

APN CAPaBLE

- Making a Difference -

Scientific Capacity Building & Enhancement for Sustainable Development in Developing Countries

International workshop on Coping with Agrometeorological Risk and Uncertainties: Challenges and Opportunities

Final Report for APN CAPaBLE Project:
CB006-08NSY



International Workshop on coping with Agrometeorological Risks and Uncertainties: Challenges and Opportunities

25-27 October 2006

New Delhi, India

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Final Report submitted to APN

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Overview of project work and outcomes

Non-technical summary

The workshop brought together leading experts who presented 27 state-of-the-art discussion papers to address coping with agrometeorological risk and uncertainties and then developing strategies to cope with these risks. Participants were encouraged to come forward as discussants on topics of their interest to facilitate an interactive dialogue and develop appropriate recommendations. In many parts of the world climate change and extreme climatic events such as severe droughts, floods, storms, tropical cyclones, heatwaves, freezes and extreme winds one of the biggest production risk and uncertainty factors impacting on agricultural systems performance and management. Coping with agrometeorological risk and uncertainties is the process of assessing agrometeorological risks and uncertainties and then developing strategies to cope with these risks. One of the most important coping strategies is improved use of climate knowledge and technology, which includes the development of monitoring and response mechanisms to current weather and future climate change. These aspects directly address the main themes of the APN Capable Agenda. The project provided scientists from 11 APN emerging and developing countries, opportunity to interact with experts from different regions. Capacity building in the area of coping strategies for weather and climate risks contributes to sustainable agricultural development, especially in the Asia-Pacific region. The proceedings will be published as a book during 2007.

Objectives

The present project aimed to:

- To identify and assess the components of farmers' agrometeorological coping strategies with risks and uncertainties in different regions of the world;
- To discuss the major challenges to these coping strategies with agrometeorological risks, such as reducing the vulnerability of different agro-ecosystems to weather and climate related risks and uncertainties, access to technological advances - particularly in developing countries;
- To review the opportunities for farmers to cope with agrometeorological risks and uncertainties in different parts of the world, and non-structural measures for strategic and tactical management of agriculture;
- To provide on-farm examples of appropriate coping strategies for minimizing agrometeorological risks and uncertainties and of sustainable agriculture;
- To review, through appropriate case studies, the use of crop insurance strategies and schemes to reduce the vulnerability of the farming communities to agrometeorological risks;
- To discuss and recommend suitable policy options, such as agrometeorological services for coping with agrometeorological risks and uncertainties in different parts of the world.

Amount received and number years supported

The Grant awarded to this project was:

- US\$ 20,000 for Year 1, 2006-2007

Work undertaken

1. Arrange for participation of participants from APN developing countries.
2. Organisation of 27 state-of-the-art discussion papers on agrometeorological risks and uncertainties, and distribution of these on a CD-RoM prior to the workshop.
3. International Workshop, 25-27 October 2006, New Delhi, India.

Workshop format:

- Opening Session with overview
- Five technical sessions covering different objectives of the workshop.
 1. Challenges to coping strategies – regional perspectives;
 2. Risks and uncertainties – perspectives from farm applications;
 3. Coping strategies for agrometeorological risks and uncertainties;
 4. Coping strategies – policies and services;
 5. Weather risk insurance for agriculture.
- A final session for discussion on the conclusions and recommendations of the workshop.

Results

The workshop was attended by 188 participants from 78 countries. Senior experts in several fields presented 27 state-of-the art discussion papers to address the objectives of the workshop. The Workshop programme was designed in to engage all the participants in discussions on each of these discussion papers and develop appropriate recommendations. The workshop discussed in depth the range of options for coping with agrometeorological risks and uncertainties in different agroecosystems, especially in developing countries with limited access to technologies and appropriate information. A large majority of the participants at the workshop were from developing countries. Representatives of developing countries to be funded by APN acted as discussants on the different state-of-the-art papers which will be presented during the workshop. In addition, they actively engaged to develop recommendations on appropriate adaptation strategies required in their countries to cope with agrometeorological risks and uncertainties. A range of policy options to cope with such risks were presented. These included contingency planning, use of crop simulation modelling, and use of agrometeorological services.

Relevance to the APN CAPaBLE Programme and its Objectives

Improved use of climate knowledge and technology, which includes the development of monitoring and response mechanisms to current weather, is one of the effective ways of helping the farming community cope with agrometeorological risks and uncertainties. The structural and non-structural measures to reduce the impacts of the variability (including extremes) of climate resources on crop production discussed during the workshop focus on different ecosystems, biodiversity and land use in different regions of the world. More efficient resource use is one of the effective measures to cope with agrometeorological risks and is an effective pathway for sustainable development, especially in the developing countries. The workshop promoted linkages between various national, regional and international institutions participating in the workshop and such linkages are crucial for the successful implementation of appropriate case studies in different APN countries that will test and validate the various climatic risk management strategies.

Self evaluation

The project has been already assessed as a success by workshop participants: Much work has been done for monitoring and prediction of weather and climate risks to agriculture. However, this workshop introduced the concept of risk management to promote sustainable development in agriculture, both for developing and developed countries. All participants were delighted with the networking and capacity building opportunities provided, and the new knowledge they have gained and some are introducing workshop material into training courses in their home countries. These are reflected in their reports.

Potential for further work

The attention of the policy makers to the conclusions and recommendations of the workshop will be drawn in two ways: through the Special Edition of a book published by Springer including the papers presented at the workshop. Discussions were held through the Fourteenth Session of the Commission for Agricultural Meteorology of WMO which brings together participants from over 64 countries around the world which met right after the workshop. A number of WMO projects are being developed as a result which focus especially on disaster prevention and management. Specifically, two work programmes are focussing on:

1. Identification of critical areas where agricultural production is sensitive and vulnerable to climate change and variability in different regions, and suggest monitoring strategies for early detection, as well as summarize coping strategies to climate risks in agriculture.
2. Reviewing the increasing frequency and severity of droughts and extreme temperatures globally, and assessing the current status of monitoring and predicting droughts including the use of drought indices in different regions to improve drought monitoring and prediction.

Participants from APN countries are promoting the linkages between science and policy discussed during the workshop.

Publications

<http://www.wmo.int/web/wcp/agm/Meetings/worisk06/>

CD-ROMS

1. Draft papers for the International Workshop on Agrometeorological Risk Management: Challenges and Opportunities, distributed prior to the workshop.
2. Presentations: Agrometeorological Risk Management: Challenges and Opportunities, distributed at the end of the workshop.

The edited papers are to be produced in a book published by Springer during 2007.

Acknowledgments

Other funding to support attendance at the workshop was provided by the Bureau of Meteorology (Australia), Technical Centre for Rural and Agricultural Cooperation (CTA), Food and Agricultural Organisation (FAO), Meteo-France, United Kingdom Meteorological Office, United States Department of Agriculture (USDA) and the World Meteorological Organization (WMO). The workshop, hosted by the India Meteorological Department (IMD) and the Ministry of Science and Technology and Earth Sciences of the Government of India.

