to pass it on to decision-makers. Fourth and finally, we have to encourage risk taking and entrepreneurship. Even though there is always a risk related to starting new businesses, without risk taking entrepreneurship many excellent ideas would not become reality.

There are clear indications that economical and financial steering is coming to support legislative means in environmental policies. Investments in clean technologies are rapidly growing globally, and shifting risk capital to the environmental industry is becoming a megatrend. Investments in innovations related to new energy sources, new sources of raw materials, dematerialisation and immaterialisation, eco-efficiency will come out as flourishing business in the future. The challenge is still to integrate better environmental issues, technology push and economical development, need for new innovations is bigger than ever.

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## Natural Disasters and Climate Change in Developing Countries Needs and Means For Adaptation

***Petteri Taalas***

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Recent trends in the number of casualties and amount of economic losses due to natural disasters together with the type (weather related or other geophysical) and the regional distribution of the disasters. While the number of casualties has decreased during 1993-2002 as their weather and climate services have improved and conduced to build up local adaptation means the compensated economic losses are growing increasingly. Even though these compensations for the poorest nations are roughly one third of those for the richest countries the economic losses in proportion to the GDP some 13 % of the GDP in contrast to some 2 % in the richest countries.

The foreseen climate change leads to a growing need for adaptation in the developing countries. This is focused to a large extent partly to an increasing frequency of floods and also in many regions to risks of recurrent droughts. Much of this hits Africa.

In the context of adaptation in tropical regions seasonal forecasts can be used to enhance the agricultural productivity as well as to use as preventive means to restrict the spreading of infectious diseases. All in all the climate services of the developing countries face great challenges and opportunities in helping the societies to adapt to the climate both in terms of its natural variability and its human-induced change.

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## Regional Climate Scenarios: Their Use for Raising Awareness, Facilitating Impact Studies and Contributing to Adaptation Planning

***Markku Rummukainen***

Rossby Centre, Swedish Meteorological and Hydrological Institute

The discussion on climate change is very much in terms of the global mean temperature in the eyes and ears of many stakeholders, and subsequently leaves them dry. The essence of climate models and, perhaps more importantly, the nature of predictability continue to elude many. Also, the distinction between climate prediction, projection and scenario is still unclear, even to many scientists outside the very climate modellers. This gives rise to confusion on how robust the science of climate change is, and bears on the feasibility of taking decisions on how to deal with climate change.

The climate system is global. To project the climate change due to the past and future anthropogenic climate forcing (such as emissions of greenhouse gases) requires the use of complex global climate models. As the future forcing is not known (rather, it depends on the socio-economic world development, and also our decisions) and as there are climate science uncertainties (such as on climate sensitivity), the future needs to be probed with many models, different scenarios and repeated model simulations. One consequence of this is the misconception of climate change being riddled with prohibitive uncertainty. Another is that in practice, regional and local climates can not be addressed en masse with global models. And yet, it is on these scales that people across the world have their first-hand experience on climate. Many climate effects, vulnerability and consequently also adaptation to our changing climate, also vary across the regions of the world.

Thus, there is a need for efforts to describe climate change in useful terms to all stakeholders and for every region of the world. Efficient outreach is extremely important in engaging the society in climate change, and for making climate change science accessible. One means for this is by way of regional climate scenarios, today pursued in many countries including such co-ordinated efforts as the recent European PRUDENCE and the now ongoing ENSEMBLES project, and their North American counterpart NARCCAP. PRUDENCE, for example, made some first steps on multi-model regional climate scenarios and pushed for an integration of these with impact studies and their communication to stakeholders. The project, ENSEMBLES, among other things, pursues more detailed and better evaluated regional climate models, with the aim of probabilistic descriptions climate change and climate impacts on different time scales.

This presentation discusses regional climate scenarios as a means of facilitating our managing with climate variability and climate change. Examples will be drawn especially from European efforts. Generic conclusions will be made on the use and usefulness of regional climate scenarios, such as promoting the local and regional "ownership" of climate change related issues, modelling spatial detail and extremes, and as one starting point for specific impact studies and in the dialogue with stakeholders.

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## Summary of Cross-Cutting Presentations

Long-term planning for living with climate variability and change presents societies with the fourfold challenges of:

1. planning for improved adaptation to the normal natural variability of climate;
2. planning for adaptation to whatever long-term changes of climate eventually result from anthropogenic emissions of greenhouse gases;
3. planning to reduce (mitigate) human-induced climate change through greenhouse gas emission reduction; and
4. planning for adaptation to whatever changes to social and economic systems are implemented in order to keep human-induced changes of climate below "dangerous" levels.

The respective roles and perspectives of government, academia, business, and civil society in these planning processes vary from sector to sector and country to country, but can be usefully analyzed in terms of the respective motives, interests and attitudes to science, uncertainty, risk and opportunity, environmentalism, international planning mechanisms, regulation, access to expertise, as well as to planning practices and time-frames.

Learning to live with climate variability and change is a complex and challenging process involving both public and private sectors in a wide range of planning and risk management activities. There are many aspects of the process that are common to all or most climate-sensitive sectors and to both developed and developing countries. There is also substantial scope for learning from existing national and international strategies for living with the natural variability of climate in preparing for the impacts of human-induced change.

Climate risk management (CRM), like all forms of risk management, aims to protect against unintended negative consequences while in pursuit of positive goals. Risk management consists of risk identification, risk reduction, and risk transfer. Here the concern is with risk identification that involves the assessment of a climatic (or weather related) *hazard* *frequency* or probability of occurrence. Such hazards are potentially damaging physical events, phenomena that may cause loss of life or injury, property damage, social and economic disruption or environmental degradation. One might also add the potential for damage to the climate itself from human activities. In addition, one needs to know the *exposure* of people living in communities, their infrastructure and their economic activities to any of these hazards. *Vulnerability* is the integrated measure that identifies the conditions, determined by physical, social, economic, and environmental factors or processes, which increase the susceptibility of a community to the impact of hazards. The risk of a negative outcome depends both on the hazards and the on vulnerabilities; a disaster eventuating whenever thresholds at their intersections are exceeded. CRM is about tailoring processes for supporting decision making that will reduce the risks from climate and weather related hazards. In risk transfer, new insurance instruments are needed, with the recently innovated "hunger insurance" in Ethiopia providing a case study in point.

Interdisciplinary applied research is critical for successful CRM with multi-organizational activities, such as those being undertaken through the Earth System Science Partnership (ESSP), along with social processes offering the opportunities and frameworks for engaging in higher order CRM.

Many new steps need to be taken to improve CRM. One four-pronged strategy suggests that simultaneous and synchronous actions are needed at all levels in:

- creation of a market for innovative products and services;
- providing sufficient resources for R&D and innovation;
- improving the structural mobility; and
- building positive attitudes and a culture that is favourable to entrepreneurship and risk taking.

The needs and means for CRM and adaptation in developing countries are of particular concern due to the large existing information gaps. There is a great need, for example, to produce national level climate scenarios and national adaptation strategies. Climate services in developing countries need to be strengthened, with the responsible organizations, e.g. National Meteorological Services, learning to innovate and develop new outcome-oriented services that will meet the requirements of particular user groups. Such organizations also have to learn to dialogue with user groups in both the development and implementation of these services to ensure that they are properly integrated into broader decision making processes across economic, social and environmental concerns. In this regard, there is a strong requirement for well posed regional climate scenarios. Regionalization adds significant value to the more commonly available global-scale scenarios, as they provide a more realistic context for communities to focus on and thereby are more effective at raising local awareness. Regional scenarios can also contribute to adaptation planning by providing guidance on the range of options that might be open – doing this best when they are expressed in terms of impacts or consequences.

# Working Group Reports

## Decision Making

Co-Chairs: Nigel Harvey (University College London, London, UK) and
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Rapporteurs: Sabine Marx (Columbia University, New York, USA) and
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### *Introduction*

The following report is intended to provide guidance about decision processes to those engaged in making decisions that incorporate uncertain climate information, as well as to those who manage research and/or programs/projects to which decisions processes are pertinent. Psychology, behavioural economics, and game theory can add important insights for the development of decision resources. Climate-related decisions take place in the context of economic, political, and social (formal and informal) institutions that shape the interactions among various political, economic, and social opportunities and constraints and the physical environment. It is important to apply a perspective to the provision of climate information that takes into account the psychological, political, economic, and cultural circumstances that influence the production and use of climate information. These circumstances differ in multiple ways in developing and developed countries and are best known to the users of climate information. The provision of climate information and prescriptive advice about its usage in climate-related decisions thus needs to be the product of ongoing interactions between the producers and users of climate-related decision resources.

The high and sustained participation of conference attendees in the Decision Making track is indicative of the relevance and perceived importance of the topic to the provider and user communities. Participants in the breakout sessions on Decision Making came from disaster management, climate scientists from met offices and academia, agriculture, public policy/government, health, water, and energy most of whom were involved in some climate-related decision in the recent past.

### *Review and critique of current approaches to decision making*

The discussions in the working group included a review of current approaches to decision making which can be categorized as (a) normative and (b) descriptive models.

**Normative decision theory** for judgments of likelihood and for decisions under risk and uncertainty includes Expected Utility Theory, Risk/Return models, and Bayesian Updating. To make a rational decision one needs to know what alternatives are available, what the future states of the world and their probabilities or likelihoods can be, and what outcomes the different choice alternatives will have under the different future states of the world.

The advantages of these normative models are as follows: (a) they tell us how a rational decision maker should behave which provides a good benchmark against which actual behaviour can be compared; (b) they have a clear analytic basis which can easily be updated; (c) the cost and benefit of generation/acquisition of additional information can easily be assessed. However, normative models also have some weaknesses: (a) they do not explain why people make the decisions we observe; (b) for predictions we cannot expect decision-makers to be fully rational; (c) they assume the decision maker is well informed about the key components of the decision problem; (d) they often assume that there is sufficient knowledge about the outcomes; (e) they assume knowledge of quantitative probabilities and ignore the use of affective reactions and other heuristic processes to assess likelihood; (f) they often consider only one individual decision-maker; (g) they do not consider the process (the interactions) evolving while decisions are made; (h) utility functions of decision makers are difficult to identify; (i) risk/ return models often use variance and expected value as measures where information requirements are often too high for practical applications; (j) they often lack a spatial component, which matters greatly in regard to impacts of climate variability and change.

In sum, normative prediction approaches are important since they help to structure the information requirements and can help to structure the decision situation and to serve as relatively simple benchmark. Yet, in order to make reliable predictions of how people decide, descriptive models which integrate psychological processes into the decision model will be required.

**Descriptive Decision Models** take into consideration the multiple modes by which people have been observed to make decisions, namely calculation-based, rule-based, and affect-based decisions. They assume a combination of analytic and experiential processing of information, and take into account the different effects that personal experience and statistical summary information have on the assessment and management of risks.

Integrative models (whether they use normative or descriptive elements) also need to include a decision maker's multiple goals and incentives and need to be able to deal with groups of decision makers and their potentially conflicting objectives rather than a focus on individual decision makers. The latter point is particularly useful when addressing environmental decisions which are most commonly made by groups that are composed of individuals who have both aligned and conflicting goals.

Personal experience or vivid descriptions often dominate over statistical information, even though the latter typically provides more—and more reliable—information. Experiential processing relates current situations to memories of one's own or others' experience. Analytic processing, by contrast, includes mechanisms that relate the current situation to processed ensembles of past relevant experience and thus can easily and naturally express statistical constructs such as probability and sample size. Past experiences often evoke strong feelings, making them memorable and therefore often dominant in processing (Slovic et al., 2002; Loewenstein et al, 2001). Decision processes may involve both kinds of processing. The role of analytic processes in the understanding of (climate) uncertainty and in decisions involving such information, however, has often been overestimated and the role of experiential processes has been ignored. A better appreciation of experiential processing may point us towards improved communication strategies.

***Institutional Aspects***

Currently, we can identify two strategies in dealing with the unpredictability of climate. Climate "vagaries" are internalized, either culturally embedded (indigenous forecasting) or formal understanding of trend, normality, extremes (national meteorological services). Climate shocks are understood and the decision system is set up to cope. We could say the response is "hard-wired." Another form of response reacts to observed climate "triggers" such as unexpected hydro-meteorological events.

The mere availability of climate information does not guarantee that societies will be able to respond pro-actively to climate risks. To benefit societies better, climate forecasts should be accompanied with resources that enable an adequate response. They should also be tied in with socio-economic settings and existing institutional and policy contexts.

Institutions structure the political, economic, social (and environmental) interactions. They include informal customs and codes of conduct as well as formal constitutions, laws and property rights. Methodological approaches to studying institutions and decision making include the following: textual analysis; hermeneutics (interpretive): human, textual, historic sources; mapping (normative) / (empirical); Delphi techniques (expert judgment); impact analyses (hypothesis and testing); and participant observation ("who participates" / "local" / "indigenous knowledge.")

In order to identify key decision points and guide decision making, it is important to consider the diversity of a society's climate-related problems and to work in a participatory manner with regional partners and stakeholders who bring their local knowledge and expertise. At the same time they should be able to build their capacity. Box 1 lays out the elements of climate

**Box 1: The Elements of Climate Risk Management (CRM)**

- Investigate diversity of climate risks
  - Key stakeholder institutions
  - Vulnerabilities to climate and development impacts

- Understand current planning / decision systems
  - Institutional roles
  - Current reactive responses

- Formulate anticipatory strategies
  - Downscaled climate forecasts (appropriate spatial & lead times)
  - Methods, tools for resource decisions for risk management
  - Decisions-policy changes + sequencing & sustainable resource flows

- Acceptance and Implementation of CRM solutions
  - Demonstration embedded in stakeholder institutions
  - Capacity building (climate, risk management)
  - Evaluation of all CRM components

risk management (CRM) which can serve as a guideline for working with an institutional framework.

To summarize, when working within an institutional framework, it is important to recognize that institutions have a mandate, leadership of some quality, and accountability. One has to be aware that impacts can be irreversible. Who bears the costs and where? Who benefits and where? A web of institutions implies relationships and contradictions. Working with partner institutions may mean a co-existence of modern science and non-modern knowledge. Variables to consider when assessing the impact of existing institutions or the design of new institutions include the time and spatial scale of affected decisions, how to allocate resources, resulting costs and benefits, their distributional equity and reversibility. It is important to consider the diversity of climate-related problems and to work in a participatory manner with regional partners.

***The Role of Culture in Decision Making under Uncertainty***

"..the teacher/interventionist refuses to assume ahead of time that he or she has the appropriate knowledge…*instead he or she is willing to risk making connections, drawing lines, mapping articulations between different domains, discourses, and practices*…." (Airhihenbuwa, 1995, 111).

In addition to individual psychological factors and institutional factors, culture may also play a significant role in the perception and judgment of risk and uncertainty. A way of fixing some of the shortcomings of current approaches to decision making under uncertainty is to take into account the cultural differences of the various stakeholders (producers of information, users of information, industry, the media, the public, etc.).

Conventional forecast systems have a producer focus. They emphasize communication as key issue (e.g., probabilistic and deterministic forecasts); pay some attention to user environment; vaguely consider how end-users manage risk and how end-users cope and adapt to changing environments.

*Climate Outlook Forums* (COFs) have been heralded as a way to communicate climate information. Yet, we have to ask who is creating and validating the knowledge? Do western knowledge systems confront local knowledge systems? Linear dissemination models operated from science to end user. Outlook Forums are mostly dominated by production of climate knowledge that is "handed over" without regard for "other" knowledge. Where and how is "other" knowledge accommodated? These issues should be considered when designing end-to-end products.

Suggestions for improvement include alternative typologies of forecast systems (Vogel and O'Brien, 2003). An alternative approach should focus on the user and the user environment; "widening the discourse;" try to obtain data from end users about their risk environment; and seriously reflect on "institutional issues" and the "degree of fit" (e.g., Orlove and Tosteson, 1999).

Cultural differences exist not so much with regard to the absorption of climate information, rather cultural differences present themselves in regard to perceived relevance of climate information, perceived effort of doing something, and acceptance of climate-related risk. A risk management framework that considers the interplay of knowledge/information, policy, and practice can provide an understandable way to communicate uncertainties and allows for context-specific communication and application.

***Major Points of Discussion***

Major points of discussion during the breakout sessions on Decision Making circled around issues of terminology, importance of a back and forth between users and producers of information systems, and the need for multi-level interactions. The amount of discussion of these topics is diagnostic that they deserve further research and attention.

(a) The group saw a need for some form of a standardized terminology. Problems arise with terms such as mitigation, adaptation, the definition of types of decision, who are the decision makers/users/stakeholders? To address this point, it could be useful to establish a typology that can then be shared across sectors, disciplines, etc. Box 2 may serve as a starting point:

(b) Additionally, the importance of user-driven information systems and user input and feedback into decision resources was of major concern to the group, to assure that local knowledge is being taken into account. A key question that came up within this context was whether a generic decision model/tool applicable to all sectors and types of decision could be developed, or should the focus be on custom-tailoring? What will be more beneficial to users and what is the feasibility from a producer's point of view? No consensus was reached.

**Box 2: Towards a Typology of Decisions**

**Time scale:**

- Weather-related decisions (day-to-day)
- Climate variability (seasonal, inter-annual, decadal, etc.)
- Climate change (long-term trends)

**Spatial scale:**

- local, national, regional, global level

**Mitigation** of human-induced climate change
**Adaptation** to climate variability, climate change, extreme events

Climate-related **risks**
Climate-related **opportunities**

- Protect against unintended, negative consequences when pursuing positive outcomes (*risk homeostasis*)

**Individual Decision Maker or Group**
Communities, voters, politicians, the media, etc.
For groups differentiate between top-down, bottom-up, participatory processes

Different sectors/users

In all of the above:

– Varying availability of personal experience
– Varying levels of uncertainty

(c) It was pointed out throughout our deliberations that we should engage in a multi-level interaction which includes strata of government divisions (communal, district, province, state, and country), the multitude of non-government institutions, and other players involved. Disagreement among the discussion group members in this context existed with regard to the question of who should be the institution dealing with the translation of the climate information to be used by decision makers?