Technical Report

Abstract

Leading experts in several fields presented discussion papers to address challenges and opportunities for coping with agrometeorological risks and uncertainties at an international workshop. The workshop allowed participants to develop recommendations. Participants were encouraged to come forward as discussants to facilitate this interactive dialogue. The workshop provided an opportunity for the APN scientists to learn about the extreme weather, climate and farming risks; examples of preparedness and coping strategies; methods of evaluating the weather and climate risks; decision support systems for on-farm applications; crop insurance and credit strategies and contingency planning and services to cope with climate risks and uncertainties.

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1.0 Introduction

Agricultural production is highly dependent on weather, climate and water availability and is adversely affected by weather and climate risks (Meinke et al. 2003). During the past four decades, weather and climate risks such as droughts, floods, storms, tropical cyclones, heatwaves and wildland fires and windstorms have caused major losses in the agricultural sector (Sivakumar, 2005). Communities that are most exposed to these risks are those with limited access to technological resources and with limited development of infrastructure. Currently there are many opportunities that can assist in coping effectively with agrometeorological risks and uncertainties (Meinke and Stone, 2005). One of the most important strategies is improved use of climate knowledge and climate risk technologies. Both structural and non-structural measures can be used to reduce the impacts of the variability (including extremes) of climate resources on crop production (Wilhite, 2005). Planning, early warning and well-prepared response strategies are the major tools for mitigating losses.

Decision-making in agricultural production is a complex process in which many risks need to be considered for an informed decision to be made. Farmers face many types of risks related to production, marketing, legal, social and human aspects. Production risk is the random environmental variability associated with the farming process and includes the variability in yield and quality due to weather, soils, diseases and pests. Market risk is due to the uncertainty of prices in buying inputs, selling crops or livestock, and the accessibility of inputs. Legal and social risks are due to the uncertainty of governmental policies influencing production practices, such as ownership of land and other production factors, changes in price and income supports, tax, credit and environmental policies of the government. The human sources of risk are those due to poverty (social class), labour, education, health and input management factors present in agricultural production. Although agrometeorology particularly deals with production risks and evaluation of possible production decisions, to solve local problems of farming systems the other risk factors have to be taken into account in that same process.

In many parts of the world, weather and climate are one of the biggest production risk and uncertainty factors impacting on agricultural systems performance and management. Extreme climatic events such as severe droughts, floods, cyclonic systems or temperature and wind disturbances strongly impede sustainable agricultural development. Hence weather and climate variability is considered in evaluating all environmental risk factors and coping decisions.

Coping with agrometeorological risk and uncertainties is the process of measuring or otherwise assessing agrometeorological risks and uncertainties and then developing strategies to cope with these risks. There are many challenges. The above already listed events have a direct influence on the quantity and quality of agricultural production, and in many cases adversely affect it. This is especially the case in developing countries, where technology generation, innovation and adoption are too slow to sufficiently counteract the increasingly negative effects of degrading environmental conditions. For example, inappropriate management of agro-ecosystems, compounded by severe climatic events such as recurrent droughts, from West Africa till northern Sudan, have tended to make the drylands increasingly vulnerable and prone to rapid degradation and hence desertification. Even in the high rainfall areas, increased probability of extreme events can for example cause increased

nutrient losses due to excessive leaching, runoff and water logging. Lack of attention to preparedness and response strategies is a major challenge.

Currently there are many opportunities that can assist in coping effectively with agrometeorological risks and uncertainties. One of the most important strategies is improved use of climate knowledge and technology, which includes the development of monitoring and response mechanisms to current weather. By providing new, quantitative information about the environment within which the farmers operate or about the likely outcome of alternative or relief management options, uncertainties in crop productivity can be reduced. Quantification is essential and computer simulations can assist such information and may be particularly useful to quantitatively compare alternative management and relief options in areas where seasonal climatic variability is high and/or that are prone to extremes.

Both structural and non-structural measures can be used to reduce the impacts of the variability (including extremes) of climate resources on crop production. The structural measures include irrigation, water harvesting, windbreaks, frost protection, artificial and controlled climates (greenhouses), microclimate management and manipulation and other structural preparedness measures. The non-structural measures include use of seasonal to interannual climate forecasts, improved application of medium-range weather forecasts and crop insurance. Crop insurance can be resorted to only when there is sufficient spatial variability of the environmental stress (e.g. with hail). But it remains extremely difficult to implement for some of the major risks, such as drought, which typically affect large areas, sometimes whole countries. One of the techniques that have been adopted with credit and insurance is to make them conditional to the adoption by farmers of improved risk-reducing practices, like early planting. Contingency planning is an important part of such strategies, as ways must be found to avoid, reduce, or cope with risks. In some of the drought-prone areas around the world, contingency planning is commonly used by governments as an effective strategy to cope with risks.

Given the current recognition of the importance of preparedness to cope with risks and uncertainties as compared to the practice of reactive responses, it is necessary to take stock of the opportunities that exist in coping with agrometeorological risks, to develop suitable practices/strategies and to disseminate them widely.

It is with this background that the World Meteorological Organisation (WMO) proposes to organized, jointly with several co-sponsors, an International Workshop on Coping with Agrometeorological Risk and Uncertainties - Challenges and Opportunities. The workshop was held from 25-27 October 2006 in New Delhi, India, in conjunction with the 14th Session of the Commission for Agricultural Meteorology of WMO.

There were six main objectives of the workshop were:

1. To identify and assess the components of farmers' agrometeorological coping strategies with risks and uncertainties in different regions of the world, e.g extreme climatic events;
2. To discuss the major challenges to these coping strategies with agrometeorological risks, such as reducing the vulnerability of different agro-ecosystems to weather and climate related risks and uncertainties, access to technological advances - particularly in developing countries;

3. To review the opportunities for farmers to cope with agrometeorological risks and uncertainties in different parts of the world, e.g. with structural measures (irrigation, water harvesting, microclimate management and manipulation and other preparedness strategies) and non-structural measures (use of seasonal to inter-annual climate forecasts, improved application of medium-range weather forecasts) for strategic and tactical management of agriculture;
4. To provide on-farm examples of appropriate coping strategies for minimizing agrometeorological risks and uncertainties and of sustainable agriculture;
5. To review, through appropriate case studies, the use of crop insurance strategies and schemes to reduce the vulnerability of the farming communities to agrometeorological risks;
6. To discuss and recommend suitable policy options, such as agrometeorological services for coping with agrometeorological risks and uncertainties in different parts of the world.

The overarching goal of the workshop project is to enhance the international network of scientists, forecasters, disaster management officials and resource managers skilled in agrometeorology in the use of climate information to increase the resilience of APN nations to cope with agrometeorological risks and uncertainties in different parts of the world. A secondary aim was to enhance capacity building through sharing of knowledge, experience, scientific information on climate change impacts, vulnerabilities, adaptation and mitigation; and, through the dialogue initiated at the workshop.

2.0 Conference Outputs

2.1 Conference Papers

Twenty-seven state-of-the-art papers were presented. Summaries of these are listed in Appendix 4. Firstly weather and climate events and risks to farming from droughts, floods, cyclones and high winds, and extreme temperatures were identified through risk and risk characterization. These climate extremes and anomalies provide challenges for coping with agrometeorological risks and uncertainties, with risk having both natural and social components. Extreme poverty makes communities very risk averse. Agrometeorological risk and uncertainty permeates the entire marketing system with far-reaching consequences. Global and regional perspectives were given and several speakers identified that developing countries are hardest hit.