***Recommendations and Conclusions***

The wide range of climate related decisions discussed at this meeting suggests that it could be useful to adopt a typology of climate related decisions. Such a typology needs to include the following categories:

- Time scale (Day-to-day, Seasonal, Long-term)
- Spatial scale (local, national, regional, global)
- Mitigation and/or Adaptation
- Climate-related risks and/or opportunities
- Individual or Group
- Sectors/users

*General Recommendations*

- Develop a generic decision-making resource that incorporates flexible guidelines and risk assessment tools
- This resource could be produced in collaboration with all stakeholders and sectors
- This resource could be made available by suitable interface organizations and endorsed by Met organizations; it could be distributed to all relevant sectors and parties
- Separate tools need to be made available for mitigation and adaptation

*Specific Recommendations*

- Develop simulations (e.g., virtual strategy games) to provide experience in climate-related decisions
- Ensure multi-disciplinary development exploiting advisors from suitable agencies and parties
- Interface organizations could take primary responsibility for design and development
- These simulations could be formed by adapting current programs to include a ”climate button”

*Required Research*

- Search out and exploit “guidelines” already developed by sector organizations which make climate-related decisions. Comprehensively review and examine existing policies, law, and work done on decision types in the sectors; conduct surveys where needed
- Investigate methods for making decisions under high scientific uncertainty and how they can better inform climate-related decisions
- Encourage feedback from user community into climate science research agenda, which could include support for networks and interface staff
- Study the decision-making processes at local community level involving climate-related events in some selected countries

- Collect and assess principles for climate-related decisions, perhaps including a web-based forum
- Evaluate impacts from recommendations and organize a forum (e.g., workshop) to assess the impacts
- Evaluate outcomes, both intended and unintended, of measures implemented to facilitate living with climate uncertainty

*Dissemination*

- Share experiences of climate-related decisions, perhaps via a website
- Identify the stakeholders and partners that would be using climate information and communicate it in appropriate language
- Communicate regularly (with peers, industry, and other users) through a wide variety of media (e.g., trade journals, newsletters, and electronic sources)

*More Specific Recommendations*

While the above recommendations and research suggestions are general to make them widely applicable, the working group on decision making would also like to offer more specific decision making recommendations.

- Based on the observation that experiential and analytic processing systems compete and that personal experience and vivid descriptions are often favoured over statistical information, we suggest the following research and policy implications:
- Communications designed to create, recall and highlight relevant personal experience and to elicit affective responses can lead to more public attention to, processing of, and engagement with forecasts of climate variability and climate change. Vicarious experiential information in the form of scenarios, narratives, and analogies can help the decision makers imagine the potential consequences of climate variability and change, amplify or attenuate risk perceptions, and influence both individual behavioural intentions and public policy preferences.
- Likewise, the translation of statistical information into concrete experience with simulated forecasts, decision making and its outcomes can greatly facilitate an intuitive understanding of both probabilities and the consequences of incremental change and extreme events, and motivate contingency planning.
- Yet, while the engagement of experience-based, affective decision making can make risk communications more salient and motivate behaviour, experiential processing is also subject to its own biases, limitations and distortions, such as emotional exhaustion and resulting inaction due to a finite pool of worry and inadequately simple preventive action, since worry or concern is often alleviated by a single preventive or evasive action.
- Ideally, climate forecasts and communications should encourage the interactive engagement of both analytic and experiential processing systems in the course of making concrete decisions about climate, ranging from individual choices about what crops to plant this season to broad social choices about how to mitigate or adapt to global climate change.
- One way to facilitate this interaction is through group and participatory decision making. Group processes allow individuals with a range of knowledge, skills and personal experience to share diverse information and perspectives and work together on a problem.
- Communications to groups should also try to translate statistical information into formats readily understood in the language, personal and cultural experience of group members. In a somewhat iterative or cyclical process, the shared concrete information can then be re-abstracted to an analytic level that leads to action that incorporates both sources of information.

In summary, risk and uncertainty are inherent dimensions of all climate forecasts and related decisions. Analytic products like trend analysis, forecast probabilities, and ranges of uncertainty ought to be valuable contributions to stakeholder decision making. Yet decision makers also listen to the inner and communal voices of personal and collective experience, affect and emotion, and cultural values. Both systems – analytic and experiential – should be considered in the design of climate forecasts and risk communications. If not, many analytic products will fall on deaf ears as decision makers continue to rely heavily on personal experience and affective cues to make plans for an uncertain future. The challenge is to find new and creative ways to engage both systems in the process of individual and group decision making.

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## Disasters and Early Warning

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Rapporteur: Blair Trewin (Bureau of Meteorology, Melbourne, Australia)

This report summarizes the results of breakout group discussions in the area of managing risks associated with climate variability and change. The group addressed four areas related to various aspects of disaster risk management and early warning:

1. An overview of decision-making and extent to which climate is involved
2. Decision-making requirements, opportunities and constraints
3. Recommendations for research, development and action in priority areas
4. How to disseminate improved decision-making approaches.

The part of the report provides an overview of the disaster risk management field and gives five perspectives on different aspects of disaster risk management and early warning. The second part of the report offers cross-hazard observations on the above themes. Major climate-related hazards addressed during the discussions include drought, floods and cyclones but also rainfall-triggered landslides, heat waves, storm surges and sea-level rise – all of which were examined particularly related to the changing trends under the assumption of on-going background climatic variability and change.

### *Introduction*

As well as providing many benefits, the climate system is also a source of risk. Seasonal-to-interannual variability of rainfall and temperature, along with extreme weather and climate conditions, challenge communities, infrastructure and economic activities. The combination of climate-related hazards (e.g. drought, floods and cyclones, heat waves) – and societal vulnerability to these and other hazards is the major source of disaster-related mortality and economic loss worldwide. The potential for changes in hazard frequency and severity associated with climate variability (e.g., ENSO) and climate change provides further impetus for seeking to improve how climate-related risks are managed in order to reduce losses.

Risk management, and specifically climate risk management, provides a framework for better linkage between the scientific and technical climate community with the various other communities involved in disaster risk identification, risk reduction and risk transfer. Traditionally, disaster management has focused on post-disaster response but a new international movement is shifting towards more preventative and preparatory measures. Milestones in this evolution include:

- World Summit on Sustainable Development (2002)
  - Sustainable development and natural hazards
- World Conference on Disaster Reduction (Jan 2005)
  - Hyogo Framework for Action: 2005-2015
- Global Early Warning Survey (2005-2006)
- G8 Summit 2005
- UN Summit 2005
- Third International Early Warning Conference (March 2006)

Disaster Risk management seeks to reduce the likelihood of undesired, negative outcomes such as disasters in the course of pursuing positive goals. Its three components are risk identification, risk reduction and risk transfer.

1) 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 transfer.

2) Risk reduction involves measures to prevent losses. Specific measures include hazard-resistant infrastructure development, land use planning and zoning. Risk reduction also includes 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.

3) Risk transfer involves the use of financial mechanisms to share risks and transfer them among different actors (e.g., at-risk populations, government, and private sector). These include weather derivatives, catastrophe bonds and different types of insurance.

Risk management decisions and actions take place at a variety of levels – local, national, regional, international – and involve a number of different communities. These include scientific/technical, development/planning, humanitarian and civil protection, and financial risk transfer communities, different economic sectors and ministries, and populations directly at risk.

Due the multi-sectoral impacts of climate-related hazard events, a wide range of decisions and actions is required to successfully identify, reduce and transfer risks of climate-related losses. A coordinated approach therefore is facilitated when decision-making occurs purposefully and systematically within a governance and organisational framework. This requires the various communities to work together more effectively and in a coordinated fashion to ensure that appropriate information is produced, communicated and utilized effectively in support of different decisions involved in different aspect of this process. There is a need to move from supply-driven science to demand-driven science, and for consideration of how the scientific and technical community can meet the needs of the decision-makers involved in different aspects of disaster risk management, more effectively at community, national, regional and international levels.

A more coordinated and cooperative approach is needed among key communities including: development and planning, civil protection and humanitarian, financial and insurance, economic sectors and scientific and technical involving public and private sectors, academia and NGOs, etc. There are issues, gaps and needs to be examined and addressed at these interfaces.

Climate risk management stakeholders can be thought of as falling into two groups:

1) One group constitutes the customers or clients. These stakeholders are, in effect, risk managers in both public and private sectors. Their ability to achieve their goals is potentially affected by climate variability and change and they therefore in theory have an interest in managing climate-related risks in order to protect their interests. Examples of stakeholders in this group include climate sensitive businesses (e.g., public utilities, agribusinesses, hotel chains, insurance and reinsurance companies) health services, water resources management authorities, planners, politicians, and at least a portion of the public.

2) The second group constitutes those stakeholders who provide, in effect, a "climate risk management scientific and technical support system." These actors seek to provide tools, products and services to the client/customer group that are intended to lead to demonstrably improved outcomes achieved by the latter. These stakeholders include meteorological services, research institutes, climate centres and climate experts working in health, agriculture, infrastructure, water and other sectors sensitive to climate variability and change.

Whether they are profit-motivated or public sector oriented, the success of the climate risk management support stakeholders depends on the perceived value of their products and services by their clients.

Currently, neither group of stakeholders is particularly well articulated. The interfaces between the two segments have not been defined. The communities have not come together to clearly articulate the needs and what can be delivered to address those needs. This stems from the fact that the client base for climate risk management-related services has not been fully characterized. Also, despite significant progress in recent years, climate risk management support is provided by an ad hoc stakeholder network that only partially capable of addressing the needs of its potential customers.

There is need for:

1) A more rigorous process of scoping the climate risk management client base,
2) Segmentation of this client base with respect to their needs and requirements (e.g., different segments in the energy sector such as exploration and production companies, energy traders, public utilities, etc need different information from the providers) ,
3) Identification of target segments' decision-processes and relevance of climate information input,
4) Development of products and services based on what science can deliver
5) Development of systematic operational and reliable channels to provide appropriate products and services would therefore be a useful step in the further evolution of disaster-related climate risk management.

As disasters by definition involve wide-scale losses across multiple economic sectors, the process of identifying the full set of clients for climate risk management support – the risk managers whose effective action is needed to reduce such losses – is an inherently complex undertaking that goes beyond what could be achieved by a conference working group. The examples and issues below, however, may assist in a small way in advancing in that direction.

In order to support better risk management decisions and promote improved end-outcomes in any particular climate-sensitive context, specific questions include:

- Who is the target user?
- What are the target user's decision processes, options and tools?
- What are the potential interfaces for utilization of scientific and technical information?
- What are the gaps and needs for scientific and technical information and expertise?
- What are the concrete areas of collaboration at the interfaces based on what science can deliver?
- What are the most effective mechanisms for collaboration?
- What are the future directions in coordinated scientific research to address identified needs?

***Disaster risk management and early warning decision contexts***

The following sections provide background and examples on decision contexts and frameworks related to disaster risk management and early warning, including brief summaries of the presentations within the Disasters and Early Warning Segment, key conclusions and emerging questions for further follow up.

***Early warning and disaster risk reduction - building on the Hyogo Framework for Action and the Global Survey of Early Warning Systems***

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The Hyogo Framework for Action was negotiated in 2005 amongst 168 countries to establish a clear framework for building disaster resilience. It identifies priorities for action:

1. Disaster risk reduction as a priority with strong institutional basis for action
2. Identify, assess and monitor disaster risks and enhance early warning
3. Knowledge, innovation, education for culture of safety and resilience
4. Reduce the underlying risk factors
5. Strengthen disaster preparedness for effective response.

The Hyogo Framework provides guidelines as to how these high-priority areas should be addressed at national, regional and international levels, building on institutional capacities, networks and expertise from different communities. A key element of the Framework is reporting indicators of progress in disaster risk reduction, especially pertaining to the priority areas listed above, at all levels.

The Hyogo framework is supported by the International Strategy for Disaster Risk Reduction (ISDR). The ISDR seeks to enable international and regional agencies and governments to work together in a more cohesive and coordinated fashion to provide guidelines and support to the countries in establishing their disaster risk management governance organisational structures and operational mechanisms. One example is a seven-agency consortium established recently in support of providing coordinated advisory services and support to countries in the Indian Ocean towards building their national capacities for tsunami warning and response systems.

There is a particularly important role for the scientific and technical community related to priorities 2 and 3 above, and the need for better integration of scientific information in various decision-making processes at different levels. There is currently a disconnect between the perspective of scientists (supply-driven science) and the needs of managers (demand-driven).

In the specific case of people-centred early warning systems, four phases can be identified: risk assessment, preparedness, warning services and communication. A global early warning survey has recently been carried out in response to a request by the UN Secretary General. This found that:

- There are many gaps and shortcomings in EW systems, especially in developing countries
- Dissemination, preparedness and response is the weakest link worldwide
- There are weaknesses in political commitment, EW institutions, and public participation
- BUT great capacities exist upon which to base a globally integrated system, particularly within the scientific and technical domain.

*The key question that emerged from this presentation is how the scientific climate community (e.g., earlier identified as climate risk management scientific and technical support system) can support available international and regional mechanisms to ensure that scientific and technical information is best used in decision-making (input into risk assessment and early-warning systems for different applications in disaster risk reduction).*

***Risk assessment and early warning systems – private-sector perspective***

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The reinsurance decision context in this presentation provided examples from two perspectives, including:

1) The specific perspective of the reinsurance industry (private sector needs for climate information), and
2) Perspective of the Munich Re Foundation, a non-profit organisation working to facilitate community-based capacity for building resilience through early warning systems and other community-based preparedness programmes.

With respect to decision processes of the insurance and reinsurance sectors, there are numerous examples of impacts of hydro meteorological hazards on the insurance and reinsurance sector, and an increasing number of disasters, potentially partially forced by climate change.

The reinsurance industry has a wide variety of mechanism to cope with potential losses arising from increased frequency and severity of natural hazards, including:

- Adequate pricing
- Substantial deductibles
- Accumulation control
- Loss prevention
- Improved claims settlement
- Liability limits
- Exclusion of certain hazards
- Exclusion of particularly exposed areas
- Reinsurance, retrocession
- Tax reductions (reserves)
- Product development (new markets).

The industry is seeking better information (especially quantitative attribution) from the scientific community (in a more coordinated fashion) regarding the impacts of climate variability and change on trends in severity, frequency and location of natural hazards.

Warning time scales most relevant to the reinsurance industry are from seasonal to multi-annual. Six month lead-time forecasts, particularly of probabilities of extreme events, have some value; whereas one-year year lead-time forecasts and 3-5 year lead-time forecasts have very high value. Warnings on timescales of days or hours are of value for operational and risk quantification purposes for assessing potential scenarios of expected damage (i.e., tropical cyclone warnings) in case of an expected emerging disaster.

There are other emerging financial risk transfer mechanisms, such as weather derivatives markets, designed to address risks associated with climate variability (seasonal to yearly variations) These products in the developed countries is being developed through reinsurance sector, and major investment banks and the energy companies, whereas initiatives are being undertaken through the World Bank, World Food Program and the local insurance sector to facilitate these products in developing countries. There is a need to develop tools that can be implemented in developing and least developed countries. A major hurdle is lack of high quality historical hydro-meteorological data, for which a minimum of 30 years is needed. In many cases when such data is available, it is either of inadequate quality or only available on a commercial basis. The value of data is not at its raw stage but rather when it has been incorporated into the development of risk management solutions. Availability, quality, and high prices of raw data present a hurdle for the development of these markets.

The Munich Climate Insurance Initiative was started by Munich Re in collaboration with several other companies and experts, to assess the scientific and economic feasibility of climate insurance mechanisms for insuring risks associated with climate change. This initiative is nearly two years into the process.

*The key needs of the insurance/reinsurance sector from the scientific/technical sector are:*

1. Better attribution of the linkages between extreme events and climate variability and change (both historic and projected). There is need for more coordinated scientific research to link climate variability and climate change to trends and patterns in extreme events.
2. Better forecast information on timescales relevant to the sector (months to years). These are both areas where the key-limiting factor is progress in the science itself, not failures in inter-sectoral communication.
3. Better data products (historical and real-time) are also required (particularly to facilitate assessment of the viability of an effective weather derivatives market and design of emerging financial products).
4. Identifying the best mechanisms for communication and collaboration between the reinsurance sector and the broader scientific community (beyond the sector's own internal scientific expertise).

In addition to commercial reinsurance offered by the Munich Re Corporation, the Munich Re Foundation undertakes community-based projects in developing and least developed countries to facilitate early-warning systems and capacity within communities for managing risks associated with small-scale hazards. There is also potential for local community-based observation systems, although these will work best if they can be incorporated into broader networks. Such projects can assist communities to do their own monitoring and members of the community can be designated to identify potential risk and disseminate risk information to all community members to enable them to prepare and take action. In the case of large scale events there is potential for linking the warning centres supported by national agencies to these local systems to ensure that at-risk people receive warning information and can act on it. There is also potential that community observations be a focus for collaboration between the community level and the broader national/regional/international sector.

### *Risk Identification: The Global Risk Identification Program (GRIP)*

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The GRIP is being prepared and supported by several UN agencies, international development agencies, development banks, and non-profit foundations, with the goal of reducing disaster losses in high-risk areas, through:

- An improved evidence base for disaster risk management, consisting of
  - Risk evaluation, of risk levels and causal factors, and
  - Loss information, to assess the impact of disasters on development and for risk assessment calibration, and
- Increased use of risk information for disaster risk management
  - To support identification of risk management priorities, and to
  - Facilitate disaster risk management decision-making.

- This global programme will support country-specific risk and loss-assessment projects.

The chief interest is in major hazards such as drought, floods, and tropical cyclones, as well as major geophysical hazards. The goal is to build risk assessment capacities within countries by bringing key agencies and experts at national and international level into the process of developing hazard mapping and risk assessment capabilities in support of development planning.

The expected GRIP outputs are:

- Demonstrated use of risk information for risk management in a few high-risk countries
    - Risk assessment at national level
    - Identification of most effective risk reduction options
    - Establish conditions for risk management implementation
- A global risk update and report
    - Local/national level information on risks and losses in 10-15 countries, and a
    - Global level assessment
- Capacity development
    - Databases and basic information
    - Methodologies and training programs
    - Lessons learned and best practices, and a
    - Community of practice (experts, authorities, contacts, institutions).

There are many opportunities for the scientific and technical community to engage, through NMHSs and other expert networks within countries, with the GRIP projects. A critical contribution from the climate community is the provision of high-quality historical hazard data and expertise related to characteristics and analysis of these hazards in support of risk assessment and mapping activities and applications. NMHS's and national and regional research centers will be key partners in promoting national ris assessment work.

### *The Humanitarian Community's Need for Early Warning Info*

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International humanitarian coordination and response involves cases where international attention is required to address countries' needs post-disaster. Recently, humanitarian reforms are being undertaken whereby this community, whose traditional focus was on post-disaster response, is moving towards a focus on anticipating and preparing for disasters that may require international attention.

The reform has two primary elements: 1) use of early warning information for early action, particularly in monitoring emerging situations; 2) establishment of humanitarian trust funds to enable better planning and faster response.

Information-sharing and coordination tools used by the humanitarian community include:

- Virtual On-Site Operations Coordination Center (OSOCC)
- Early warning/early action quarterly reports for the Inter-Agency Standing Committee (IASC) (a consortium of 40 humanitarian agencies such as OCHA, FAO, WFP, UNICEF, IFRC). 3-6 month forecasts of hazards such as drought, locust swarms etc. are potentially very useful here.

- Disaster monitoring with regional desks and 24/7 operational capacity
- the UN Disaster Assessment and Coordination (UNDAC) system (rapid-response assessment team that can be deployed to disaster areas)
- the Global Disasteer Alert and Coordination System (GDACS)
- the Humanitarian Early Warning System (HEWS) web page
- Humanitarian Information Centres (HIC) – established post-disaster

A major challenge is to coordinate information from a huge variety of actors, and communicate effectively, in the shortest time possible. To this end, particularly on the warning side, more coordinated information sharing from WMO and the climate science community would be highly valuable to this sector. There are also issues with having to handle some disasters brought about by natural hazards such as droughts in a conflict situation.

Key issues to be further discussed:

- How scientific and technical information can be better facilitated in these humanitarian tools, specifically, a number of tools that are designed to incorporate advance warning information, including:
    - the early warning/Early action quarterly reports,
    - HEWS webpage
    - Scenario analysis of regional desks.
- The importance of seasonal forecasts in support of post-disaster humanitarian response and fundraising (e.g. of seasonal climate conditions following the Pakistan earthquake 2005). These forecasts should be provided operationally through the NMHSs.
- Mechanisms for facilitation of scientific and technical information into the humanitarian networks and tools (e.g. climate outlook forums, ENSO information)
- Incorporation of non-traditional forms of information (e.g. “bloggers”) into information-sharing systems.

### *Community-based Approaches to Disaster Preparedness and Response*

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National Red Cross and Red Crescent societies support disaster preparedness and response with a focus on community-based approaches for building community resilience. These activities include community preparedness and response programs for building resilience to climate-related risks.

Premises of successful early warning and preparedness are:

- Local people save lives, and well-informed communities save more lives
- Understanding risks is critical
- Improved capacity to cope with dangers
- Linking knowledge (both ‘traditional’ knowledge and science) and facilitating information flows in both directions
- Preparedness
- Team work and working together.

Additional climate change questions which are being addressed at the community level include:

- How to cope with increasing intensity and frequency of disasters?
- How to cope with unknown risks?
- How to use climate information to strengthen community resilience?

On important tool is vulnerability and capacity assessment. Climate information is used in various stages of these assessments.

The IFRC has established a climate centre to facilitate improved capacity through the activities of RC/RC societies in countries. A plan has been established for preparedness for climate change in 2006-07, with four stages:

1. Internal workshop on the risks of climate change
2. Taking a closer look at the risks of climate change in the country and the priorities and programs of the national RC societies
3. Capacity building for climate change resilient RC programs
4. Establishment of climate change resilient RC programs.

Needs for climate information include:

- Dialogue at the national level between the RC and the meteorological/climate community
- Analysis of trends in extremes, past and projected (and better communication of the work that has already been done in this field)
- Early warning, including seasonal prediction.

Issues to be discussed further:

- Concrete areas of activities between WMO and IFRC, and at the national level between NMHSs/climate networks and national RC societies (Early warning information, joint programmes for community education and preparedness);
- Providing extensive information on climate variability and change links to trends and characteristics of extremes, regional analyses, etc.
- Training of the RC facilitators to ensure they have adequate climate science knowledge.

### *Decision-making requirements, opportunities, constraints and priorities*

*An overview of decision-making in the disaster and early warning sector*

Risk identification is a key element of disaster risk management decision-making and early warning. The degree to which the different climate-related hazards have been characterized varies considerably from hazard to hazard. In the case of some hazards (e.g. tropical cyclones), scales of measurement and naming conventions are well established. Droughts and floods, however, are not tracked in any. This makes the risks associated with these very important hazards difficult to accurately assess in many cases, particularly in developing countries. Risk identification also has a dynamic aspect, that of determining that an event has taken, or is taking, place, or is imminent, something which is crucial in making an effective response, as well as for early warning in some situations. Improved characterization and tracking, as well as forecasting of climate-related hazards, therefore, and particularly of drought and floods, is needed both for early warning and for the construction of long term hazard records.

Decision-making for risk reduction occurs on a range of timescales, and can be separated into long-timescale preparatory actions, and early warning on shorter timescales that a particular hazard is likely or imminent. Climate and weather information is typically a major part of early warning systems. Traditionally, this has usually taken the form of warning of a specific hazard, such as the approach of a tropical cyclone, on timescales ranging from hours to days, but seasonal prediction is playing an increasing role, particularly for long-duration hazards such as droughts. The climate system is not predictable on seasonal timescales everywhere, but it is fortuitous that the greatest predictability is mostly in tropical areas, coinciding with many of the areas of greatest vulnerability to natural hazards. Climate information can also be an input into multi-faceted early warning systems, such as the early warning quarterly reports issued by OCHA.

Long-timescale preparatory actions include the development of response plans (both in the early warning phase and post-event), and the development of appropriate infrastructure (physical and otherwise) for reducing the risk associated with a hazard. The key role for climate information here is as an input to the identification of risks, and to designing what infrastructure is required to deal with a particular hazard; constructing physical defences against flood is of little use unless one has the necessary climatic information to know the level of flood for which those defences need to be designed.

Risk transfer is an emerging area of interest. Traditionally, in developed countries, the major avenues of risk transfer have been through insurance, and through state intervention to assist those adversely affected by disasters. Insurance markets in the developing world are typically poorly developed, but there is increasing interest in using risk-hedging instruments, such as weather derivatives, to transfer risk from the individual in environments without effective insurance markets, reducing transactional costs (since there is no need to assess individual losses, only the value of the specific variable covered by the derivative contract) and lessening difficulties of moral hazard. Climate information is critical in the effective pricing of risk transfer products, and sometimes (as with weather derivatives) in determining an outcome.

*Requirements of, and constraints on, decision-making*

Characteristics of an ideal decision-making structure include:

- decisions are well-informed by good science and good data;
- all relevant parties are involved in decision-making and information is communicated to all relevant parties;
- decisions are made and implemented in a timely manner;
- there are no institutional impediments, particularly political and economic, to implementing well-informed decisions.

A major constraint to decision-making across a wide range of hazards is a lack of good data. Good data are critical in providing good evidence to be used in decision-making, and in seeking political and community support for appropriate decision-making, as well as in facilitating risk transfer mechanisms such as weather derivatives. Ideally, data should be locally specific, of long duration and high quality and homogeneity, be communicated in a timely fashion (preferably in quasi real-time), and be archived in a form which makes it easily accessible to potential users, both in the public and private sectors.

In practice this ideal is often not achieved, particularly in developing countries. In the meteorological field specifically, networks are often too sparse to fully capture relevant phenomena, something which has not been assisted by a widespread degradation of observing network infrastructure. This degradation is most commonly driven by financial constraints (although armed conflict and lack of necessary technical expertise for maintaining network infrastructure, and communications are factors too). Financial constraints have also been a major driver in restricting the free flow of meteorological data between agencies and potential users, as many NMHSs operate on a commercial or quasi-commercial basis and treat data as a commercially valuable commodity (although there are signs that this trend has peaked and that data availability is progressively improving). These financial constraints and commercialisation pressures have often been driven by agencies such as the IMF.

The situation is even worse for many forms of non-meteorological data. Whilst implementation is often far from perfect, the World Meteorological Organization provides an institutional structure for data collection standards and data exchange. For most other environmental indicators relevant to hazard assessment, no such institutional framework exists and decisions about which data to collect and how it is collected and distributed are taken at the national level, resulting in many gaps and almost no international co-ordination.

Good decision-making depends on good linkages between the actors involved. Sometimes the appropriate linkages do not exist. A separate problem is a failure of institutional memory. Many decision-making structures are dependent on the knowledge of key individuals and are not sufficiently robust to withstand the loss of those individuals when they move on.

System inertia is a major constraint on decision-making. This can take a very wide range of forms. These include the existence of legacy capital stock with low turnover rates, dating from periods when risks were less understood, with inappropriate design values or inappropriate locations, and people living, or carrying out agriculture, in locations with a very high level of vulnerability to hazards, often forced by economic imperatives (e.g. that is the only land they can afford). System inertia is a particular problem in situations where the nature of the risk is changing over time, as is occurring for many risks because of climate change, because it places a constraint on adaptation strategies: a 10% reduction in mean annual rainfall may result in a 100km move in the boundary of the region suitable for growing a particular crop, but it is difficult to simply move a farm 100km (and it is even more difficult if there is an ocean or a national boundary in the way).

Effective decision-making for risk reduction can be constrained by a mismatch of incentives, both political and economic. On the economic scale, it is well-established that risk reduction usually has a very high benefit-cost ratio (figures of 7-10:1 are often quoted), but that does not provide a direct incentive for spending money on risk reduction if those incurring the costs are not those who (directly) receive the benefits – a common situation in the developing world where donors are more likely to provide funds for post-event response than for pre-event preparation. Risk reduction often requires decisions to be made with very long lead times, with no guarantees of payoffs. There is also a tendency for institutional focus and resources to be devoted to whatever appears to be the most urgent threat – in recent years, tsunamis, terrorism and, to a lesser extent, SARS and avian influenza – to the neglect of other risks.

On the positive side, the reinforcement of collective and political memory that occurs following a crisis can provide opportunities for rapid implementation of risk reduction strategies, with the investment in early warning systems following the 2004 Asian tsunami being an obvious example. Such opportunities can be most readily exploited if the necessary planning groundwork is already in place. Disasters are also a major disruption to system inertia and can provide scope for the replacement of inappropriate legacy systems (as occurred, for example, with the rebuilding of Darwin under more stringent building codes after the destruction of 90% of its buildings in Cyclone Tracy in 1974).

The extent to which the state of scientific knowledge is a constraint on decision-making varies considerably between hazards and timescales. On short timescales, the science of weather forecasting is now sufficiently well-developed that it is not a major constraint on the reduction of risks from many short-period weather hazards, such as tropical cyclones or mid-latitude windstorms (although the effective communication of those forecasts is still an impediment). There is, however, still considerable scope for further scientific development in seasonal forecasting, as well as in very short-range forecasting which would be useful in warning of hazards such as flash floods and tornadoes.

In an environment where a changing climate must be factored in to an assessment of the hazard risk, the state of scientific knowledge of likely future climate change is crucial, both in appropriately identifying hazards, and in designing appropriate infrastructure. As most infrastructure is expected to have a lifetime of decades or even centuries, an accurate assessment of projected climate change is very important. There is still a great deal of uncertainty in climate change projections, particularly as one move towards the local scale from the global and considers variables other than temperature, such as precipitation or the occurrence of extreme events. The science in this field, however, is continually improving, particularly the ability to make projections on small spatial scales.

A significant information gap is in the availability of climate information on timescales between those covered by seasonal outlooks (typically 3-6 months) and those covered by climate change projections (30 years or more). Information on timescales between a few months and a few years is of particular interest to the risk transfer community, as this is the timescale on which decisions are made regarding the pricing of risk and strategies in dealing with risk, whilst information on time horizons of 5-20 years is sought by many sectors.

Political boundaries complicate decision making in risk identification and risk reduction. As noted earlier, they can place a constraint on response strategies. They can also be an impediment to information exchange (it is not unknown for useful information to be withheld on the grounds of military sensitivity). Actions which reduce hazards in one jurisdiction can increase them in another. This is an endemic problem in multi-national catchments, most obviously in the sharing of flows during times of shortage, but also in the management of flood situations (for example, one country may choose to release water from a dam, reducing risks to its own territory but increasing them downstream). Whilst the existence of a political boundary is not a necessary condition for such conflicts between different interests, it makes one much more likely.

The fear of litigation is an increasing influence on decision-making. In the weather and climate forecasting field specifically, whilst there is no known instance of a forecaster or forecasting agency in any country being successfully sued for negligence as a result of a failed forecast, unsuccessful legal actions (and other legal activities, such as post-event public inquiries) have diverted resources and led to a desire among forecasters to avoid being drawn into such situations, which may have the potential to lead to forecasts being made on the basis of what is least likely to cause trouble, rather than what is most likely to be useful.

*Pertinent approaches to decision-making*

An approach driven by needs and requirements is seen by the working group as being important in decision-making. Users are most likely to feel empowered, and to make effective decisions relevant to their own circumstances, if information is focused on what users (customers) need for their risk management decisions, rather than being supply-driven in a top-down, one-size-fits-all approach.

Many critical decisions, especially in responding to early warnings, take place at the community (including individual) level. Such decisions need to be as well-informed as possible, which means that the information must be communicated effectively. It is crucial that:

- the technical means of communicating the information is effective
- the information is communicated in a form which is comprehensible to the intended users
- the source of the information is seen as credible by the users.

The last of these is a particular problem in many developing countries, where government agencies may not enjoy great respect, and where traditional forms of knowledge may occupy a higher weight in the minds of many. The building of credibility with users is crucial, and is a long-term process, particularly as meteorology is an inherently inexact science and it is likely that there will be forecast failures from time to time.

Careful consideration needs to be given to the form in which information is communicated. This includes the use of appropriate technology and language (in some cases, information is distributed in an official language, such as English, French or Portuguese, which may not be widely understood within the general population), and the use of a source that is most likely to be seen as credible by users. In some cases this will be a national-level agency (for example, a meteorological service); in others it may be community-based sources such as local community officials or elders.

Building of partnerships can be an effective strategy for involving as many relevant people as possible in the decision-making process. This can bring together agencies which are not normally effective communicating with each other – the Civil Risk Partnerships developed in the UK are an example of this.

***Recommendations for improved research and development, and filling gaps in existing systems***

The working group makes the following recommendations for improved research and development and filling gaps in existing systems:

1. That data collection, archiving and distribution be improved across all relevant sectors. In particular, that:
    - increased resources be devoted to basic data collection infrastructure, particularly in developing countries;
    - effective, complete and accessible hazard databases be developed, and made as widely accessible and frequently updated as possible, preferably through making use of the web;
    - data be exchanged freely between countries and between sectors within countries, and not be treated as a commercial or militarily sensitive commodity;
    - a suitable institutional structure, under the auspices of the UN or otherwise, be established for the collection of relevant environmental indicators and the setting of standards for this.
2. That reviews take place, at national and international level, of the key inter-agency linkages, that any missing links in chains of responsibility be identified, and that as an outcome of such reviews all relevant agencies are aware that they are within a chain of responsibility and their position within it.
3. That a comprehensive assessment take place of the current state of science on climate change, and the implications of climate change projections for identified risks and whether climate change will serve to increase or decrease those risks.
4. That tools developed in support of decision-making be placed on a systematic basis within institutions, to render them more robust to changes in key personnel.
5. That national assessments take place, guided by information provided by the outcomes of recommendation 3 above, of how hazard risks are likely to change with changes in the climate and what strategies are available for adaptation in particular locations.

*Methods for disseminating improved decision-making approaches*

The working group notes that the dissemination of improved decision-making approaches is a specific objective of IRI, which has a number of programs in this field. The GEF also has a fund for adaptation projects which may be able to be applied to this process.

Improved decision-making processes are most likely to be adopted if they are seen as being successful. Approaches which are known to be successful should therefore be promoted widely, with a view to other countries and sectors adopting approaches which have been found to be effective in their country of origin. The documentation of case studies where good decision-making has led to favourable outcomes (and where bad decision-making has led to adverse outcomes) is important here.

A template for identifying climate-related projects and risk management solutions, therefore, includes the following steps:

- identify a significant climate-related problem affecting the achievement of important social of economic goals
- identify stakeholder partners with the ability to influence the outcome and their decision-making options and calendar
- with these partners, design an operationally useful product to support the specific decisions they identify
- conduct research needed for development of the product
- produce a prototype decision-support product
- apply the decision-support product on an experimental basis, working with the intended users
- verify the results and make modifications as necessary
- upscale the resulting climate risk management tools and techniques to a broader range of stakeholders facing similar issues, making adjustments as necessary.

A systematic attempt to apply this template to addressing climate-related risks affecting societal outcomes will assist in the short run with managing seasonal to inter-annual climate variations as well as build adaptive capacity for managing long term climate change. A variety of applications for this approach have been identified by the working group. Many others can be found across a variety of climate-sensitive sectors. Better management of risks across these sectors is key to reducing the risks of climate-related disasters.

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## Agriculture and Food Security

Chair: Walter Baethgen (IRI, Palisades, USA)

Rapporteurs: Mark Howden (CSIRO Sustainable Ecosystems, Canberra, Australia), Holger Meinke (Department of Primary Industries and Fisheries, Toowoomba, Australia) and Melissa Ann Rebbeck (South Australian Research and Development Institute, Adelaide, Australia)

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The Agriculture and Food Security work group used a participatory procedure to define priorities and to establish its recommendations. During the initial working group session, each participant defined a set of issues that were considered crucial for the effective integration of climate risk information into agricultural and food security systems. These issues were grouped under four categories:

1. Data and information
2. Capacity building,
3. Communications
4. Integration.

The participants then broke into in four sub-groups, with each group discussing in depth its respective category. The group agreed that the categories were not distinct or independent of each other and that it is important to pay attention to the entire value chain. Furthermore, the working group emphasized the importance that “boundary integration or interfacing institutions” would play in acting on the group’s recommendations.

The following sections include a summary of the identified priorities and established recommendations in each of the four groups.

***Data and Information***

Data relevant for agriculture and food security cover a wide spectrum of technical areas, including climatology and its related disciplines. Food security, in particular, often relates more to access to food than to food production *per se*. The actual set of climate-related data required to assess impacts and risks along the food chain may be large, given that each link from food production or collection of wild products to storage, transport, processing and consumption can be sensitive to weather or hydrological processes.

a. Data policy

The technical and financial constraints on data collection dictate that responsible national authorities must develop formal data policies.