Papers on approaches to dealing with risks highlighted preparedness planning, risk assessments and improved early warning systems that can lessen the vulnerability of society to weather and climate risks. A special session examined the use of crop insurance strategies and schemes to reduce the vulnerability of the farming communities to risks posed by weather and climate extremes. Enterprise diversification, contract hedging, crop insurance, weather derivatives and weather indices for insurance played a key role in developing agricultural risk management strategies. The speakers in this session came from the re-insurance, food security, and banking sectors and they stressed the importance of weather and climate information, especially on climate change. This was an encouraging sign since the issues of the agrometeorological community were

being recognized by other disciplines.

A number of strategies were identified to cope with risks. These include the use of seasonal forecasts in agriculture, forestry and land management to assist alleviation of food shortages, drought and desertification. Also, strategies on integrated pest management and wildfire fire were discussed. The use of integrated agricultural management and crop simulation models with climate forecasting systems give the highest benefits. Strategies to improve water management and increase the efficient use of water included crop diversification and better irrigation. Especially important was the application of local indigenous knowledge.

Papers on the perspectives from farm applications for agrometeorological risks and uncertainties examined optimization of farm technologies at differing input levels, using climate information approaches and decision support systems. A combination of locally adapted traditional farming technologies, seasonal weather forecasts and warning methods were important for improving yields and incomes. These included use of structural measures (irrigation, water harvesting, microclimate management and manipulation and other preparedness strategies) and non-structural measures (seasonal climate forecasts, improved application of medium-range weather forecasts) for strategic and tactical management of agriculture.

Challenges to coping strategies were many and identified in several papers. Particularly important was the impact of different sources of climate variability and change on the frequency and magnitude of extreme events. Lack of systematic data collected from disasters impeded future preparedness, as did the need for effective communication services for the timely delivery of weather and climate information to enable effective decision-making.

Finally a range of policy options to cope with such risks was presented. These included contingency planning, use of crop simulation modelling, and use of agrometeorological services. Contingency planning is especially important when dealing drought and several examples of such tools were described from the United States and Australia. In order for drought preparedness and contingency planning to be effective, many information sources and from diverse organizations are required and this information must be timely and reliable. Another factor to consider is that information policy aspects can easily lead to unnecessary complexities when different government agencies are involved at a national or local level. There are several economical and ecological benefits as result of using crop simulation modelling such as the reduction of chemical inputs in the ecosystem; soil fertility conservation; smaller amount of chemical residuals in food; work quality improvement; reduction in the development of resistant forms; safeguarding of natural predatory; and more acceptance of the farmers' work in public. There must be a comprehensive approach to improve agrometeorological services to cope with risks and uncertainties. A comprehensive data management system is essential. A blend of technology, including indigenous technical knowledge and modern technology (remote sensing, GIS) with operational applications of agrometeorological indices is useful. Accurate and reliable weather and climate forecasts for agriculture are needed.

2.2 Workshop Recommendations

As outputs, the workshop produced a number of recommendations. Key recommendations are listed below. These and other recommendations were distributed to workshop participants by e-mail.

- Development of a pro-active risk-based management approach to deal with adverse consequences of weather extremes and climate anomalies including risk scoping, risk characterization, risk management and monitoring and review;
- Use of decision-support systems as risk management tools should be promoted as an effective means of providing output of integrated climate-agronomic information;
- Utilization of climatic risk zoning to quantify climate-plant relationships and the risk of meteorological extremes for planning of agricultural enterprises;
- Research into the introduction of new scientific-based weather and climate forecast services, which provide accurate and reliable outlooks into the local indigenous cultural traditions in many poor rural areas;
- Research into the application of seasonal forecasts for crop management strategies and risk management planning;
- Increased attention in many developing countries to facilitate access by the rural poor to technical expertise and technological innovations;
- Need for an urgent review of drought contingency planning, drought preparedness and drought impact assistance policies because of climate change, and measures to pursue desertification must be vigorously pursued;
- Development of agrometeorological products with an emphasis on local user communities.

2.3 Other Outputs

Workshop and conference website:

<http://www.wmo.int/web/wcp/agm/Meetings/worisk06/>

This website contains links to introductory note and the workshop brochure, and lists the co-sponsors. It also contains a summary of the workshop recommendations and PDF files of the 27 PowerPoint presentations presented at the workshop.

WMO's Agricultural meteorology website:

<http://www.wmo.int/web/wcp/agm/agmp.html>

CD-ROMS

1. Draft papers for the International Workshop on Agrometeorological Risk Management: Challenges and Opportunities, distributed prior to the workshop.
2. Presentations: Agrometeorological Risk Management: Challenges and Opportunities, distributed at the end of the workshop.

The 27 state-of-the-art papers are currently being edited, and will be published in a book published by Springer in 2007. The book will be widely distributed to

all participants and member countries of the World Meteorological Organization.

3.0 APN-Funded Participants

The funds were used to support 11 participants all from developing countries (Appendix 2). The funds were largely used to support their air-fares, accommodation and per diem costs to travel to New Delhi, India to attend the 3-day international workshop. Feedback from the participants outlining their fields of interest and how the conference was valuable for their career agendas, especially for networking and capacity building is summarised below.

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Weather and climate are the major risk and uncertainties factors that challenge farmers in their agricultural production. The development of coping strategies can help farmers to reduce risk and uncertainties and make better decisions for sustainable agriculture. The topics of the International Workshop are all important and interesting. In the Chinese Meteorological Administration (CMA) there is much research and services on monitoring, predicting, early warning, assessing and preventing countermeasures for meteorological and agrometeorological disasters. However the concept of risk management and the view of expanding from natural to economic-social problem as well as relative methodologies are still new and interesting. After returning to China, presentations based the workshop were made at a CMA training course about the predicting and early warning of agrometeorological disasters. All the audiences from provincial meteorological services were most interested.

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Weather and Climate are major production risk and uncertainty factors that challenge Agro-meteorologists today. The development of coping strategies can

help to address agro-meteorological risks and uncertainties and make better decisions for sustaining production and ensuring quality.

Attendance in this workshop has enriched my technical and scientific knowledge, enhanced skills in dealing and developing coping strategies to suit our local needs for risks associated with weather and climate. As a focal point in Agro-meteorology in the meteorological service, I have a responsibility to diversify and identify climate data and products for improved services to cope with weather and climate uncertainties and help farmers manage their agricultural systems to address the agro-meteorological risks and also explore opportunities to make better decisions for social and economic progress.

During the three day workshop, I have gained personally and professionally:

- identify and access weather and Climate risks and uncertainties;
- understand major challengers to cope with Agro-meteorological risks and uncertainties;
- understand major opportunities to cope with Agro-meteorological risks and uncertainties;
- policy gaps, implications and risk transfer (insurance).

Recommendations

- more workshops on similar nature and scope are to be organized in the region;
- A special workshop that address the effective communication of weather and climate information for various levels of end users;
- Provision of scholarships for Agro-meteorologists or climatologists in the region to meet the of Agro-meteorological services for sustainable food production.