The elements of such policies should include:

- a prioritization of data to be collected, based on a cost/benefit assessment of scientific, economic and political relevance;
- the need for data preservation (including rescue where necessary), and systems that make real-time and historical data easily available to the community of users;
- procedures that ensure an efficient two-way flow of data between institutions, producers and other regular users;
- the systematic geo-referencing of all data, including agricultural statistics, impact assessments etc, to facilitate comparisons of data types across spatial and temporal scales;
- liability/accountability – data producers bear a responsibility for the quality of their data and, at least, should be able to provide with each data item an estimate of its accuracy; and
- standard data exchange formats – the value of data use is often compromised by the lack of standard formats. Standard formats do exist, but their use must be generalized and accepted in the user community

b. Data diversification

The term ‘data diversification’ is meant to imply that attention be paid to several data categories that may not be routinely covered by the agricultural, climatological and food security communities in all countries. The policy outlined above needs to be applied to the following data categories:

- real-time observations of: crop and livestock production, food availability and food prices, crop stage (phenology) and condition, impact of pests and diseases (including migratory pests), atmospheric pollen and pollination, freshwater fisheries, forestry and agro-forestry, animal health, rangeland production and quality;
- reference and historical data: the items to be covered are essentially the same, with the historical perspective providing the basis for risk assessments;
- data sources and types: *in situ* ground and lower atmospheric data up to ~ 1500m (e.g. for desert locust monitoring and forecasting), variables sensed from satellites, current and normal weather analyzed on grids at various spatial scales, soil maps, agro-ecological zones, crop distribution maps for global and national studies, etc.; and
- weather forecasts, seasonal forecasts and climate scenarios at various spatial resolutions, including such forecasts that are available for non-weather variables (e.g. future farming systems).

c. Tools and Methods

Tools and methods include the development and dissemination of algorithms and procedures, hardware, software, and communication tools.

Priority areas are:

- downscaling and disaggregation of climate and socio-economic data sets, such as reference climate, human population and cattle densities;
- development of integrated data bases, including climate/weather, population, nutrition, agricultural statistics, etc.;
- tools for including intra-seasonal and spatial variability of weather to seasonal forecasts and climate scenarios for more realistic impact assessments and projections; and
- new products such as radiation and Leaf Area estimates from satellite data.

***Capacity Building***

*Working question:*

> *What are the really 'big things' that are stopping us from making climate more effective for risk management in agriculture and food security?*

a. Definition

Capacity building is a process for developing within a society the skills, institutions and resources, which facilitate collective action that benefits of the society. In the context of climate risk management, capacity building is the process of promoting constructive action in response to information about hazards and opportunities that might arise from climate variability and climate change.

b. Current situation

Throughout most societies there is some awareness of climate risk, particularly in societies affected by high impact events such as those related to ENSO (i.e. climate variability). Increasingly, societies throughout the world are also becoming aware of the risks posed by climate change. The awareness of risk, however, does not of itself lead automatically to constructive management of risk. Constructive management of climate risk means avoidance of the negative consequences of climate variability and change, as well as taking advantage of any opportunities they present.

For the most part, there is a lack of capacity at all levels of decision making to respond beyond the simple awareness of climate risk. At the field and farm scale, capacity could be enhanced by translating climate forecast information to the spatial scale and lead times that match those used in farm decision making and further, by developing the skills of farmers to make decisions under uncertainty through the judicial use of probabilities that certain events might or might not occur.

Seasonal-scale forecasts of rainfall and temperature are generally made for relatively large areas of a country, typically on a monthly basis for the ensuing three months but sometimes only once per calendar season. Such forecasts can lack local relevance, and often filter down through layers of decision making too late to influence practical farm decision making. Forecasts of climate variability in the form of cumulative expected rainfall and average expected temperature are often not as important to farmers as the expected start and end of some defined growing season.

In most regions, specialists in climate risk management come from diverse backgrounds and, in many regions, people with these skills are rare. Those working in this field often have diverse backgrounds, e.g. extension, agronomy, economics, having come into it by accident. There is no systematic educational process for generating professionals in this field, for linking them professionally and for facilitating their continuing professional development.

c. Building capacity

A broad perspective of capacity building is required. There are different limiting factors for each context, and a broad perspective enables critical factors to be identified and addressed.

Capacity building includes both formal and informal ways of facilitating climate risk management throughout society. Formal capacity building takes place via education, from primary schooling to tertiary education, as well as through continuing professional development programs. Informal capacity building takes place through relationships and interactions that build trust, goodwill and understanding between all stakeholders, and lead on to beneficial social outcomes for all concerned.

Informal capacity building in climate risk management involves bringing scientists and farmers together to explore how climate information might best be used in local decision making, and to formulate delivery of climate services into these terms. This process is necessarily a locally, context-specific task, and may require a change in the institutional structures used to design and deliver climate science. The institutions that develop and use climate science to generate ongoing information about the climate should aim to capitalize on the economies of scale and comparative advantages of a centralized service delivery that is well integrated with regionally and locally relevant structures for transforming and delivering this information.

In many cases the institutions for delivering locally relevant climate risk management services, i.e. information and training on how to use it, do not exist. Where possible, such institutions should be designed and developed such that they are well connected with the climate science and monitoring organizations, and with existing farmer and extension networks.

d. Recommendations

- The introduction of climate risk management into school curricula.
- Training in communication and people skills for climate scientists, particularly in matters that relate to understanding the needs of stakeholders and responding in the ways that best meet their needs.
- The development of systematic and institutionally supported pathways for the training of climate risk management specialists who can link climate science with society, including tertiary qualifications and short courses.
- The inclusion of journalists and other media-related personnel in capacity building activities.
- The development of training and awareness programs for farmers, the media, community groups and the general public on how to interpret and use climate information in their specific situations.

***Communication***

a. Packaging the Message

Information needs to be well packaged. Often there is a lack of communication between the relevant institutions, sometimes with tendencies to compete with, rather than complement each other. Communication also needs to be effective vertically, i.e. wherever there are hierarchies involved in decision making. Trust in the information available will be increased through:

- Close relationships and frequent dialogue between different levels within institutions and across institutional boundaries.
- Attention to accuracy and consistency.
- Increased confidence in when and how to use the information correctly.

In some situations, language barriers can be a serious problem to communication. Such barriers can also emerge within one language when information providers and users have their own jargon for talking about their own or even common matters of expertise. Thus, attention needs to be given to:

- The way information is written down.
- The existence of different communication protocols and cycles within different provider and user groups.
- The language used by scientists when conveying information orally to non-scientists.
- Research on appropriate ways to transfer information, including the use of new technologies.

To the extent possible, information should be simplified before transfer between stakeholders. In particular, information for policy makers and other stakeholders, which provides guidance on the allocation of resources, needs to be to be communicated in timely manner and sufficient for decisions to be made. Information providers need to be able to view what they are transmitting from the perspective of those who are receiving it. The same is true of feedback, i.e. users such as farmers and others up the food chain need to have some understanding of the constraints, uncertainties and limitations on the information that climate scientists and those monitoring the climate can provide, especially with respect to prediction. Thus, attention needs to be given to:

- The wider publication and tailoring of climate information for specific users.
- Mechanisms for obtaining feedback, e.g. through farmer associations.
- Training of communications specialists to help climate scientists and monitoring institutions disseminate information clearly and succinctly.
- Greater clarity on the kind of information policymakers require to reach specific decisions, what they are trying to manage, and how climate fits into the picture.

Value in the food chain, from producer to consumer, will vary in different socio-economic contexts, as will the importance of specific decision makers. Careful consideration needs to be given therefore in how best to service the 'gap' between the farmer and decision making frameworks further down the chain. One needs to ensure that all the links in the chain have well-grounded and generally common understanding of the notions of probability and what is means in a climate risk management sense. Identifying and encouraging progressive farmers who have grasped the concepts well to assist others can help build a broader level of trust. The preparation of case studies that groups can easily relate to is another useful strategy.

There are many existing 'tools' that can be used for getting a message across within developing countries and where more formal institutional arrangements may not be so well established; they include the local media, schools, community groups, and women's associations. A gap analyses in each community should reveal opportunities and groups that might be co-opted for the purpose. It is important that thought be given to the intergeneration transfer of information that might not be formally taught in schools or even written down. Particular care needs to be given to avoiding mixed messages.

b. Current Situation.

Too often there is an un-bridged communication gap between an information provider and its users. In such a situation there is the need for a better outreach programme that is adequately financed, as well as for capacity building activities for various stakeholders. In particular, providers of climate information require a good, on-the-ground grasp of user needs and situations in which the information will be applied.

c. Recommendations

  - Better packaging of information.
  - Reduction of the 'language barrier' including the translation of scientific information into actionable knowledge.

- Simplification of information transferred between stakeholders.
- Recognition of the need to service all links in the food chain and that the nature of each chain will vary from community to community and country to country.
- Use of local communication/adaptation mechanisms, especially where formal institutional frameworks are less well developed.

***Integration***

a. Connecting the Links

Food security is an important concern in the developing world, especially in the all-too-frequent situations of crisis. The current strategy of centralized storage of reserves at national level must be complemented by an effective distribution system linked to a decentralized network of food reserves, from on-farm to village cluster scale. Food security also has to move beyond the typical 3-4 staple grains to the complete range of foods consumed by local communities in order to maintain the highest levels of nutrition. In situations of crisis, the traditionally large, domesticated biodiversity of a region has in the past been an important form of insurance in managing climate risk. It is critical therefore that the vast erosion of biodiversity be arrested.

In some regions of the world the term ‘agriculture' conveys a larger emphasis on field crops. The more inclusive term ‘farming system’ reflects an integration of different components in the mix of farm-field crops, trees, livestock, and other farming enterprises. This broadening of scope brings the different perspective on goals, data, methods, and tools of climate risk management.

The term ‘climate risk’ represents the negative consequences of climate change and climate variability. A positive component, however, should also be considered and might be termed ‘climate opportunity’. Focus on the latter could generate new options for various users including farmers, policy makers, and the farming financial sector. Indeed, profit generated from efficient utilization of climate link opportunities could help increase resilience to climate risk.

There are several initiatives that relate to development, yet there is no overarching framework within which these initiatives can be linked, duplications reduced, gaps filled and synergy achieved.

Among key stakeholders, policy makers, international communities, civil society, the interpretation of different concepts, such as food security and risk management, can vary. This lack of agreement can lead to a lack of consensus on problem diagnosis and deciding what needs to be done and in what order.

b. Communication - again

The task of integrating the contributions of many stakeholders needs to be supported by well packaged communication systems that provide information uniformly and with clarity. Good, across the board, communication will reduce the chances of particular stakeholders loosing interest on a cross-cutting issue should one sector appear dominate.

Communication between the various stakeholders and how they interact should be driven by a common and coherent agenda, which provides the strategic direction for achieving international and national goals, and to which all government are prepared to commit. At the same time, this agenda must be sensitive to and as far as possible be aligned to existing policies and programmes.

Risks associated with climate variability and change can be managed better by incorporating climate information and prediction, provided in a timely manner and with sufficient lead time to take corrective measures and safeguard. The history of climate variability and change risk should also be accessible so that all stakeholders can assess previous impacts and the response measures within their respective sectors. Clearly too, raising the accuracy of climate forecast would raise the confidence of the decision makers and stakeholders in the information they are receiving.

c. Indigenous knowledge

Communities frequently exposed to extreme weather, water or climate related hazards usually develop their own early warning systems for an impending event. The methods used vary among communities, and range from approaches that can be readily connected to a sequence of natural events leading to the onset of a severe or extreme event to approaches that are less easily explainable. Sometimes, forecasts provided by an outsider are not well accepted. In such cases, a strategic communication system that is linked to a formal or informal, local institutional process is needed to deliver the information to a community, and also to get feedback in order to further improve the system.

d. Integrated Databases

Many countries, particularly in the developing world, do not have integrated and well managed databases on the impacts of climate extreme events or climate hazards. In most countries, regardless of development, the norm is for different sectors keep their own data and sometime use different methods to record the impact. Too often, data in one sector are not accessible by other sectors. Problems arise also on a wide range of compatibility and record length issues. Countries with federated forms of government can often have many state, provincial or regional authorities dealing with data from one sector. Such situations are exacerbated when there are changes in responsibilities arising from changes in government, e.g. from a centralized to a more decentralized system. Technology has removed the need a large, single database model, but it has dictated the need for a consistent approach to formats and protocols for collecting, processing and archiving data in order to achieve the goal of an effective distributed database model.

e. Timeliness, Scale and Relevance

There are considerations of time, user-scale and relevance that need to be integrated into the processes of data collection, management, analyses and interpretation that lead to information being injected into a decision process. The value to decision-makers that climate information adds is driven by the following:

i. The operational scale and the spatial scale of influence of the decision-making;

ii. The ease with which the climatic information can be structured to the targeted level of decision-making;

iii. The extent to which the information and the formulation of the decision must be tailored to suit the appropriate users of the decision;

iv. The level of effectiveness that can be achieved in mainstreaming climate information throughout the decision-making structure, whether it be local, national, regional or global.

f. Co-ordination & Collaboration

Collaboration between sectors for policy making and operational service delivery is clearly essential, and there also needs to be strong collaboration amongst the various sciences research and development for the setting of priorities, and mobilizing and allocating resources. Taking the case of the Avian flue outbreaks as an example, one might ask how much of climate data was used for informed choice of intervention and preparedness.

In exploring how institutions might best cooperate and work together the following factors should be borne in mind:

i. Establishing the basis for collaboration and coordination between various stakeholders;

ii. Information to be exchanged among stakeholders;

iii. How best to ensure responsiveness to the needs of various end users;

iv. The need for involvement and briefing of high level decision makers.

g. Current Situation

Climate information addresses mainly the needs of agriculture crop-production. The value and utilization of the data would be greatly enhanced if the information also addressed the larger decision-making requirements of agriculture and indeed of all stakeholders along the food chain, from farmers, through processors, commodity traders and exporters to wholesalers and retailers.

***Recommendations***

To address the various interfaces between institutional arrangements in the usage of climate information and for greater effectiveness of planning processes:

i. Climate information should become freely available through networking and collaboration between institutions which share overlapping objectives

ii. Commonly accessible climatic information by several institutional arrangements would enlarge the end-user-base with the overall achievement of multiple objectives from a common pool of information, which will be cost-effective to the various institutions.

iii. Strengthen inter-institutional capacities in the use, interpretation and application of climate information;

iv. National agricultural and food chain policies, long-term strategies, development plans and programmes should factor in risks from climate variability and change;

v. Lack of legislation to support community should be overcome through better governance at national and local level by taking action and decision from government and local community.

vi. Information systems should be packaged to fulfil the following expectations:

- To explain why particular groups are vulnerable to climate shocks
- To guide the choice of intervention to reduce vulnerability
- Users friendly information package and its availability to key decision, policy makers at all levels.

## Human Health and Disease Control

Chair: Carlos Corvalán (World Health Organization, Geneva, Switzerland)

Rapporteurs: Diarmid Campbell-Lendrum (World Health Organization, Geneva, Switzerland), Leslie Malone (WMO, Geneva, Switzerland) and Madeleine Thomson (IRI, Palisades, USA)

***Introduction***

Human health is an integrating theme of climate variability and change. Population health is affected by climate and particularly by climatic effects acting through natural disasters, climate-sensitive diseases and through climate-sensitive sectors such as agriculture, water, or the built environment. This results in spatial and temporal changes in a huge variety of health risks, from heat waves to floods and landslides, to malaria and malnutrition, and more indirectly through disruption to human societies, employment and livelihoods. Health is therefore both a key climate-sensitive sector in its own right, and also provides an important justification for addressing climatic impacts on other sectors.

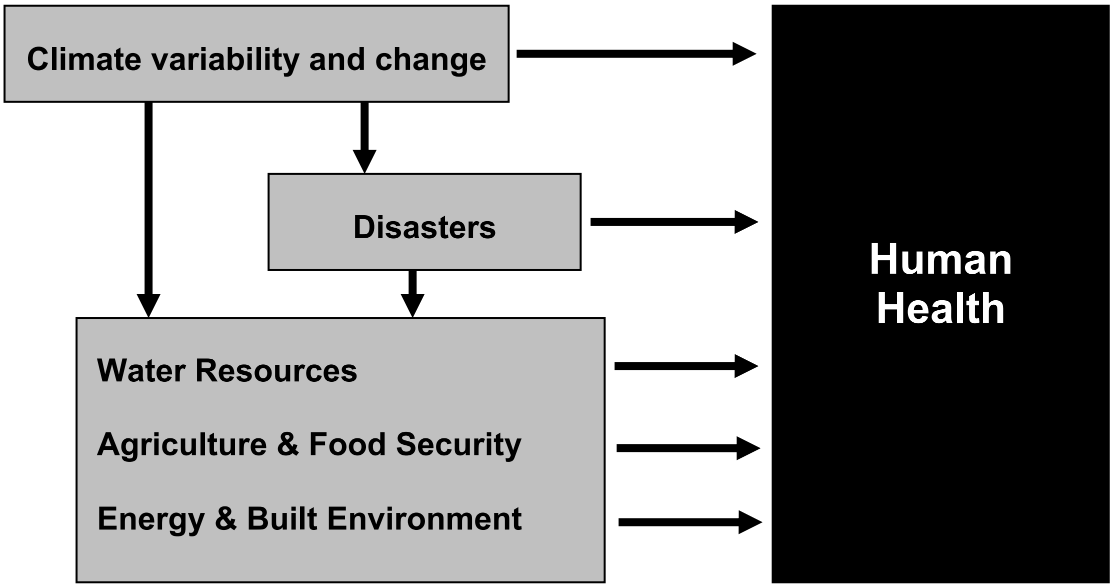



**Figure 7.** Health as an integrating issue in climate variability and climate change. Decisions taken along all of the causal links ultimately affect health outcomes.

The report identifies a series of central issues that underpin attempts to protect health under a variable and/or changing climate. These include (i) the health sector has a clear mandate and strong sense of ownership over many health protection decisions, but only provides limited input into health-relevant decisions by other sectors; (ii) the sector will take up climate information most effectively through an "approach driven by needs and requirements" that is designed to increase effectiveness of their core activities; (iii) most decisions to control climate-sensitive diseases do not necessarily utilize climate information, but there is an important subset of decisions (e.g. spatial targeting and early warning systems) where climate information can make a valuable contribution; (iv) the health sector does not currently make effective use of climate information, partly due to absent or ineffective institutional partnerships and in part due to lack of an interdisciplinary knowledge base and education system; (v) there is a need for a more stable and systematic interaction between the health and climate community to define and meet information needs; (vi) this needs to be supported by enhanced capacity building, demonstration projects and outreach activities to support health decision-makers, from householders to international policy makers.

***Current approaches to decision making under uncertainty in the health sector***

***The health sector, principally national ministries of health, has a clear mandate for most health protection decisions***. This includes both preventive (e.g. vaccination programmes) and curative measures. The health sector has relatively well-established operational procedures, and methods for incorporating new evidence (e.g. through epidemiological studies) in order to change standard practices. The integration of climate information into health decisions should therefore be "driven by needs and requirements", bringing about clear improvements in health protection, and contributions to wider objectives, such as the Millennium Development Goals.

***The health sector underplays its role in influencing health-relevant decisions that are taken in other sectors***. Decisions taken in other sectors, from energy production and the built environment, to water infrastructure, have very large effects on health. In many cases these have larger impacts than decisions taken within the health sector. Institutional structures and focus on immediate priorities have resulted in the health sector having low involvement in these important decisions.

***Health sector decisions are often taken under uncertainty***. It is rarely possible to identify in advance which people are going to suffer disease at any one time. The main approaches to dealing with this uncertainty are (i) through preventive approaches at the population level (e.g. mass vaccination for infectious diseases, or widespread dissemination of health information), or (ii) through reactive approaches when the disease has occurred (i.e. treating sick people). The majority of resources within the health sector are directed to reactive responses.

***Although climate underpins all human health (e.g. through maintenance of food and water supplies, determining disease distributions), climate information is directly relevant only to some health decisions***. The fact that human health ultimately depends on a stable climate in itself provides a justification for sustained, high-quality monitoring of climate conditions. At the level of operational health planning, however, climate information has a more restricted set of uses. Even for climate-sensitive diseases, the majority of preventive approaches are implemented without reference to climate information. These include, for example, development and dissemination of improved malaria drugs, or greater investment in water and sanitation infrastructure or in health services. The main roles for climate information in operational health decisions are:

1) Identification of climatically suitable or high-risk areas for particular diseases (i.e. spatial targeting based on climatology)

2) Early warning systems for climate-sensitive diseases that vary over time (i.e. temporal targeting based on either weather observations or forecasts).

***Climate-based early warning and reaction is most useful within restricted, but still important, zones***. These are mainly around the margins of the disease distribution in either time or space. They are less useful either where there is low variability (e.g. hyperendemic malaria zones where transmission is high every day, of every year), or where the resilience of the health sector is either very high (i.e. where the underlying disease burden is small), or very low (i.e. there is no capacity to respond to early warnings).

***Constraints on using climate information to support health decisions***

***The health sector has a low recognition of the importance of climate variability and change***. While most health professionals will acknowledge some links between climate and health, they tend not to have a strong appreciation either of the essential role of a stable climate in underpinning health, or of how climate and weather information can improve their day-to-day operational decisions. Exceptions are (i) the El Niño phenomenon, which is well studied, relatively predictable and triggers preventive action, and (ii) systems that are beginning to be put into place as a response to catastrophic climate events in specific regions, such as the heat-health early warning systems that are being developed and implemented in Europe, partly as a response to the deaths in the 2003 summer heat wave.

***Until now, the health sector has expressed only low level demand for climate information***. This is due to failure to appreciate the operational value of climate information, and ignorance of the kinds of services that be supplied by the climate community. In contrast, the climate community has been more pro-active in approaching the health sector, but often with limited understanding of the kinds of information that are required to support health decisions.

***Interdisciplinary work remains weak.*** Most collaboration between the health and climate sector is on an *ad hoc*, project-by-project basis. There is a lack of active official partnerships between health services and meteorological services. Of the 24 (out of a total of 52) countries within the WHO- European region who responded to a recent survey, only 2 reported active partnerships between health and meteorological agencies.

***There is little understanding of the kinds of information that have most impact on health decision-makers***. It is not clear, for example, the extent to which decision-makers respond to accurate quantification of likely deaths or disease cases arising from climate threats (e.g. numbers of deaths in a cyclone), or are willing to respond to less precise or qualitative assessment of a wider range of impacts, such as possibility of infectious disease outbreaks and damage to health infrastructure.

***Methods for prioritization of health responses are weak.*** Climate variability and climate change bring a very wide range of health threats. However, demands on health services already outstrip available resources, especially in developing countries. Health services are therefore faced with tough choices as to the resources they should direct to responding to or preventing climate-based threats, as opposed to other health priorities, and which climatic threats they should address first. There is therefore a need for a better understanding of the effectiveness of alternative interventions, as well as their economic efficiency and equity implications.

***Health sector decisions reflect short-term rather than long term priorities.*** This is partly because other health issues (e.g. the HIV pandemic) are considered to be more certain and more urgent than health threats arising from climate variability and change. This results in a "fire-brigade" approach that deals only with the most immediate issues. Planning decisions are often taken without a long-term view. For example, health facilities destroyed in natural disasters are often rebuilt in the same site, 20% of health care facilities in Europe are situated in disaster-prone areas (EEA), and health facilities are often highly energy inefficient, with high carbon dioxide emissions.

***Recommendations for improved decision-making approaches***

***Recognize the wide range of decisions that can help to protect health in a changing climate.*** Decisions that relate to maintaining a stable climate (i.e. relating to greenhouse gas emissions) should take account of the health risks that are likely to result from climate change, and the potential health co-benefits of actions to reduce climate change, e.g. through reductions in air pollution. There are also multiple interventions that can protect health from climate variability and change that is now occurring, ranging from immediate (e.g. heat-health warning systems), and long term interventions (e.g. investment in disease surveillance systems), that can occur both within and outside the health sector.

***Give priority to "no regrets" interventions.*** At least in the early stages of development of using climate information to inform health decisions, it is important to ensure that the actions that are taken will still bring some benefits even if the assumptions on which they are based are later shown to be inaccurate. Examples include strengthening basic disease surveillance systems during the development of a, more sophisticated, climate-based early warning system.

***Place greater emphasis on assessing economic implications***. Decision-making, particularly at the national level, is largely driven by economic considerations. Yet there is little appreciation of the impacts of climate change and climate variability on economic development, either through health or through other sectors. Greater involvement of economists in comprehensive studies of climate impacts, and assessment of the economic benefits of decisions that take account of climate information, should lead to greater uptake by decision-makers.

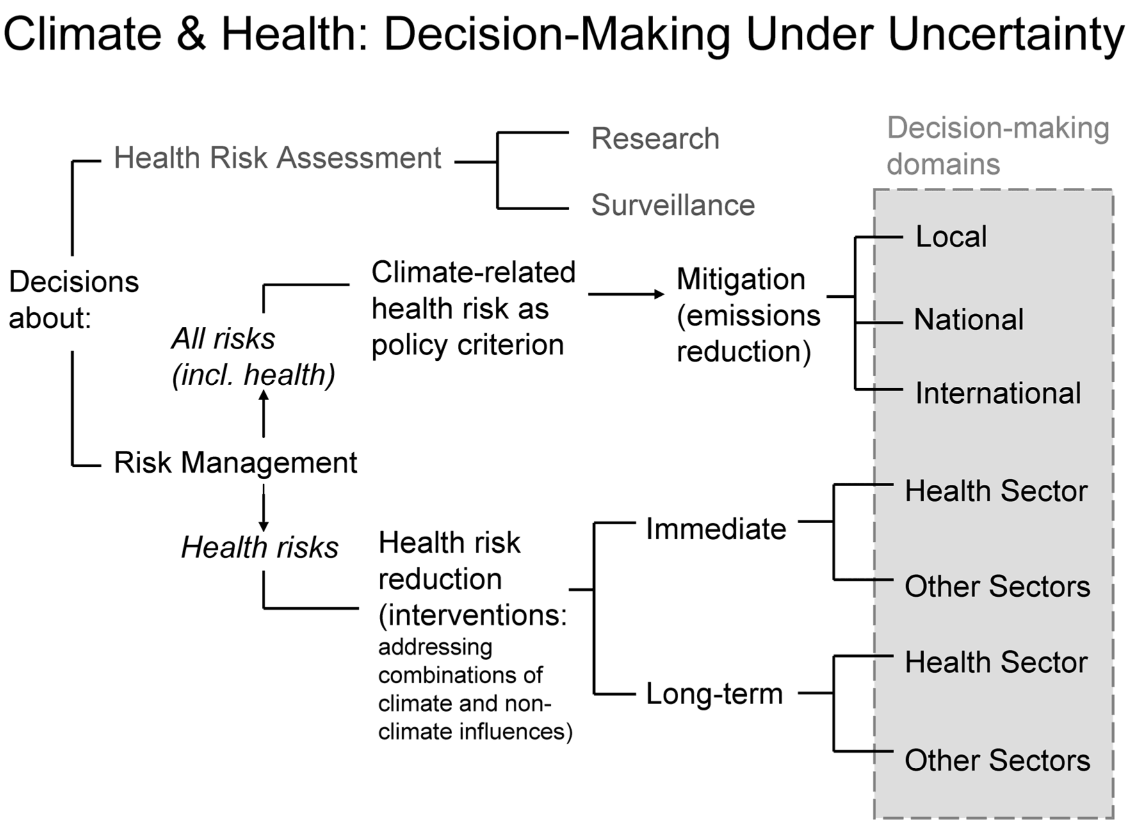



**Figure 8.** An overview of the kinds of decisions that can contribute to protecting health under a changing climate.

***Pay greater attention to prioritizing interventions, and making best use of scarce resources**.* Even for "no regrets" options, it is important to recognize that resources are limited, that there is an opportunity cost if the best option is not selected, and that intervention effectiveness should be maximized. Available tools include; **(i)** Economic approaches such as cost-effectiveness, cost-benefit and equity analyses to aid prioritization; **(ii)** Sharing of core health and climate information across countries and sectors, to increase efficiency; **(iii)** Tailoring of climate information to local conditions and specific decision-needs, to increase effectiveness; **(iv)** Use of seasonal forecasts and climate change projections to give maximum warning of likely changes in disease patterns; **(v)** Use of "simulation" of health threats caused by climate variability, to test the effectiveness of warnings and action plans; **(vi)** Integration of indigenous knowledge and methods of climate forecasting and reaction, to add information and improve take-up by affected communities.

***Recognize that reliable and high quality surveillance systems are a pre-condition for disease prevention**.* Disease surveillance systems are essential in themselves, as the most reliable means of detecting changes in disease patterns. They also provide the data that is necessary to develop "add-on" climate-based early warning systems, which can in turn improve lead times for operational responses, and fill gaps in health surveillance data. The existence of disease surveillance systems is an important part of the justification for developing more sophisticated systems that integrate risk factor information, including meteorological information, into predictive early-warning systems. When used appropriately and in an outcome-oriented way, Geographic Information System (GIS) techniques can be a powerful tool in combining basic disease surveillance information with climate and other environmental information to aid multi-organizational cooperation and response.

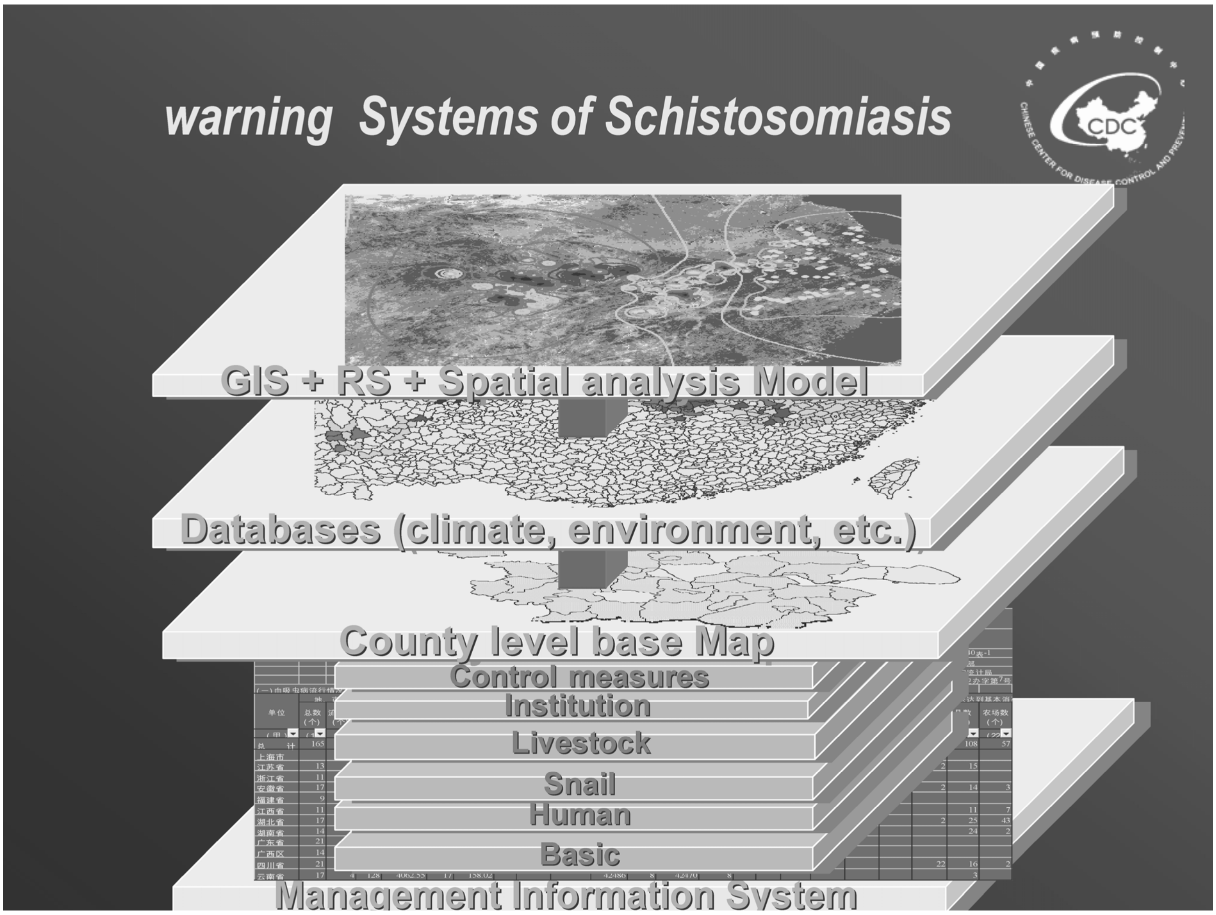


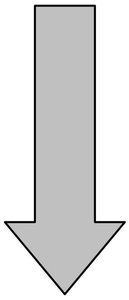

**Figure 9.** An illustration of how climate information can be combined with and add value to information gathered by disease surveillance systems, and facilitate interpretation and planning of control actions (adapted from presentation by Dr. Zhou Xiaonong).

***Support climate-based early warning systems with effective action plans***. Early warning systems without effective action plans are a waste of resources. The Météo France heat-health warning system is an example of an apparently well-designed system, with clear demarcation of roles and responsibilities of key actors, pre-prepared interventions such as public health information messages, and well-developed mechanisms for information dissemination, sustained over time.

***Carry out continuous and iterative evaluation of the effectiveness of early warning systems***. This should take into account the accuracy of the warning, in terms of both failure to warn of real threats and false alarms, the effectiveness of the response that is implemented, and of the costs of the system. It should include feedback from the operational sector back into the research community.

***Analyse, refine and replicate successful models of interdisciplinary decision-making.*** Successful models include the task force organized by the Pan-American Health Organization to plan responses to El Niño events. This leads to actions such as the early release of emergency funds when it is apparent that a strong El Niño event is likely to occur. The approach is facilitated by the fact that El Niño is quasi-periodic, and exerts a strong effect in the region. This in turn justifies long-term support from international agencies to maintain the task force.

**Decisions based within the health sector**



**Health input into decisions taken by other sectors**

- Prevention of climate-sensitive diseases; e.g., vaccines, bednets, water and food safety
- Disease surveillance
- Disease early warning systems
- Disaster preparedness
- Scenario-based forecasts of future risks
- Development of intersectoral engagement
- Public education
- Planning decisions to reduce impacts on climate

**Figure 10.** Areas where the health sector can contribute to protecting health under a changing climate.

***Recommendations for research and development***

***Generate support for evidence-based decisions**.* The health sector traditionally requires a relatively high level of proof to justify a change in practice. It is therefore essential to generate high quality studies that describe the links between climate and health, and that address how this can be taken through to changes in operational practice.

***Place greater emphasis on understanding climate effects on health in the context of other influences**.* Many early studies placed an undue emphasis on testing the influence of climate as opposed to other influences, through an either/or approach. More recent studies integrate climate with non-climate influences, such as changes in population immunity levels or other characteristics of vulnerability, leading to increased credibility within the health community, and better explanatory and/or predictive power.

***Promote interdisciplinary collaboration in research between the health and climate sectors**.* There are multiple examples of health experts carrying out climatological studies (e.g. studies of climate trends in areas that have experienced disease increases), and climate experts carrying out health research (e.g. developing early warning models for infectious disease). Each community has a responsibility to recognize the complexity of the other sector, to seek specialist input, resulting in publications authored by teams with both sets of expertise.

***Develop more stable and systematic interactions between the health and climate communities**.* While the health sector asks for an "approach driven by needs and requirements", they often have very little idea of exactly what their true needs are, and whether they can realistically be met by the climate sector. There is a need for sustained coordination and development of an interdisciplinary knowledge base between the health and climate sectors in order to create and develop an effective demand for climate information and to improve health sector decision-making through better use of climate information. This could potentially occur through an international commission or working group on health in a variable and changing climate, led by the health sector in close partnership with the climate community. Although the nature of this group requires further definition, it could involve international agencies working on health and on climate (e.g. WHO, WMO), boundary organizations with specific experience of applying climate information in affected sectors, operational personnel from the health and climate sectors from particularly vulnerable countries, and experts in research on links between climate and health. A group such as this could carry out systematic reviews of requirements for climate information in health planning, as well as review current availability and gaps in provision of data and models, and needs for interdisciplinary research. This would provide a firm basis for developing "best-practice" guidelines, with supporting data and information that is appropriately packaged and disseminated for health end-users and climate service providers, supported by demonstration projects. This interaction should be mirrored at the national level, for example through development units within meteorological services, or specified collaborating centres. In planning this improved coordination and knowledge development, it is important to ensure that the efforts clearly add value to both health and climate communities, and that inefficient or redundant bureaucratic structures or mechanisms are strictly avoided.