I am thankful to the organizers and the funding agencies and in particular, APN, without whom, my participation would not have been possible. It is my sincere hope that you will continue to fund upcoming activities for the benefit of the developing countries of the South-West Pacific.

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Many parts of India are being subjected to climate risks, the impacts of which are impeding the agricultural development. Therefore, efforts are needed to improve capacities, infrastructure, knowledge and partnerships related to climate risk management and to apply them to better manage agricultural activities. The workshop brought together the cream of agrometeorological scientific community working across the globe. The state of art papers presented and the fruitful interactions I had with the scientists enable and support me in evolving effective adaptation strategies to reduce vulnerability to climate and environmental changes to promote sustainable agricultural development in the world in general and India in particular. The workshop was also extremely useful to me because I have co-authored two scientific papers for the workshop and I have also been actively involved in the activities of

Expert Team on the Guide to Agrometeorological practices (ETGAMP).

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The workshop was very valuable and has met its overall objectives. Major challenges to coping strategies with agrometeorological risks, for example on how to reduce the vulnerability of different agro-systems to weather and climate related risks and uncertainties were discussed and recommended to be implemented.

For farmers to cope with agrometeorological risks and uncertainties, non-structural measures such as seasonal and inter-annual climate forecast related to ENSO (or other extreme climate events) is very crucial for strategic and tactical management of agricultural for region most affected by El-Nino phenomena such as Malaysia. Accurate seasonal climate forecast will minimize the agrometeorological risks. Malaysia is very much interested if such forecast is available in the market or probably to have joint research or project collaboration with APN to enhance our networking and capacity building.

The special symposium during the workshop with regard to the use of weather and crops insurance strategies and schemes to reduce the vulnerability of the farming communities to agrometeorological and extreme climate events risks for agricultural, needs to be further detail reviewed and studied with appropriate practicable case studies. Unlike India, the weather insurance scheme is totally new to us and has not been developed and implemented yet in Malaysia. We take this opportunity if a workshop could be held in Malaysia during the intersessional period of CAgM under OPAG 3 to include weather and crops insurance matters as part of the sessions in the workshop.

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The lectures presented at this workshop were very useful and involved the actual problem, which agrometeorologists should be solving in near future to be reach to the sustainable livelihood. The drought concept, desertification and agrometeorological risk tasks are much more attention from the side of participants who are living in arid and semi-arid regions. Also the special seminar was very new kind of knowledge that all developing countries are started or tried to do the best service and application to the users. After coming back to my institute-IMH, I am preparing a presentation to our staff and who are interested in the risk management issues. The lectures and workshop copies were distributed to agrometeorologists who are working in Institute of Meteorology and Hydrology (IMH) and Computer and Communication Center (CCC) of the National Agency of Meteorology, Hydrology and Environment Monitoring (NAMHEM), Mongolia.

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As a section chief of agricultural meteorology, my special field of interest is in agro-meteorology and climate change. It is my great opportunity that I could attend that International Workshop where I got the lesson how we are suffering in the field of agriculture and what are the problems and risks we are challenging now. Problems and challenges created opportunities to learn more by developing sound management in the field of networking and capacity buildings to cope with the risks. A lot of papers presented there were great assets to me to learn about the facing challenges and opportunities in the present world. This is a multidisciplinary fields where we all do the work together.

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Being an agricultural country, representation of Pakistan in the subject workshop was of the great importance. Geographically, Pakistan experiences almost all kinds of climate. The biggest risks and uncertainly factors on our agricultural systems are imparted by the extreme climatic events such as severe droughts, floods, cyclonic systems, heat waves and dust/thunderstorms, frosts. Coping with Agrometeorological risks and uncertainties has a direct linkage to the quality and quantity of agricultural production.

In coping these challenges at the first instance is the improved use of climate knowledge and use of latest technology i.e. development of monitoring and response system to the impending extreme weather. During the proceedings of the workshop, exchanges of ideas in coping mechanism were done. Adopting the following measures could avert the adverse affects of the extreme climate to the agriculture:

- Quality of Agrometeorological data and expanding the coverage of agrometeorological observation system in the country
- Study of extreme weather condition and their affects on the yield.
- Designing micro-climatic zone maps on the basis of Agrometeorological conditions.
- Use of latest technology i.e. automatic instruments, computers, data communication through satellite etc. for timely dissemination of agrometeorological products to the end users.
- Medium-range / Short-range climate/weather predictions for the guidance of decision makers / planners to adopt strategies in mitigating

- the affects of extreme climate features e.g. drought and desertification, tropical cyclone, floods, flash floods etc.
- Education of the farming community in adopting the agrometeorological reports for planning of their crops operations.

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My field of interest is climate change and impacts on the agricultural sector, due in part to my involvement in our national interagency on climate change (in which we are tasked to craft recommendations for policies addressing climate change). The monthly assessments of climate impacts on major crops production and the provision of seasonal climate forecast primarily for agriculture and water resource management are two of our main functions in our national meteorological and hydrological service. The value and importance of my participation in the International Workshop is immense in terms of the knowledge I have acquired in the course of my preparing my paper and the information-sharing and exchange of views during the workshop, and in the networking offered by the pool of expertise among the participants (as a number of the participants offered to share their resources).

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Russia has a huge area of agricultural land. Russia's main agricultural region extends from the Central district in European Russia, bordering Ukraine and Belarus, to western Siberia 3,000 miles to the east. Of the country's nearly 200 million hectares of agricultural land, roughly 120 million is planted to row crops (chiefly grains, annual or perennial forages, sunflowers, potatoes, and vegetables) or temporarily fallow. The remainder is devoted to permanent meadow or pasture. As a result Russian agriculture covers all kinds of continental climate zones from the Arctic, to the dry deserts of the south. Many of the largest risks and uncertainties to Russian agriculture arise from climate change and variability, and climate extremes such as heatwaves, winterkill from severe frosts and snow, floods, and large areas of severe drought. Cyclonic systems, heat waves and dust/thunderstorms, frosts. Coping with the range of climate variability and extremes is very important for crop and livestock production and yields. This will also affect coping strategies with climate warming which is likely to produce mixed effects – with more wild fires, droughts and floods as permafrost areas melt.

During the three day workshop, fruitful collaborative interaction was done with APN and other scientists. This identified beneficial coping strategies to reduce vulnerability to agriculture. To improve this many useful strategies were discussed included:

- Use of seasonal forecasts in agriculture, forestry, and land management with strategic relevance in respect to planning to help cope with drought, desertification and floods;
- Use of integrated agricultural management, crop simulation models and climate forecast systems to reap the highest benefit;
- Surface irrigation and steps to reduce excessive groundwater utilization, increased efficiency in the rainfed areas and crop diversification for efficient water use;
- Improved cultural/farming practices such as tillage, sequence of cropping, use of crop residues, appropriate soil and water management.

I am grateful to the organizers and especially APN, who assisted in my participation.

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I would like to APN again regarding the support of my attendance in the workshop. The conference discussed a large range of matters, and the diversified strategic issues applied in various countries are obviously interesting. Those could also support the confidence on our own strategic map developed for the National Meteorological and Hydrological Service during last few years. However, the achievement of the output and outcome in each country needs to be verified of its viability to the traditional agricultural folklore. We hope to learn and practice together with APN, the Commission for Agricultural Meteorology and its Members for our safety in the world.