***Facilitate access to climate data****.* The health sector feels that there have been several negative experiences in their interactions to date with some meteorological services. This is partly due to national policies, in some cases, that restrict access to or charge for the basic observational data that is often most useful for health decisions, while facilitating access to products such as seasonal climate forecasts that are more sophisticated, but are often less relevant. The health sector recognises, however, that National Meteorological and Hydrological Services climate experts are trained in the intricacies of use and analysis of climate data, and that their advice and collaboration in the use of the climate data would add value to the process and results, and further agreed that in the long run, the best way to ensure more open access to climate data would be to demonstrate to decision-makers at national levels that the collaboration produces proven results of socio-economic benefit to the relevant communities.

***Support international training in climate-health interactions****.* There are many examples of high quality training programmes and materials for training health experts on climate issues, and vice versa. These include, for example, training modules developed by WHO and WMO, IRI, Oulu University, the London School of Hygiene and Tropical Medicine, and the Australian National University. However, these exist as isolated short courses. These could be assembled into a single comprehensive course that could be taught by international or regional institutions.

***Support national and community level capacity building****.* There is a need for greater basic capacity at the operational level, and within the specific communities that actually suffer health impacts from climate change. At the sub-national operational level, capacity-building could be structured around training programmes around shared interests in statistics from both the climate and health sector, e.g. through projects such as Intersect. This could take a tiered approach that begins with basic descriptive statistics, with more advanced modules on analysis of satellite images etc. At the community level, it could include modules within secondary school teaching programmes, using meteorological and health data as a basis for teaching basic mathematics and statistics, e.g. through description of seasonal disease patterns.

***Methods of presenting and disseminating information and approaches***

***It is important to recognize the broad range of decision-makers, from households to national policy makers****.* It is essential to have a clear vision of the main stakeholders throughout the decision chain leading to health protection, so that information and decision-support approaches can be accurately targeted. This would avoid wasted effort or actual harm - e.g. through disseminating inaccurate risk information to the general population, without accompanying information on effective responses.

***"Two-step processes" may improve effective communication.*** Scientists and health practitioners often have poor skills in developing and communicating risk messages. Professional communication experts could be used to develop information, and training courses, targeted to specific audiences. This could include introductory training of journalists and of disaster response agencies (e.g. IFRC volunteers), particularly in developing countries.

***Describe and disseminate "success stories*****"**. There are a limited number of good examples of how climate information has been incorporated into health and other development decisions. These include the use of basic climatology for spatial targeting of disease interventions, and the use of real-time observations, short term and seasonal forecast to support to heat-health warning systems in North America and Europe, and Malaria Early Warning Systems in southern Africa. These should be more widely disseminated.

***Use communication methods that reach populations directly***. National Governments are at times unable, and occasionally ineffective in disseminating climate risk information to the population. There is therefore a role for direct contact from health and climate agencies and NGOs through radio, TV, web etc. Successful examples include ACMAD's use of rural radio (RANET) to support food distribution during drought crises.

***Use innovative, locally appropriate methods for communication***. Good examples include a Finnish model that includes an initial e-mailing and SMS of basic risk information to targeted institutions such as rescue authorities, with directions to more detailed information on the internet, leading to a snowball effect with increasing pick-up by the public. Methods need to be appropriate to local conditions. In developing countries with poor communication infrastructure, the most effective communication means may be through NGOs, story telling, and information messages through schools.

## Water Resources

Chair: Roberto Lenton (IRI, Palisades, USA)

Rapporteurs: Casey Brown (IRI, Palisades, USA), Molly Hellmuth (IRI, Palisades, USA), and Jozef Syktus (Queensland Department of Natural Resources, Indooroopilly, Australia)

This report summarizes the results of the conference deliberations in the area of water resources, based on the discussions in the plenary sessions and in the breakout sessions of the water resources working group. It is divided into three parts.

***Overall Conclusions***

The working group on water resources analyzed a wide range of issues related to decision making in the water resource sector as a whole, including climate-related risk management in particular. The discussion covered four main issues: current water resource decision making approaches, what is needed for good decision making, pertinent approaches to water resources decision making when climate change and climate variability is involved, and research and development (R&D) needs and processes for incorporating climate variability and climate change in water resources decision making.

The conclusions of the working group on each of these six topics are summarized below. However, the working group wishes to highlight first one key over-riding issue: the need to ensure that processes to develop better policies and practices for climate related risk management in water resources are driven and led by the water resources institutions and agencies that are responsible for decision making in the sector at all levels. This implies that climate institutions and agencies will need to act as service providers (i.e. as extension and technical assistance agents) to the water sector, rather than as principals. This will require a change in philosophy and organizational approach from the climate and weather community.

***Current water resource decision making approaches***

Many factors influence decision making in water resources development and management. Climate is an important stressor but other factors, including population growth; existing infrastructure; increasing poverty; and environmental change play equally important roles.

Against this background, there is general recognition that decision-making in the water sector should be guided by an Integrated Water Resources Management (IWRM) approach, which involves bringing together the people and institutions who affect and/or are affected by water decisions in order to ensure the coordinated management and use of water, land and related resources. In this way, IWRM strives to achieve an appropriate balance among economic efficiency, social equity and environmental sustainability. This approach reflects the fact that water is an integrating resource that impacts on a wide variety of other "sectors", including health, agriculture, energy and the built environment, and natural disasters. It reflects the fact that water resources issues are intimately connected to land use, including land degradation. And it reflects the fact that water management involves the management of both supply (i.e., water availability) and demand. Demand management – i.e., managing the use of water for various purposes, including terrestrial and aquatic ecosystems as legitimate users of water -- entails changes in policies and governance arrangements as well as the use of economic and other instruments to improve the efficiency of water use.

Climate variability and change play a significant role in water resource decision making, at various time scales. Decisions affected by climate considerations include both water hardware (infrastructure and technology) and software (management, policies, laws, governance arrangements). Strategic (decadal scale) decisions on such issues as infrastructure for storing water, which play a crucial role in adaptation and mitigation strategies and have long-term impact, must be made in the face of uncertainty about future water availability and requirements. Tactical (seasonal or interannual scale) decisions on such issues as water conservation measures or reservoir releases must be made in the face of uncertainty about seasonal and interannual flows. And operational (day-to-day) decisions on such matters as opening and closing sluices must be made in the face of uncertainty about weather conditions that impact on water requirements. Decision makers on all these matters operate at various levels, from very local to national and even transnational (in the case of trans-boundary water resources).

Climate data and information are used to a greater or lesser extent in all these decisions. There are good examples of the use of climate predictions at different time scales to improve decision making. There are also cases in which available information is not used because of concerns that such information may not necessarily lead to improved decisions. Ensuring access to information is crucial, since even where good information is available it may not necessarily be accessible by the relevant decision makers.

While in principle a pro-active rather than a reactive approach to climate risk management in water resources is to be preferred, experience in many countries, including Brazil, Mozambique and Tanzania, suggests that crisis situations, such as a major drought or flood, can bring together the different agencies that are required to resolve the crisis, and in particular to bring together the water resources practitioners and policy makers (climate information users) and the Met services (climate information suppliers). This suggests that, although it is preferable to put in place effective decision making systems before a crisis occurs, crisis situations can be effective integrators. The challenge is how to sustain such integrated decision making approaches once the crisis has subsided, and how to be prepared to take advantage of crisis situations in order to put in place better decision making mechanisms that would be difficult to implement in normal times.

Despite the fact that there is general recognition that decision-making should be guided by an IWRM approach and that climate variability and change play a significant role in water resource decision making, in practice there remains a significant gap in the use of seasonal forecasts in decision making and in considering the effects of climate change. For example, although most of the IWRM plans prepared in response to the Johannesburg target for the preparation of such plans implicitly or explicitly are based on climatic considerations, they rarely make explicit reference to climate variability and change.

One reason for the above may be that the linkage between the management of water resources and the role of climate is not direct -- water resource managers focus not on the climate variables themselves (i.e., precipitation, temperature, etc) but on the way in which changes in these variables translate into changes in water availability (streamflow, groundwater, soil moisture), in water quality (physical, chemical and biological), in water regulation capacity (glaciers, snow, wetlands) and in water requirements (for agriculture, industry, etc.). The relationship between rainfall variability and change and streamflow variability and change is particularly important, especially since small changes in rainfall can be amplified into large changes in the hydrologic response.

Another reason may be that national level processes for the preparation of externally-driven strategies and plans, such as IWRM plans, National Adaptation Plans of Action (NAPAs), and Poverty Reduction Strategy Papers (PRSPs), are often disconnected from one another and from overall national development plans. To avoid these problems, national development plans should come first and act as the integrating mechanism for all other plans.

***What is needed for good decision making: constraints to (and elements that support) the incorporation of climate information in current water resource decision making***

One of the key constraints for the incorporation of climate information in water resources decision making is better baseline information and data. Streamflow information and data are particularly important, but unfortunately in many developing and industrialized countries budget allocations for streamflow data collection have been declining. Translating rainfall data into streamflow data requires information on (changing) land cover, including patterns of land use and management, requiring ground observations while also benefiting from remote sensing. At present our capacity to develop good information and data on rainfall is much greater than our capacity to translate such information into streamflow data. Streamflow is also important because changes in a wide range of variables such as land use patterns manifest themselves in changes in streamflow.

To halt the decline in budget allocations for streamflow data collection, it will be important to provide evidence of the value of such information in terms of improved decision making. Case studies that demonstrate the added value of the integration of climate information in policy and practice could play a valuable role in creating a demand for better climate information.

A systemic problem is the lack of attention to hydrology as a profession, and the lack of recognition of hydrology as a science in its own right with integral links to climate science. At present, links between hydrology and climate science are weak. Developing regional scenarios and downscaling seasonal forecasts and climate change projections to make them relevant to water resource decision making will require much greater attention to hydrological science and practice.

While there is much debate on the extent to which seasonal climate forecasts and climate change projections are and can be used to improve decision making in water resources, there is little doubt that effective water resource decision making on climate-related risk management issues will require much more interaction between climate scientists and hydrologists to better apply emerging – and rapidly maturing – climate science to water resource problems. Clearly, climate information in general and seasonal forecasts and climate change projections need to be more responsive and more tailored to the needs of water resource decision makers.

Effective incorporation of climate information in water resources decision making requires agreement among both users and suppliers on the data sets to be used in decision making. This is of critical importance, since often more than one seasonal forecasts and climate change projections are available to decision makers, not all of which are consistent with one another.

In many developing countries, a key constraint is the lack of professional and institutional capacity to make the best use of available information and knowledge for decision making. A particular difficulty is providing incentives to attract qualified staff to remote areas, far away from capital cities, where good decision making often is most critical. Governments often see the ranks of their professional staff depleted by NGOs who are able to attract staff by higher salaries made possible through donor funding. Broader development planning processes that look at the interactions of all these factors are required to help address these constraints.

In water resources, many decisions require information and action from neighbouring countries that share transboundary water resources such as rivers, aquifers or lakes. In these cases, good decision making is often constrained by difficulties in accessing such information. Sharing information across borders is thus critical in such situations.

A further trans-national dimension of water relates to international trade and the export/import of “virtual water” in the form of export/import of agricultural and other water-intensive products. Current trade regimes may constrain the ability of developing countries to cope with climate variability by constraining their capacity to increase agricultural exports at times of good water supply. The relationship between international trade regimes and climate variability and change deserves closer examination.

***Recommendations on most pertinent approaches to water resources decision making when climate variability and change is involved***

In keeping with the principles outlined in the first section, water resources decision making in the light of climate variability and change should be guided by an IWRM approach. In particular, it will be important to bring together people and institutions from the water resources and climate communities, so that seasonal climate forecasts and climate change projections can be taken into account in water resource decision making, especially strategic (decadal scale) and tactical (seasonal or interannual scale) decisions.

Simulation models and other decision support tools have an important role to play in translating changes in climate into changes in water availability, water quality, water regulation capacity and water use -- a necessary pre-requisite to incorporating seasonal climate forecasts and climate change projections in water resource decision making.

As climate variability and change information, forecasts and projections are increasingly downscaled to regional and local level for use in improving decision making, the role of the climate community will need to evolve towards that of a service provider to the user sector. As indicated earlier, this will require a change in philosophy and approach.

In addition, decision making in the water resources area could be improved through:

- More effective planning systems. Planning needs to be more long-term, in order to appropriately balance immediate needs with longer term issues such as adaptation to climate and other changes. Planning also needs to be dynamic rather than static, providing frameworks for decision making that can incorporate changes over time.
- More effective translation of research knowledge and information to policy making processes. This in turn requires more effective communication of information from researchers to policy makers.

The preparation and widespread dissemination of case studies that show how decision making in climate-related risk management has been improved through the use of seasonal climate forecasts and climate change projections, as well as the lessons learned through such efforts, could help in improving decision making approaches in a larger number of locations.

Finally, incorporation of climate information into water resources decisions must be driven by the needs of the decision makers. Supporting the use of climate forecasts and projections by the water resources community requires an understanding of the particular decisions that are faced and the relevant timescales and skill needed to provide decision support. This can only be accomplished through close collaboration between operational water managers and decision makers and the forecast community. Climate forecasts and projections that are tailored to meet the particular context and information needs of water managers and policy makers are more likely to be used, assuming there is a sufficient level of skill and demonstrable value. However, when this is not the case the forecasts and projections are likely to be disregarded.

***Recommendations on R&D needs and processes for incorporating climate variability and change in water resources decision making***

As indicated earlier, there are clear indications of a gap between the climate community and water resources practitioners. On the one hand, there are some positive examples of water resource managers using climate information especially on the seasonal time scale. On the other hand, climate variability and change do not seem to be considered in the many crosscutting aspects of water, such as its special role in development. A few relevant research and development areas that may facilitate the uptake of climate information by practitioners in water resources are outlined below.

First, the need for hydrologic data is critical. In many parts of the world, the collection of hydrologic data is in decline. While remote sensing is a useful supplement to some station measurements, it is not, as yet, a substitute for streamflow data. The collection and maintenance of streamflow stations cannot be replaced. In an environment of constrained resources, research that provides guidance for achieving optimal selection of data stations is required to realize the maximum benefit of new investments in data collection. It is notable that global databases of assimilated climate variables, such as surface temperatures, precipitation, atmospheric pressure, are freely available on the web yet there is no equivalent dataset of hydrologic variables. As a result, accounts of climate change on water resources are necessarily piece-meal, typically performed for single regions or nations. A major effort is needed to create global datasets of hydrologic variables that allow comparable analyses of climate impacts on hydrology and water resources. Such an effort should be built on the strengthening of local and regional streamflow data networks. Ultimately streamflow data is most useful to decisions in the local basin.

Local/national networks are useful for taking cognizance of local hotspots and making operational decisions on issues that relate to climate variability and change, while global datasets of representative catchments are useful for international comparative assessments. Global data efforts should acknowledge the primacy of local use and serve as an integrator of these local, regional and national efforts. In order to access the necessary resources, users of data must provide evidence of the benefits of investment in data collection and the maintenance of hydrologic stations. Thus the links between water and economic development and health, inter alia, must be exploited to show the impact of variability and change and the benefit of data for designing measures for reducing those impacts.

There are many variables of interest, such as health indicators, water demand, groundwater and water use efficiency, that depend on or are influential to hydrologic variables, such as streamflow, but that have not been investigated themselves in terms of the impacts of climate variability and change. Water quality and water for ecosystems are already impacted by multiple pressures, of which climate is one of the least considered. These are all useful research areas that should also provide insight as to the benefits of hydrologic data. In addition, research that examines the performance of water institutions and policies in a changing and variable climate provides the necessary understanding of context that often dictates the use and value of climate information. This multitude of hydrologically-related interests that are influenced by climate change and variability illuminate the need for a holistic approach to studying and managing river basins as human-hydrologic systems with ramifications that reach far beyond the river banks.

In the research areas described above, it is apparent that close collaboration with partners outside the climate and hydrology fields is needed. Exploring the links between climate, water and aspects of development requires accessing expertise in development. Through such efforts the criticality of water resources will become more apparent and likely facilitate the garnering of support for data collection.

Research onto the use and value of forecasts and projections in water management is ongoing. Further research is needed. Early warning systems of floods and droughts are a prominent need. Such research must be aligned with the needs of practitioners. The research is too valuable to be conducted and communicated in a way that cannot be taken up by those who actually manage water. Therefore there needs to be a good working relationship between researchers and practitioners and its important that in this research area the efforts are demand driven. Climate information must be provided in such a way that it can be used for decision making. Researchers will not have a sense for whether this is true without understanding the needs of the user community which is achieved through close collaboration. Case studies of the implementation of forecast and projection based decision making in water resources are needed. The “lessons learned” from such studies provides critical guidance for enhancing the working relationship between the climate community and water practitioners. In communicating the results of this research, it is important to be clear in expressing the uncertainty of forecasts and not to oversell their possible value in implementation.

## Energy and the Built Environment

Chair: Michael Coughlan (Bureau of Meteorology, Melbourne, Australia)

Rapporteurs: Heather Auld (Environment Canada, Toronto, Canada) and Tanja Cegnar (Environmental Agency of Slovenia, Ljubljana, Slovenia)

### *Introduction*

Infrastructure is critically important to individuals and to communities. It serves to shelter and protect the life, health, psychological and social welfare of all of its inhabitants from the weather elements; it sustains aesthetic and cultural values; and underpins economic activities. Examples of critical structures include houses, hospitals, schools, factories, industrial facilities, roads, bridges, communications structures, power generation and distribution networks, and water structures. Extreme weather events are capable of inflicting severe damage on infrastructure or demolishing it entirely. Any increases in severe weather risks have the potential to impact safety and security, disrupt economic activities and result in a natural disaster. Further, over time, weather and climate variations eventually take a toll on most human constructions, and again any change in the general conditions for which the structure was designed to withstand can shorten its useful life.