4.0 Conclusions

The workshop brought together leading experts who presented 27 state-of-the-art discussion papers to address coping with agrometeorological risk and uncertainties and then developing strategies to cope with these risks. The organizers of the workshop ensured that there was sufficient discussion after each paper for participants to raised issues and provoke ideas for the recommendations. Participants were encouraged to come forward as discussants on topics of their interest to facilitate an interactive dialogue and develop appropriate recommendations that were captured by the recommendations session of the workshop. These recommendations and summaries of the discussions will be used by WMO and participants to guide WMO's Commission for Agricultural Meteorology during the next four years

In many parts of the world climate change and extreme climatic events such as severe droughts, floods, storms, tropical cyclones, heatwaves, freezes and extreme winds one of the biggest production risk and uncertainty factors impacting on agricultural systems performance and management. Coping with agrometeorological risk and uncertainties is the process of assessing agrometeorological risks and uncertainties and then developing strategies to cope with these risks. One of the most important coping strategies is improved use of climate knowledge and technology, which includes the development of

monitoring and response mechanisms to current weather and future climate change. These aspects directly address the main themes of the APN Capable Agenda. The project provided scientists from 11 APN emerging and developing countries, opportunity to interact with experts from different regions. Capacity building in the area of coping strategies for weather and climate risks contributes to sustainable agricultural development, especially in the Asia-Pacific region. The proceedings will be published as a special book during 2007.

Several conclusions emerged from the discussions. There are numerous risks in agriculture on which weather and climate and their extremes act. These and their extremes will impact on yield, production, prices (for example shortages due to drought), incomes, finances and often on institutions. As risk considers not only the potential level of harm, but also on the likelihood that such harm will occur. Therefore climate anomalies and extreme climatic events dominate in providing challenges for coping with agrometeorological risks and uncertainties. But risk has both natural and social components. Therefore, the risk associated with weather and climate for any area is a result of the region's exposure to the event, which is the probability of occurrence at various severity levels, and the vulnerability of society to the event.

Extreme poverty makes communities most risk averse. Farmers facing these circumstances often avoid activities that will entail significant risk, even though the production or income gains might be larger than for less risky choices. This inability to accept and manage risk and build up production or wealth is known as the "poverty trap". In most developing countries, livelihoods are not insured by international insurance or reinsurance providers, capital markets or often by governments. So without access to credit, risk averse farmers are locked in to poverty, often using old technology and faced with inefficiencies.

Agrometeorological risks and uncertainties permeate across the entire marketing system with far-reaching consequences. For example the El Nino/Southern Oscillation can produce drought in many food producing regions, and disrupt fisheries. The risk and occurrence of such an event often forces up prices for grain and livestock in many parts of the globe through feed shortages. This is just one of a vast array of risks and uncertainties that directly or indirectly impact the global agricultural marketing system.

Fortunately there are well established approaches to characterizing and managing risk, which includes risk scoping, risk characterization and evaluation, risk management and monitoring and review. This leads to preparedness planning with risk assessments, utilising early warning systems so that vulnerability to society can be greatly lessen weather and climate risks to society and communities. With effective risk management, management and policy changes between climate hazard events are used so that the risk associated with the next event is reduced. This is through the implementation of well formulated policies, plans and mitigation actions than have been utilized by farmers and others. Approaches include taking actions to reduce the likelihood of the risk event occurring, avoiding the risk, redistributing the risk and reducing the consequences. Actions can consist of enterprise diversification, contract hedging, having financial liquidity, use of crop yield insurance, crop revenue insurance and household off-farm employment or investment. Farmers have many choices for managing the risks they face so can use a combination of strategies and tools. Latterly weather derivatives and weather index insurance play a role in developing agricultural risk management strategies.

However, there are requirements for the management of these risks by farmers

and communities. There has to be an awareness that weather and climate extremes, their variability and climate change will impact on farm operations. This requires an understanding of weather and climate processes, including the causes of climate variability and change which can operate over large spatial scales. Part of this requires a good knowledge of weather extremes and climate variability in the location of farm operations, and analytical tools to describe these. Forecasting tools and early access to early warning and forecast conditions from hours to weeks give advance advice on the likelihood of extreme events and the seasonal climate anomalies. However, the farmer must have the ability to apply these forecasts and warnings in the decision making.

There are a range of risk coping strategies that can be utilised. Operational agrometeorological services provide a good source. These include:

- The use of seasonal climate forecasts in agriculture, forestry and land management with strategic relevance to national policy can be used to assist the alleviation of food shortages, and to cope with drought and desertification.
- The use of integrated agricultural management systems give the most benefit. These use climate forecast systems together with the simulation of crops. Pesticide application can be minimized with the knowledge of the interaction between meso- and microclimate, and the effects on the cycles of disease agents and prediction of climate effects.
- Improved water use efficiencies through surface irrigation, steps to reduce excessive groundwater utilization, increased efficiency in the rainfed areas and crop diversification
- Technological innovations
- The use of Integrated Pest Management systems that can reduce the amount of chemical use.
- Early warning systems for wildland fire can reduce the negative economic, social, and environmental impacts of uncontrolled wildland fire.
- Local indigenous knowledge which aid coping mechanisms of farmers to various environmental and natural challenges
- Improved cultural and farming practices such as tillage, sequence of cropping, use of crop residues, suitable soil and water management
- Optional use of resources such as crop and variety diversification

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Meinke, H., and Stone, R.C.: 2005 'Seasonal and interannual climate forecasting: The new tool for increasing preparedness to climate variability and change in planning operations', *Climatic Change* 70, 221-253.

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Wilhite, D.A., 2005, 'The role of disaster preparedness in national planning with specific reference to droughts', in Sivakumar, M.V.K., Motha, R.P and Das, H.P. (eds) *Natural disasters and extreme events in agriculture*, springer-Verlag, Berlin, 23-38.

Appendix 1 Programme

INTERNATIONAL WORKSHOP ON AGROMETEOROLOGICAL RISK MANAGEMENT: CHALLENGES AND OPPORTUNITIES New Delhi, India, 25 - 27 October 2006

PROGRAMME

WEDNESDAY, 25 OCTOBER 2006

08:30-09:30 hrs Registration at the Vigyan Bhavan, New Delhi

SESSION 1

OPENING OF THE WORKSHOP (Chairman: B. Nyenzi)

- 09:30 hrs Welcome
Sanjiv Nair
Joint Secretary, Department of Science and Technology
Government of India and
Permanent Representative of India with WMO
- 09:35 hrs Welcome from Convenors
R. P. Motha
President
Commission for Agricultural Meteorology
World Meteorological Organization
- M.V.K. Sivakumar*
Chief
Agricultural Meteorology Division
World Climate Programme Department
World Meteorological Organization
- 09:45 hrs Welcome from co-sponsors
- M. Salinger*, APN
R. Gommès, FAO
E. Cloppet, Météo-France
I. Barry, UK Met Office
R. P. Motha, USDA
- 10:10 hrs Address
P.S. Goel
Secretary, Ministry of Earth Sciences
Government of India
- 10:10 hrs Workshop opening
H.E. Sharad Pawar
Honourable Minister of Agriculture
Government of India
- 10:25 hrs Presentation of MAUSAM awards of India Meteorological Department
- 10:55 hrs Group Photo and Tea/Coffee Break