*There is growing concern worldwide that changes in climate will have significant impacts on infrastructure and communities. As the climate changes, it is likely that risks for infrastructure failure will increase worldwide due to shifting weather patterns and extreme weather conditions becoming more variable and regionally more intense. Existing studies indicate that small increases in weather and climate extremes have the potential to bring large increases in damages to existing infrastructure.*

Studies indicate that damage from extreme weather events tends to increase dramatically above critical thresholds, even though the high impact storms associated with these damages may not be much more severe than the type of storm intensity that occurs regularly each year. In many cases, it is likely that the critical thresholds reflect storm intensities that exceed average design conditions for a variety of infrastructure of varying ages and condition. An investigation of claims by the Insurance Australia Group (Coleman, 2002), as shown in Figure 1, indicates that a 25% increase in peak wind gust strength above a critical threshold can generate a 650% increase in building claims. Similar studies indicate that once wind gusts reach or exceed a certain level, entire roof sections of buildings often are blown off, or additional damages are caused by falling trees. Typically, minimal damages are reported below this threshold. Similar results have been obtained for flood and hailstone damages. For example, similar damage curves exist for flood damage events, indicating that a small increase in flood levels may vastly increase flood damage as incremental flood levels overwhelm existing infrastructure and flood protection systems.

*In many countries, the infrastructure and built environment that exists today has been designed using climatic design values calculated from historical climate data on the assumption that past extremes will represent future conditions. Changes in climate will require changes to these climatic design values, as well as to larger societal changes.*

Evidence from around the world indicates that the costs of weather related disasters are increasing over time. Since the decades of the 1950s, the annual direct losses from natural catastrophes in the 1990s increased 14 times, rising from US$3.9 billion to US$40 billion a year using 1999 dollars (Munich Re, 2006), while population grew only by 2.4-fold. In reality, these losses are larger by a factor of two, when losses from less severe weather-related events are included.

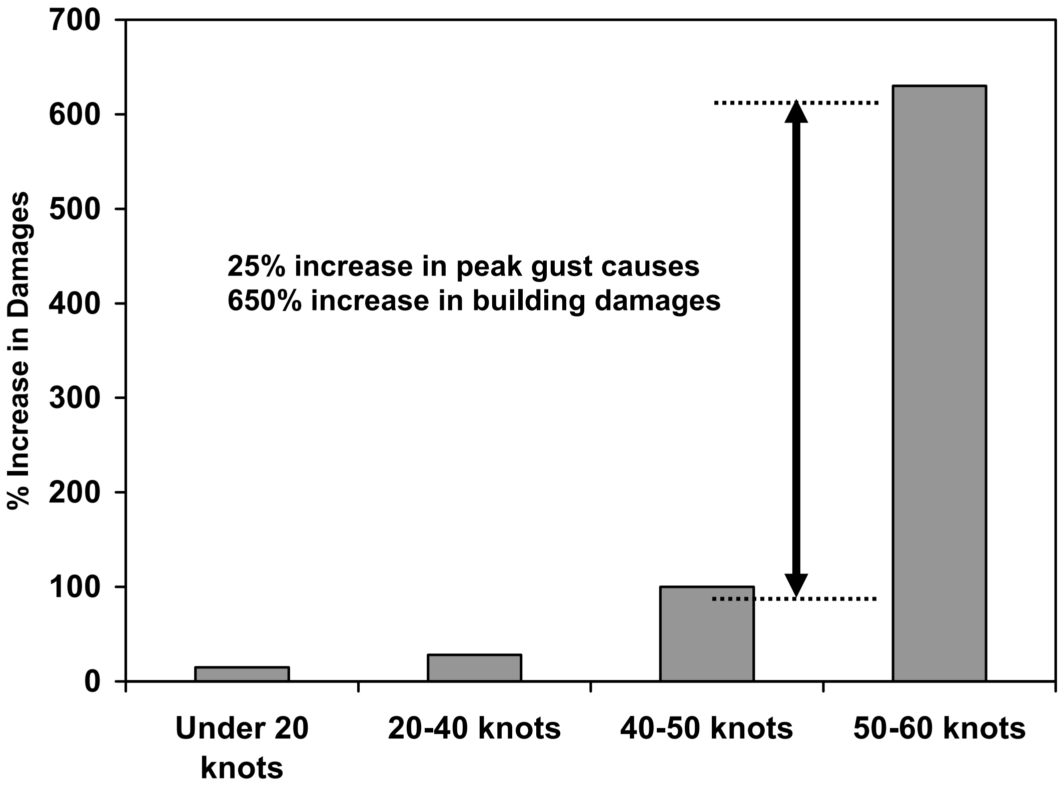



**Figure 11.** Building claims as a function of peak gust speed (Insurance Australia Group, Coleman, 2002)

While it is normal to expect large year-to-year variations in the number and intensity of natural hazards, it is not normal for the costs of natural hazards to continue rising over time. When a natural hazard becomes a disaster, the result is as much a function of the way that the community does business or adapts to the hazard as it is of the natural hazard itself. The fact that both insured and uninsured losses have been rising rapidly in constant monetary terms reflects a failure of communities and society as a whole to adapt well enough to current climate variability and extremes.

In most countries, natural hazard policies have traditionally focused on emergency preparedness actions that minimize the impacts during a disaster and provide immediate relief and support to victims. Although disaster response is important, it fails to address the causes of disaster losses especially those losses affecting the built environment. Effective management of disasters requires the coordinated and comprehensive integration of mitigation, preparedness, response and recovery actions and plans. The combination, known as “disaster management”, tries to minimize existing vulnerabilities, to prevent or to limit adverse impacts of hazards (mitigation and preparedness) and to ensure that comprehensive plans are in place to react to emergencies and to recover after disaster impacts (rehabilitation and reconstruction). The challenge in disaster management is to construct a program that is viewed as more desirable than the “status quo”.

National Meteorological and Hydrological Services (NMHS) are well-placed to reduce the “adaptation deficit” in several ways, in addition to emergency response and disaster recovery through the provision of early warnings for operational decisions. Additional support includes better disaster preparedness through the provision of hazards information for community risk impact assessments and land use planning; improved climatic design information for safer infrastructure; and better preparedness for emergency response through the provision of environmental prediction products and hazard assessments that assist in interpreting potential risks and impacts. As illustration of the linkages between these actions, weather and climate forecasts and warnings for emergency preparedness need to differentiate disruptive weather and climate conditions from the most hazardous outcomes likely to trigger disasters, which are most likely when critical thresholds of vulnerability are exceeded. Information on atmospheric hazards and their trends, accurate climatic design values and consistent forensic analysis of failures all are important in helping to identify the critical thresholds of vulnerability, in differentiating the most hazardous events, and in translating weather and climate warning terminologies into risk information.

Many aspects of managing climate related risks for the energy industry and the built environment sector involve considerations of an economic nature. Consequently, considerations of finance, insurance and markets are essential ingredients for assessing the decision making processes in these sectors.

### *Integrating Climate Information*

There are several factors motivating decision making processes in the energy and built environment sectors, to respond to the challenges of living with climate change and variability. They include:

1. Risk management considerations
2. Operational savings & efficiencies
3. Public/consumer demand
4. Regulations and codes
5. Business opportunity/new markets
6. Peer and community pressure

Each motivating factor offers opportunities for climate sensitive industries to initiate or tap into a collaborative enterprise with scientific, technical and service oriented organisations with data, information and knowledge on the current and possible future states of the climate system.

#### *Risk management*

In order to ‘mainstream’ climate risks into complex decision-making processes, it is essential that they be integrated according to their importance into existing decision-making frameworks. By doing this, climate risks are considered in the context of other factors involved in the making of a decision. For some decisions, climate risks will be unimportant relative to other risks, while in other instances attention to climate related risks will be essential and central to the outcome (see chapter on Decision Making).

In the UK, for example, this approach has been formulated by the UK Climate Impacts Programme into the risk, uncertainty and decision-making (RUD) framework. This methodology is based on UK stakeholders and decisions, but could be applied or modified for elsewhere. It is based on a standard 8-stage decision-making process: a process in which climate risks and adaptation responses are judged on wider objectives.

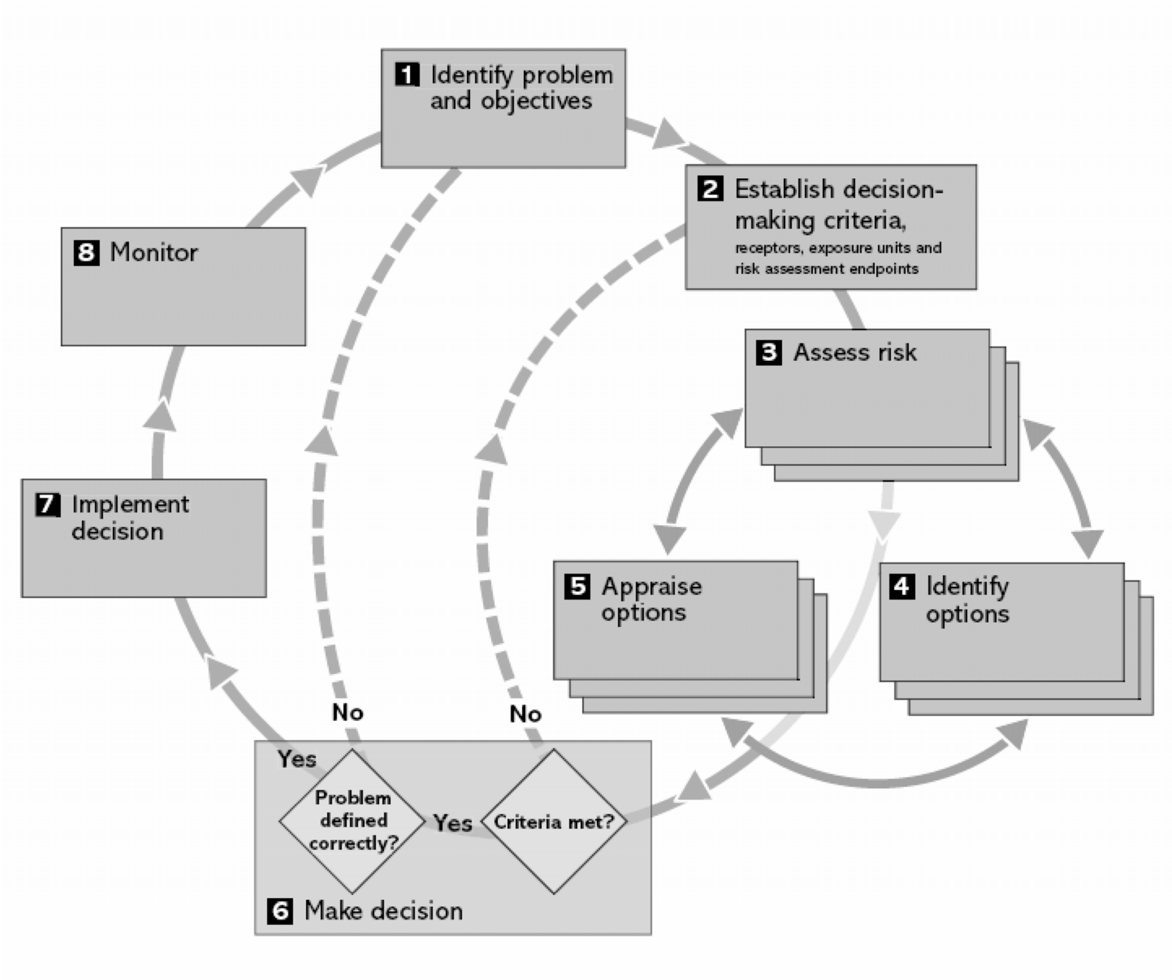



**Figure 12.** The UKCIP risk, uncertainty and decision-making framework.

Such a framework also requires decision-support information of various kinds in order to be most effective:

- *Guidance on how to use the framework in language the user understands*. UKCIP has produced a supporting report with guidance on how to work through the process, along with training workshops for stakeholders. An 'Adaptation Wizard' web-tool has also been developed, a simplified version of the RUD framework, aimed for use as a project management tool.
- *Supporting tools and guidance, which allow the climate risk to be correctly assessed.* These instruments involve both climate and non-climate information. An integrated toolkit, for example would include climate change scenarios, economic costing methodologies, a set of principles for good adaptation, socio-economic scenarios, adaptation example case studies, e.g. Connell & Willows (2003), and Australian Greenhouse Office (2006).
- *Partnership working*, so that decision-making criteria and downstream effects of the decision can be fully evaluated from a range of stakeholder perspectives. What makes a good decision regarding climate adaptation for one group of stakeholders might make it more difficult for another group to adapt.
- *Case studies*, to highlight examples of good (and bad) practice where a decision-making framework has been used. Even if the application is different, the lessons learnt might apply across different sectors.

The way in which climate information feeds in to a risk assessment, risk management, decision-making framework depends on the type of decision being taken. For example, many climate-sensitive decisions are directly driven by the need to reduce or otherwise manage anticipated climate risks. For the most part, such risks are assessed by referring to the statistics of past weather and climate. Many enterprises are required to manage their climate-related decision-making on the basis of the expected consequences of variability in climate: cold years, flood events, seasonal droughts, storm surges, extreme wind speeds, freezing conditions, heat waves. These are decision areas where climatic factors have long been acknowledged as being of primary consideration in the choice of management option. Climate change is expected to alter the choice between different options for managing the risk and the balance of risk associated with them. In some circumstances the prospect of climate change may provide the sole reason for considering decision, which can be referred to as a **climate adaptation decision**.

There are, however, many decisions where the outcomes could be affected by climate change and variability among several other factors. These decisions are also climate sensitive. For example, an outcome may not itself be directly sensitive to one or more climatic hazards, but may be indirectly affected by climate-dependent events or by the consequent decisions of others. Such decisions are called **climate-influenced**, and include decisions that could be taken to exploit the opportunities and/or avoid the threats associated with climate change and variability.

One also needs to recognise the need to balance information that services the occasional conflicting interests of public and private entities (Zillman, 2006).

*Operational savings/efficiencies*

Physical entities of the built environment, including the construction of power stations for energy generation, are generally designed and manufactured in the context of structural life times of decades or more. The operations of many of these entities, however, are often influenced by climatic factors on much shorter time scales. For example the demand from power stations is heavily modulated by peak demands for winter heating and summer cooling. The management of a tourist resort too can be highly seasonal in nature, with year to year fluctuations in the climate determining a better or worse than average return on investment.

Thus there are many opportunities for exploiting climate information, including climate variability predictions, in support of business operations, to achieve savings and efficiencies, to ensure reliable services for those occupying the built environment, and to ensure reliability of energy demand, supply and distribution. Such opportunities include:

- *Optimal mix for integrated energy systems*: use of climate information to manage different mixes of climate-dependent energy sources while meeting energy demand and ensuring reliability of its distribution systems. Climate sensitive components of these integrated energy systems include renewable wind, solar and hydro energy supplies, mean and peak energy demands, risks for energy distribution systems (e.g. electrical transmission and distribution infrastructure), and air quality predictions and emission requirements/restrictions from fossil fuel sources.
- *Proper maintenance of hydro-electricity and other water storage dams*: use of climate information for flow augmentation, to meet water quality standards, for the management of risks in the case of floods and low flow conditions, to ensure maintenance of minimum streamflow, temperature and water quality conditions and to ensure optimal management of hydro-electricity resources.
- *Energy trading*: spot, day-ahead and long term contracting needs can be informed by short term, medium term and seasonal forecasts; greater and more reliable climate information ensures better decisions on energy pricing and trading.
- *Weather derivatives trading markets*: climate information helps improve the efficiency of the trading markets.
- *Goods management and distribution*: climate information can be of critical importance for sensitive sectors. Examples include goods and medicine management, demand for temperature sensitive goods such as beverage demands during for hot weather,

reliability of transportation and distribution systems for “just-in-time” manufacturing, refrigeration for food safety.

- *Management of transportation risks and efficiencies*: climate information can be applied to the planning and operation of marine fleets, air traffic and road transport.
- *Management of highways and road infrastructure*: efficiencies can be made and safety improved by using climate information on thermal conditions (e.g. temperature for buckling of surfaces), and on likely precipitation phases for road surface maintenance.

*Public/consumer demand*

Inexorably, the spectre of climate change has crept over communities throughout the world and, more recently along with it, the realisation of its consequences for shorter term climate variability, and indeed for the frequency and intensity of extreme weather events. In recent surveys it has been reported that:

- 94% of Americans thought that the United States should limit greenhouse gases “at least as much as other developed countries”;
- 44% of Americans thought the United States should “do more” than others;
- More than 67% Britons said they knew “a great deal” or “a fair amount” about climate change;
- There is significant latent demand in the United Kingdom and United States for products & services that are in harmony with the environment and not deleterious to the climate.

Such outcomes have emerged from a broad range of passive and active events pressures operating throughout communities worldwide, which have included:

- The passing of the major environmental conventions following the United Nations Conference on Environment and Development and the subsequent World Summit on Sustainable Development;
- The development of the Kyoto Protocol to the UN Framework Convention on Climate Change, along with the often rancorous worldwide debate that has followed;
- The establishment of a multitude of climate change programs, activities and initiatives – some governmentally based and many more of a non-governmental nature, and together pressing an incredibly diverse range of climate change related agendas;
- The conduct of public meetings and professional conferences, the publication of public interest books, guidance materials, handbooks, and even ‘blockbuster’ movies, all dealing with one aspect or another of climate change and variability; and
- The almost insatiable interest of the media for information, controversial or not, on which to base stories related to climate change and variability.

Throughout this ongoing debate to inform and persuade the public, including decision makers, is the need to ensure a rigorous attention to the soundness of the science and the underlying data and information remains.

*Regulations and Codes*

In many countries, infrastructure and services for the built environment and energy systems are planned and designed based on legislated codes, regulations and standards. These instruments use climatic design values calculated from historical climate data under the assumption that the past will represent conditions over the future lifespan of the structure. Climate information can be incorporated into these regulations and codes through climatologists participating directly or indirectly in the work of the regulatory development and review bodies, thus ensuring a sound scientific foundation.

Opportunities exist to increase this role by better identifying and developing working relationships with relevant policy makers, advisors and implementing agencies, and through direct participation in the work of the regulatory development and review bodies. Other opportunities exist through improvements to the climate data and information systems provided to service regulatory systems and bodies for environmental assessments. Climate information can be mainstreamed into regulatory decision-making through the development of climate-derived tools to support policy development and implementation, e.g. monitoring systems for guiding drought response and relief.