SESSION 2 Weather And Climate Risks, Preparedness And Coping Strategies: Overview

(Chairman: M.V.K. Sivakumar Rapporteur: A. Züst)

11:25 hrs **Extreme weather and climate events and farming risks**
John Hay, John Hay and Associates, North Shore City, New Zealand

12:05 hrs **Preparedness and coping strategies for agrometeorological drought risk management: Recent progress and trends**
Don Wilhite, University of Nebraska, Lincoln, USA

12:45 hrs Discussion

12:55 hrs Lunch

SESSION 3 Challenges to coping strategies with agrometeorological risks and uncertainties - regional perspectives
(Chairman: *R. Mehta* Rapporteur: *V. Radhakrishna Murthy*)

14:10 hrs **Challenges to coping strategies with agrometeorological risks and uncertainties in Africa**
Adams Chavula, Meteorological Services, Chileka, Malawi
Elijah Mukhala, SADC Secretariat, Gaborone, Botswana

14:50 hrs **Challenges to coping strategies with agrometeorological risks and uncertainties in Asian regions**
L. S. Rathore, National Centre for Medium Range Weather Forecasting (NCMWRF), New Delhi, India and
C.J. Stigter, Agromet Vision & INSAM, Bruchem, Netherlands

15:30 hrs **Challenges to coping strategies with agrometeorological risks and uncertainties in South America**
C. Alarcon, Servicio Nacional de Meteorología e Hidrología (SENAMHI), Lima, Peru

16:00 hrs Tea/Coffee Break

16:30 hrs **Agrometeorological risks and coping strategies: Perspectives from the Indian Subcontinent**
N. Chattopadhyay and B. Lal, Indian Meteorological Department

17:10 hrs **Challenges to coping strategies in agrometeorology: The South-West Pacific**
J. Salinger, National Institute of Water & Atmospheric Research Ltd. (NIWA), Auckland, New Zealand

17:50 hrs General Discussion

18:00 hrs Adjournment

THURSDAY, 26 OCTOBER 2006

SESSION 3 Challenges to coping strategies with agrometeorological risk and uncertainties - regional perspectives (contd.)
(Chairman: *R. Metha* Rapporteur: *V. Radhakrishna Murthy*)

08:30 hrs **Challenges to coping strategies with agrometeorological risks and uncertainties in Europe**
Andreja Sušnik, Environmental Agency, Ljubljana, Slovenia
Lučka Kajfež Bogataj, University of Ljubljana, Ljubljana, Slovenia

09:10 hrs General Discussion

SESSION 4 Agrometeorological risks and uncertainties – perspectives for farm applications

(Chairman: R. Motha

Rapporteur: F. Abdo)

09:40 hrs **Weather and climate and optimization of farm technologies at different input levels**

Josef Eitzinger, University of Vienna, Vienna, Austria

A. Utset, M. Trnka, Z. Zalud, M. Nikolaev, and I. Uskov

10:20 hrs Tea/Coffee Break

10:50 hrs **Complying with farmers' conditions and needs using new weather and climate information approaches and technologies**

C.J. Stigter, Agromet Vision & INSAM, Bruchem, Netherlands

Tan Ying, China Agricultural University, Beijing, China

H.P. Das, India Meteorological Department, Pune, India

Zheng Dawei, China Agricultural University, Beijing, China

R.E. Rivero Vega, Meteorological Center of Camagüey Province, Camagüey, Cuba

Nguyen van Viet, Institute of Meteorology and Hydrology, Hanoi, Viet Nam

N.I. Bakheit, Abu Naama, Sinnar University, Sinnar and Khartoum, Sudan

Y.M. Abdullahi, Ahmadu Bello University, Zaria, Nigeria

11:30 hrs **Information technology and decision support systems for on-farm applications to cope effectively with agrometeorological risks and uncertainties**

Byong Lee, National Center for Agrometeorology, Suwan, Republic of Korea

12:00 hrs Discussion

12:10 hrs Lunch

13:30 hrs **Methods of evaluating agrometeorological risks and uncertainties for estimating global agricultural supply and demand**

G. Bange and K. Menzie, World Agricultural Outlook Board

United States Department of Agriculture (USDA), Washington, USA

14:10 hrs General Discussion

SESSION 5 Coping Strategies with Agrometeorological Risks and Uncertainties

(Chairman: J. Salinger

Rapporteur: Nguyen Van Viet)

14:40 hrs **Crop yield, including the use of multiple cropping**

Lourdes Tibig, Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA), Manila, Philippines

Felino Lansigan, University of the Philippines, Los Banos, Philippines

15:20 hrs Tea/Coffee Break

- 15:50 hrs **Water Management in a semi-arid reigme: An analogue algorithm approach for rainfall seasonal forecasting**
G. Maracchi, M. Pasqui, and F. Piani, Institute of Biometeorology (IBIMET), Florence, Italy
- 16:30 hrs **Water management and water use efficiency**
Y. Ramakrishna and GGSN Rao, Central Research Institute for Dryland Agriculture (CRIDA), Hyderabad, India
- 17:10 hrs Adjournment

18:00 – 20:00 hrs

**Weather Risk Insurance for Agriculture - A Special Symposium
(Presided by Mr P. Chidambaram, Finance Minister of India)**

- 18:00 hrs **Welcome**
M.V.K. Sivakumar, WMO, Geneva, Switzerland
- 18:10 hrs **Inaugural Address**
P. Chidambaram
Finance Minister of India
- 18:25 hrs **Scientific and Economic Rationale for Weather Risk Insurance for Agriculture**
Peter Hoeppe, Munich Reinsurance Company AG, Munich, Germany
- 18:45 hrs **Weather Derivatives for coping with Risks to Agricultural Production**
U. Hess, The World Food Programme, Rome, Italy
- 19:05 hrs **Weather Risk Insurance for coping with Risks to Agricultural Production**
Pranav Prashad, ICICI Lombard Bank, Mumbai, India
- 19:25 hrs General Discussion
- 19:55 hrs **Closing Remarks**
B. Nyenzi, WMO, Geneva, Switzerland
- 20:00 hrs Adjournment

THURSDAY, 27 OCTOBER 2006

SESSION 5 Coping Strategies with Agrometeorological Risks and Uncertainties (contd.)