This simple assumption that “the past climate will represent the future” will need to be modified as the climate continues to change. Infrastructure assets regionally could become more vulnerable to any increases in weather extremes at one end of the spectrum, or ‘over-designed’ at the other end. Climatic design values used in codes and standards will need to reflect changing climate conditions and, in particular, be assessed regularly against regional climate trends to determine whether existing margins of safety for structures have any remaining tolerances to accommodate increases in loadings. Regions where the climate trends are encroaching on tolerance limits will require changes in climatic design values for new structures and potential reinforcement for existing structures that have been identified “at risk” to greater climate variability and future change. It is becoming critical that information on current and future climates be mainstreamed or integrated into decision-making for the design of the built environment and energy systems.

Multi-disciplinary case studies and forensic investigations of climate-related infrastructure failures and disasters nationally and internationally yield valuable insights into critical thresholds for disasters and requirements for disaster response and prevention. Disaster management solutions can often be found through forensic investigations and monitoring of the performance of structures during extreme events. It is particularly important to identify regions that are at risk to specific natural disasters, to monitor trends in climatic variables in these regions and to develop codes, practices and regulatory mechanisms that are appropriate for minimising risk and exposure, e.g. building codes, Emergency Preparedness Acts. Because small increases in weather and climate extremes have the potential to bring large increases in damage to existing infrastructure above critical thresholds, there is a need to identify critical regulatory thresholds in existing building and construction design codes that may be sensitive to variations in the intensity and frequency of extreme event resulting from climate variability and change e.g. probable maximum precipitation and wind loadings. Critical thresholds can be very site specific, requiring accurate and detailed mapping of vulnerabilities in the built environment. In some cases, infrastructure failure can also be caused by weathering or premature deterioration from the weather elements, e.g. wind-driven rain, freeze-thaw cycles, frost, wetting and drying, erosion by abrasive materials, broad spectrum solar radiation and ultraviolet radiation, and by chemical pollutants. Climatic information on regional weathering factors is important in the implementation of preventative actions in areas such as materials selection, designs to reduce water penetration and mould risk. Premature weathering or deterioration of structural materials is becoming a concern in many regions, with changes in the physical and chemical atmosphere being attributed as causal agents.

Energy efficiency practices, codes and regulations are also sensitive to climate, particularly for housing and buildings. Thermal regions and rain exposure zones are all climatic loads that can be used to determine the engineering practices, codes and regulations needed for the design and operation of buildings and their mechanical systems. Building energy codes, for example, require various types of climate datasets.

*Business opportunity/new markets in the built environment/energy sectors*

- ***“The complete underpinnings of our economy worldwide are at risk”*** Mindy Lubber, Investor Network on Climate Risk

- ***“Climate change is happening. And it’s in the company’s interest to adapt.”*** Abby Joseph Cohen, Goldman-Sachs
- ***“You can't possibly trade knowing nothing, but you don't need to know the central risk involved in a trade to make a profit”*** John Geanakoplos, James Tobin Professor of Economics, Yale
- ***“Economy is three fifths of ecology”*** Mike Nickerson, Green Party of Canada

Energy, financial and built environment market participants are exposed to climate risks that vary in scale on a spatial and temporal basis. For example, modification of internal environments through air conditioning to compensate for temperature or humidity changes is often a direct contributor to increased emissions and local climate variations, e.g. the urban ‘heat island’. Increased variability exposes weaknesses in utilities demand and supply management strategies and can result in very large economic losses/gains to actors in the energy markets.

High temperatures directly affect energy supply due to increased thermal resistance in transmission and distribution systems resulting in lower capacity and system losses. In addition, heavy snow and ice and strong winds can damage power lines and other distribution system components. Security of supply for hospitals and other critical infrastructure may need to be improved dramatically to accommodate increased variability and change. Physical risks to natural gas and oil transportation and distribution pipelines need to be assessed with possible need for engineering design and construction changes. Gas and other thermal generation assets also have reduced efficiency and may subsequently incur loss. Coal seams have increased levels of combustion risks and may require higher watering/dewatering requirements in a water constrained environment. Thermal or nuclear plants situated in areas in close proximity to sea or water sources need to consider the potential for sea level rise and increased storm surge risks.

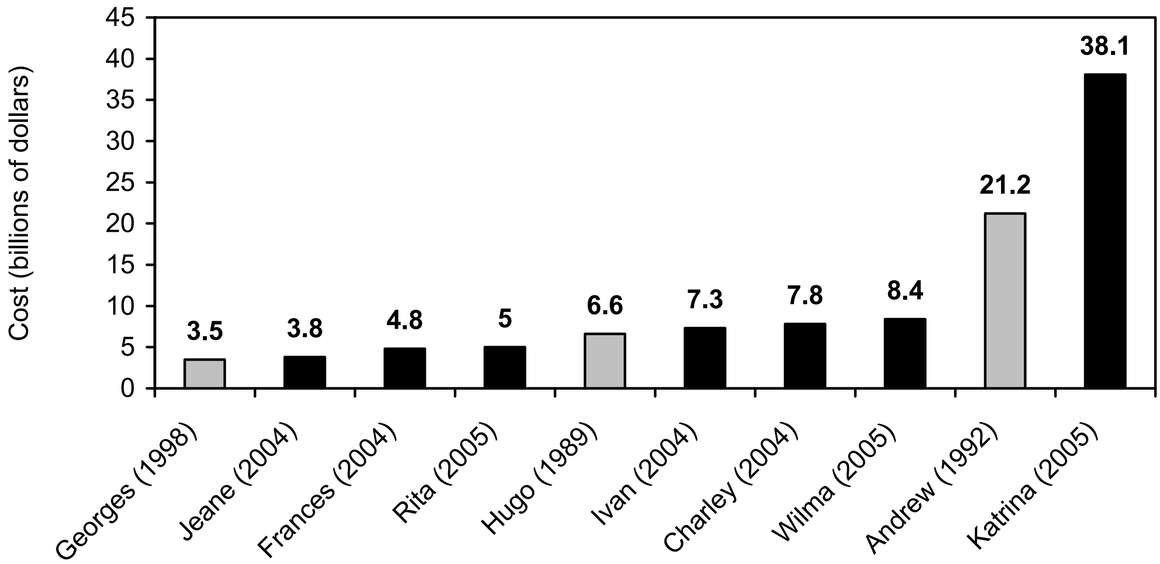



**Figure 13.** Top ten most costly hurricanes of all time (in billions of dollars).

For the general property and infrastructure sectors, climate variability and change in the form of heavier or more sustained precipitation, higher bushfire danger, stronger winds – from tropical cyclones in particular – and more intense and persistent heat waves could be expected to cause significant damage to or loss of homes, roads and associated infrastructure. Such changes will require information from the climatology community and a collaborative partnership approach involving key actors should best serve stakeholders needs.

A British study on possible effects of climate changes on buildings and construction has shown that an increase in average wind speed of 6% could translate into damage to roughly a million buildings in Great Britain, with repairs costing around GBP 1–2 billion (Graves and Phillipson, 2000).

As climate variability increases and climate change impacts awareness develops, new opportunities will be generated in the property services and construction sector. This may include

- Consulting opportunities in the provision of climate information services;
- Potential liabilities for planning authorities, designers, builders and material suppliers, sellers and agents with associated regulation and market driven opportunities;
- The development of regional or localised climate risk insurance rating methods (similar to flood risk ratings);
- Retro fitting or knock down rebuild of older stock using standards based on revised climate data;
- Prospecting and land banking in new areas based on scenarios and forecasts;
- Market flight and divestment of land and property assets / infrastructure investments from "high" risk areas; and
- Increased use of relatively high cost hard engineering adaptation solutions that may also increase mitigation.

Opportunities for joint research projects between operational climatologists, industry, academia and sectoral peak bodies should be explored.

The climate community should aim to extend its influence and reach by developing relationships with professional institutes to deliver best practice climate risk guidelines and improve cross-sectoral integrated approaches to climate variability and change.

### *Insurance and Financial Markets*

> *"Recent history has shown that weather-related losses can stress insurance companies to the point of bankruptcies, elevated consumer prices, withdrawal of insurance coverage, and elevated demand for publicly funded compensation and relief. Increased uncertainty regarding the frequency, intensity, and/or spatial distribution of weather-related losses will increase the vulnerability of the insurance and government sectors and complicate adaptation efforts."* (Intergovernmental Panel on Climate Change).

The insurance and financial markets are fundamentally linked to the property markets with many insurance companies underwriting assets based around property portfolios. As early adopters of adaptation policy, the sector continues to advocate for widespread policy and legislative change. Lloyds of London has repeatedly called for concerted action to reduce anthropogenic climate change with some commentators forecasting insurance market failure within the relatively near term of 30 years (Lloyds, 2006). Many insurers need to prepare for impacts on their own asset value and will need high quality climate information to develop suitable adaptation responses. In some areas however, variability and uncertainty has created opportunity for risk takers within environmental markets and led to the emergence of a new class of environmental financial instruments. New increasingly complex financial instruments would be expected to emerge in the near, medium and long term if climate variability increases.

Since 1997, market appetite for new climate related hedging, bonds and emerging instruments has been driven by fairly rudimentary knowledge and risk appetite for potential rewards. The finance and insurance markets rely on climate information that is material to spatial and temporal boundaries. The language and form of information is critical – a mismatch between science and business epistemologies is in itself a risk and can lead to an erosion of business confidence in the climatology community.

Information services opportunities currently exist in the following areas of the financial risk markets:

- Building new and improving existing weather derivative pricing and risk models
- Managing derivative portfolios
- Forecasting and measuring weather risk for wind and other energy types
- Weather note securing and weather risk management
- Linking climate, energy and carbon markets
- Emergent risk markets such as identifying regulatory lag relative to variability

Again industry sector-specific information needs will vary but efforts should be made to better understand end user requirements and to jointly develop products and services in conjunction with private sector consultants. Mandatory institutional reporting and disclosure of climate risk may only be 3-5 years distant. A voluntary scheme, under the Global Reporting Initiative is due to be introduced in 2007 and should contain climate and carbon related disclosure requirements.

New climate risk management firms are likely to emerge as supply side tools for engagement are developed and demand for climate risk management becomes further embedded in standard risk management methodology.

Special consideration should be given for developing nations. Scarcity of economic resources clearly limits a country's adaptation capacity. In many developing countries, the property, financial and insurance markets are immature or underdeveloped and inadequate security cannot provide resilience. Scenarios where there may be high sovereign risk or even complete economic collapse as a result of a high impact climate event need to be considered by responsible authorities and new responses planned and developed. Developing nations may have issues with the structural integrity of buildings that together with susceptibility to hydrological or other high energy events creates high levels of physical and economic risk for these countries' population. Energy supply is a major economic challenge for many small and developing nations and supply logistics may also be physically or economically affected by consequences of significant climatic anomalies.

Adaptation planning that allows for local indigenous energy sources should be considered. Low tech solutions may be more resilient and suitable than imposing a conventional developed country solution. Any wind or solar resources that maybe available in these environments will require careful assessment by climatologists. Long range or remote modelling may also be inappropriate for the local conditions. Support for current and new energy development initiatives should include climate assessments.

*Peer & community pressure*

Peer and community pressure is often an important factor in first steps, driving up the benchmark for acceptable behaviour, within and across sectors.

Some examples include:

- HSBC's carbon neutral announcement followed by Barclays, Credit Suisse, and others
- Announcement by the UK government of a 60% emissions reduction announcement forming the basis for California's 80% target.

Again the role of climate information providers is to inform the media through press releases, well founded interviews and collaboration on soundly based articles and productions. Equally there is a role for informing public pressure groups on the soundness of the many theories and statements that abound on climate related issues. Such activities could include meeting shareholder needs for information on investment options and possible impacts of industrial and planning activities.

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***Appendix: Climate Information Needs for Energy and Built Environment Stakeholders***

*Built Environment and Infrastructure Stakeholders:*

- End consumer – personal (investor, home, groups),
- Regulator – planners, consultants, Federal and other levels of governments, political representatives
- Energy regulators – energy efficiency requirements from regulators, NGOs
- Industry – design, supply chain, developers, construction industry, transport (e.g. shipping), utilities, etc
- Economy – macro, finance, insurance
- Science R&D – professional bodies
- Energy services

Climatic information supporting energy and the built environment should consider:

- Resilient infrastructure for the built environment needs to be designed using accurate estimates of return periods of extremes provided by climatologists. Best practices include probabilistic risk analyses based on long-term climate datasets and indications of future trends in climate variables. The Netherlands, for example, use long return period probabilistic risk analysis for design of coastal protection structure (e.g. 1:10000 year return period). It is important for climatologists to calculate return periods of extremes accurately.
- In developing countries, long data records may not be available to meet the needs of the built environment (e.g. long term data). The result is that investments in the built environment of developing countries may not consider the local climate, and structures will be over-designed or at risk to climate extremes. It is important to consider options such as data sharing approaches that encourage knowledge and technology transfer. Such approaches include the hiring of local students to collect or abstract and analyze data rather than the direct transfer of the data to other agencies for analyses. It is recommended that data coverage, networks and databases be improved, particularly in developing countries, and that partnership arrangements be encouraged to provide opportunities for technology transfer, the building of research capacity along with benefits for the built environment and other cross-cutting issues.
- There is a need to identify critical regulatory thresholds in existing structures and construction design codes that may be sensitive to variations in the intensity and frequency of extreme event resulting from climate change e.g. PMP, wind loadings, etc. There is a need to recognize that there can be large regional variations in thresholds.
- The efficient operations of infrastructure, energy systems and industrial facilities and processes have unique needs for climate information. Close collaboration between climatologists and these decision-makers will ensure that optimal climate information can be developed to meet short and long-term needs.

*Energy Stakeholders:*

- Transport
- Exploration
- Generation
- Transmission/distribution

- Retailers
- Regulations including Kyoto, Clean Air Act
- Fuel suppliers

*Energy Efficiency Stakeholders*

"best energy option is the energy not consumed"

- Regulators
- NGOs
- Appliances
- Government – "leading by example", best practices
- Urban Design – for sustainable communities (i.e. all energy implications considered)
- Retailers/traders
- Energy audit services

Climatic information requirements for energy stakeholders need to consider:

- Climate information needs include support for short-term and long term decisions for the operation and design of energy systems (includes user demand, peak loads, etc.).
- Energy systems and their reliability are critically important to disaster vulnerability and recovery. Redundancy in energy systems is an important adaptation option.
- Synergies exist between GHG mitigation and climate variability and change adaptation measures (e.g. energy efficient windows are more resilient to wind projectile damages, insulated buildings and pipes in cold climates delay need for emergency response in winter, etc.).
- Integrated energy systems have significant needs for climate, weather and air quality information. The information is necessary to ensure an optimal mix of energy sources to meet energy demands, which also vary with climate, and to ensure compliance with air quality and emission limits, where required. Electricity transmission and distribution systems also require a variety of information for their design and operation (e.g. design wind, ice loads, and temperatures).

*Disaster Mitigation Planning and Emergency Response Stakeholders:*

- Various levels of Governments/States/communities
- NGOs – Red Cross, etc
- Industry, business
- public

Disaster response systems and the climate information to support them differ between developing and industrialized countries and between cold and warmer climates. Developing countries tend to be the least resilient to natural disasters and bear an unequal burden in disaster mortalities. When disasters hit, not all communities have a good capability for emergency response, with more affluent countries having better preparedness.

While the debate continues on whether increases in climate extremes are contributing to escalating disaster losses worldwide, it is known that changing socioeconomic and demographic trends have also contributed to the rising trends and vulnerabilities. Included in these trends is the role of increasing populations and increasing urbanization, the location of infrastructure and communities in higher risk locations (e.g. coastal), the migration of populations from rural locations to high risk areas, the increasing dependence in the built environments on vulnerable electrical power grids, computer-based technologies and "just-in-time" transportation and commercial systems, aging infrastructure, environmentally unsound development practices, a failure to use or afford the best climatic design information along with regional increases in frequencies or intensities of extreme events.

Climatic information requirements for disaster management planning and emergency response need to consider:

- Regulatory environment – Critical risks for communities need to be identified based on accessible climatic hazard information, including good climatic design values. Risks and their management may be indirectly related to climate (e.g. communities more vulnerable to fire hazards risks can reduce their vulnerabilities through forest management practices or selection of suitably fire resistant materials for their infrastructure).

- It is critical that information on climatic hazards be accessible and well distributed to authorities responsible for disaster management and emergency response planning. Climate data needs to cover both near real-time and long term planning horizons.

- Maintenance of infrastructure is an important factor in reduction of vulnerabilities to climate hazards (e.g. pumping systems that are not well maintained or do not have sufficient fuel/energy supplies increase risks to flooding (New Orleans); blockage from insufficient maintenance of drainage infrastructure).

- Weather and climate data coverage, availability and transfer issues are important considerations in disaster management. Reductions in networks, for example, will impact the capacity to design Early Warnings Systems. Ownership of data and lack of access is also a barrier to the design and operation of Early Warning Systems. Integrated Early Warning Systems need to integrate observations with response actions.

- Studies have shown that, above critical thresholds, small increases in weather and climate extremes have the potential to bring large increases in damage to existing infrastructure. As a result, there is a need to identify critical regulatory thresholds in existing building and construction design codes that may be sensitive to variations in the intensity and frequency of extreme event resulting from climate variability and change e.g. PMP, wind loadings, etc. It is important to recognize that there can be large regional variations in thresholds. Information on the thresholds for widespread infrastructure failure also needs to be incorporated into weather warning criteria and considered in updates to climatic design values used in regulations and codes. As illustration, Heat-Health Warning systems use thresholds that are tailored for regional differences in acclimatization. Air quality issues and a greater incident of more vulnerable populations also influence thresholds for response to heat stress.

- Energy supply and distribution systems need to remain operational, if possible, following a disaster (e.g. water treatment facilities). Consequently, redundancy in energy systems is important consideration for adaptation to climate variability and change. As illustration, the Netherlands, where some 60% of the population lives below sea level, needs to pump water year-round and requires reliable energy supplies to maintain pumping to reduce risks for flooding.

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Romsdahl, Rebecca
Sachs, Jeffrey
Someshwar, Shiv
Thomson, Madeleine
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Van Viet, Nguyen