(Chairman: H. Abdalla Rapporteur:G. Srinivasan)

- 08:30 hrs **Examples of coping strategies with agrometeorological risks and uncertainties for integrated pest management**
A.K. S. Huda, University of Western Sydney, Penrith South, Australia
T. Hind-Lanoiselet, C. Derry, G. Murray, and R.N. Spooner-Hart
- 09:10 hrs **Coping strategies with agrometeorological risks and uncertainties for drought: Examples from Brazil**
O. Brunini, Center of Ecology and Biophysics, Sao Paulo, Brazil;
Y.M.T. Da Anunciacao, L.T.G. Fortes, P.L. Abramides, G.C. Blain, A.P.C. Brunini, and J.P. de Carvalho

- 09:50 hrs **Coping Strategies with desertification in China**
Wang Shili, Ma Yuping, HouQiong Wang Yinshun, China
 Meteorological Administration, Beijing, China
- 10:30 hrs Tea/Coffee Break
- 11:00 hrs **Coping strategies with agrometeorological risks and uncertainties for water erosion, runoff and soil loss**
P. Doraiswamy and E.R. Hunt, United States Department of Agriculture-Agricultural Research Service (USDA-ARS), Beltsville, Maryland, USA
V.R.K. Murthy, AP Agricultural University, Hyderabad, India
- 11:40 hrs **Developing a Global Early Warning System for Wildland Fire**
Michael Brady, Natural Resources, Ottawa, Canada
W.J. de Groot, J. G. Goldammer, T. Keenan, T. Lynham, and K. O'Loughlin
- 12:20 hrs Lunch
- 13:30 hrs General Discussion
- SESSION 6 Coping with Agrometeorological Risks and Uncertainties – Policies and Services**
(Chairman: Q. Chaudhry Rapporteur: L. Tibig)
- 14:00 hrs **Contingency planning as a case study of coping with agrometeorological risks and uncertainties**
Roger Stone and Holger Meinke
 Queensland Department of Primary Industries, Brisbane, Australia
- 14:40 hrs **Using simulation modelling as a policy option in coping with agrometeorological risks and uncertainties**
S. Orlandini, University of Florence, Florence, Italy
- 15:20 hrs **Agrometeorological services to cope with risks and uncertainties**
Ray Motha, United States Department of Agriculture (USDA), Washington, USA
V.R.K. Murthy, AP Agricultural University, Hyderabad, India
- 16:00 hrs Tea/Coffee Break
- SESSION 7 WORKSHOP RECOMMENDATIONS**
- 16:30 hrs **Agrometeorological Risk Management: workshop summary and recommendations**
M.V.K. Sivakumar, WMO, Geneva, Switzerland
R. P. Motha, U.S. Department of Agriculture, Washington DC, USA
- 17:00 hrs Discussion
- SESSION 8 WORKSHOP CLOSURE**
- 17:30 hrs **Vote of Thanks on behalf of Co-convenors**
M.V.K. Sivakumar, WMO, Geneva, Switzerland

17:40 hrs **Vote of Thanks from Host Country**
G. Srinivasan, Department of Science and Technology (DST), New
Delhi, India

17:50 hrs **Workshop closure**
H.E. Kapil Sibal
Honourable Minister of Science and Technology
Government of India

Appendix 2 List of participants supported by APN

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Appendix 3 Funding sources outside APN

Co-Funding	(US \$)
Bureau of Meteorology (Australia)	10,000
Food and Agricultural Organisation (FAO)	10,000
Meteo-France	4,000
Technical Centre for Rural and Agricultural Cooperation (CTA)	20,000
United States Department of Agriculture (USDA)	20,000
World Meteorological Organization (WMO)	75,000

In-kind Support

Host Country India

India Meteorological Department, and Ministry of Science and Technology and Earth Sciences

- (i) Provision of conference facilities including a large hall for the opening Session by the Government of India, a smaller hall for the different sessions of the workshop, a large hall for poster display and a large lobby area for tea/coffee and lunches
- (ii) Provision of transport facility between the hotels to workshop venue
- (iii) Workshop dinner on the first day

New Zealand, National Institute of Water and Atmospheric Research (NIWA)

- (i) Provision of scientists time and expertise in preparation of workshop programme, abstracts and arrangement of sessions in collaboration with WMO
- (ii) Assistance with arrangements to bring participants from countries to the workshop from the Asia-Pacific region.

Appendix 4 Workshop Paper Summaries

Opening of the Workshop

The International Workshop on Agrometeorological Risk Management: Challenges and Opportunities was held in New Delhi, India from 25 to 27 October 2006. The workshop brought together experts from around the world to discuss and develop the various aspects of agrometeorological risk management. One hundred and eighty-eight participants from seventy-eight countries attended the workshop (Annex 1).

Dr Sanjiv Nair, Joint Secretary, Department of Science and Technology of the Government of India and the Permanent Representative of India with WMO gave some welcoming remarks. Then Dr Motha, the President of the Commission of Agricultural Meteorology, welcomed all of the participants to New Delhi and thanked them for participating in the workshop. In many parts of the world climate change and extreme climatic events such as severe droughts, floods, storms, tropical cyclones, heat-waves, freezes and extreme winds are one of the biggest production risk and uncertainty factors impacting agricultural systems performance and management. He added that coping with agrometeorological risk and uncertainties is the process of assessing agrometeorological risks and uncertainties and then developing strategies to cope with these risks. To address these issues, this workshop was organized by WMO, in collaboration with a number of co-sponsors including the Asia Pacific Network for Global Change Research (APN), the Bureau of Meteorology (Australia), the Technical Centre for Rural and Agricultural Cooperation (CTA), the Food and Agricultural Organization (FAO), Meteo-France, the United Kingdom Meteorological Office and the United States Department of Agriculture (USDA).

Dr. Sivakumar, on behalf of the Secretary-General of WMO, welcomed the participants to the workshop and wished them a success meeting. The workshop will focus on the providing regional and national perspectives on coping strategies to deal with agrometeorological risks and uncertainties. These strategies include the use of seasonal forecasts in agriculture, forestry and land management to assist alleviation of food shortages, drought and desertification. And there are strategies to improve water management and increase the efficient use of water included crop diversification and better irrigation. Especially important was the application of local indigenous knowledge.

Next, representatives from the various co-sponsors in attendance gave brief comments. These representatives included: M. Salinger from APN, E. Cloppet, from Météo-France, I. Barry, from the UK Met Office, and R. Motha from the USDA.

The main opening addresses were given by P.S. Goel, Secretary of the Ministry of Earth Sciences, Government of India, and H.E. Sharad Pawar, the Honourable Minister of Agriculture of the Government of India. They stressed that the theme of this workshop on risk and uncertainty was very timely especially related to weather and climate events and agricultural production, and officially opened the workshop.

Session 2: Weather And Climate Risks, Preparedness And Coping Strategies: Overview

Dr. Hay: "Extreme weather and climate events and farming risks".

The risk based approach was needed to help managing of consequences of extreme weather events and climatic anomalies. The presentation focused on agriculture production risk and he discussed the detailed risk characterization procedure and provided several practical examples (return periods for extreme daily

rainfall, maximum temperature, and wind gusts for the area of New Delhi. The projection of risk level in the future in view of climate change was given. Several practical examples such changes in dry index and changes in grain yield for India. The paper emphasized risk management and several requirements and strategies.

Dr. Wilhite: "Preparedness and coping strategies for agrometeorological drought risk management: Recent progress and trends."

Drought risk management is necessary to understand natural and societal dimensions of drought. Several Decision Support tools were described for drought risk management which were developed by US DMC. One characteristic of these tools is the timely delivery of information via Internet. Practical examples include the US Drought monitor to assess spatial extent of drought, decision support system for decision makers, the drought impact reporter for assessment of economic losses and environmental impact, the Drought Risk Atlas, the vegetation drought response index and the National Integrated drought monitoring system.

Session 3: Challenges to coping strategies with agrometeorological risks and uncertainties - regional perspectives

Dr. Mukhala: "Challenges to coping strategies with agrometeorological risks and uncertainties in Africa".

African agriculture is influenced by unimodal and bimodal rainfall distributions. The sub-Saharan region has 90 percent land under rainfed and 10 percent under irrigated agriculture. The climate variability and change influence food security due to production uncertainty. Also, large variability of rainfall influences crop prospects by inducing negative impacts on the GDP (which is 25 percent of the national turnover) and 70 percent of work force that depend on agriculture. Few climate information supply centers like universities and international institutions provide weather data from areas which are recognized as natural disaster risk high spots. Even with these existing limitations, seasonal forecasting is done for the benefit of farmers through some pilot projects initiated by the international organizations (USAID-IRI) attempts are being made to issue tailored seasonal forecast in decision-making by the farmers. In order to address intra-seasonal variability, some on-farm coping strategies like crop diversification, rain harvesting, finish land preparation well before rain begins etc., are suggested. Weather-based crop insurance may reduce poverty. However, necessary precautions to fill the gaps in availability of climate data have to be initiated. He described certain tools, methodologies, etc., which are useful for taking decisions on what, when, and where to plant prior to sowing need to be developed. There is a need for inter and intra institutional cooperation and that available tools and methodologies coupled with a holistic approach is required to achieve a solution to the farmers' problems.

Dr. Rathore: "Challenges to coping strategies with agrometeorological risks and uncertainties in Asian regions".

It is critical to examine the possibility of blending different coping strategies with preparedness for every risk that the region faces. The risks identified are the short term extreme events like high intensity rainfall and floods, tropical storms, tornadoes, and strong winds, extreme temperatures including heat and cold waves, droughts, and wild and bush fires. Also, the key challenge is how to combine these strategies and face a combination of risks and arrive at an effective tool. In the region the emergency relief response strategies require the planners to determine the probability of occurrence of these risks and disasters at first instance and immediately evolve effective mechanisms like identifying activities and sub-activities, define the level of response, specify authorities, determine the response

kind, workout individual activity plans, have greater response teams, undergo preparedness drills, provide appropriate delegations and have alternative plans. He stressed that these mechanisms have to be organized identically but must have different contents for each type of disaster. The cyclone preparedness strategies followed by Indian villages that include livelihood-focused support, preparation perspectives, and community perspectives are classical examples in reducing adverse effects of risks and disasters in India and should be followed by other Asian countries. Preparedness strategies must be identified and listed with serious concern by taking local, federal, and international support by the respective governments and/or NGOs (local level) and these actions must be supported by the other higher authorities. The Indian Agromet Advisory Service (AAS) of National Centre for Medium Range Weather Forecasting (NCMRWF) and is a successful methodology for preparedness in India.

Mr. Alarcon: "Challenges to coping strategies with agrometeorological risks and uncertainties in South America".

This paper concentrated on natural phenomena that affect agriculture and on the role of NMHSs in disaster risk reduction in South America. Like other regions in the world, the climate is a natural resource that also affects the agrarian production in South America. El Nino affects agriculture, the provision of potable water, the generations of energy, the communication infrastructure, etc. El Nino events are occurring more frequently in recent years and the areas affected and experiencing agrometeorological risks include most countries in South America. In the region, 80 percent of the natural disasters and 30 percent of deaths are hydrometeorologically related. Natural phenomena that affect agriculture in South Latin America include volcanic eruptions, global climate changes, floods, droughts, and strong winds. At the farmer's level certain tools for prevention and mitigation could significant improvements such as proper land use, selection of correct seed, and efficient use of irrigation water. Tthe following coping strategies are suggested for the implementation in region: implement and operate early warning systems; elaborate the national and regional levels of territorial vulnerability; improve water-use efficiency; implement pursuit systems by means of environmental indicators; support programmes of biodiversity and desertification; and develop systems of information and their applications to land use classification. To improve early warnings, there is an increasing need to generate scenarios of sectoral risk and to connect the systems of early warning with the government level of planning.

Dr. Chattopadhyay "Agrometeorological risks and coping strategies: Perspectives from the Indian Subcontinent".

Several recent natural disasters in India were described. Climatological data helps in the advance preparation of long-range policies and programmes for disaster prevention. The prevention of formation of tropical cyclones is not in the realm of possibility, but much of their disastrous potential can be reduced. The Government of India is concerned about improving the agricultural economy of the country irrespective of the existing status of infrastructure in a given area and to a certain extent, irrespective of the vagaries of weather too. More inputs would be required for more vulnerable areas if development were to be carried out in a balanced manner across India and all the existing services must be geared for that purpose. Agroclimatic analyses can help in selection of crops and cropping practices such by matching their weather requirements with seasonal phenological events, endemic periods of pests, diseases and hazardous weather can be avoided. Environmental planning is necessary to avoid or mitigate losses from disasters and by using such instruments as land-use planning and disaster management. Natural disaster reduction measures are in place in a significant number of the nations surveyed and that ongoing research and development to improve and expand these measures are also a feature of many national strategies to minimize the adverse effects of extreme events in agriculture.

Dr. Salinger: "Challenges to coping strategies in agrometeorology: The South-West Pacific".

This region is vulnerable to El Niño Southern Oscillation (ENSO) events and farmers are always suffering from droughts, warmer and cooler climates, and floods due to these events. The climate system in this region provides a large source of inter-annual to multi-decadal fluctuations beneath a theme of regional climate warming and that this situation provides challenges to coping strategies for agrometeorology including crop yields and quality, water management, soil salinity, water erosion, and runoff. Large-scale destruction to crops and infrastructure through high intensity rainfall and severe winds are caused by tropical cyclones that are one of the most devastating risks for agrometeorology on the small island developing states (SIDS). Even though the warning systems predict the cyclone tracks in advance, currently little can be done to protect crops and agriculture from the full impacts of extreme rainfall and hurricane force winds. The Interdecadal Pacific Oscillation (IPO) is also an important source of multidecadal climate fluctuations and can cause shifts in the mean climate state (temperature and rainfall) but has little threat to agrometeorological coping strategies. Global warming will have more immediate concern in the region and in New Zealand and Australia coping strategies are more sophisticated and involve both structural and non-structural measures to reduce the impacts of change on crop and livestock production. The greatest challenge associated with any warming above 2°C will be additional stresses like droughts, the potential increase and spread of pests and diseases. The warming also will pose additional problems and threats like further strengthened tropical cyclones (higher wind speeds and high intensity rainfall) especially in the SIDS.

Dr. Kajfež Bogataj: "Challenges to coping strategies with agrometeorological risks and uncertainties in Europe".

Some characteristics of European agriculture and what has to be done to cope with agrometeorological risks in the region were presented. Europe is one of the world's largest and most productive suppliers of food and fibre with high agricultural productivity. There are several changes in agriculture in the region due to significant changes in land ownership structure, high fragmentation of land, inadequate compensation schemes, and socio-economic factors. In Europe, the soil is threatened by erosion, water stress is increasing, water is polluted from agriculture and it is generally perceived across the region that prevention is cheaper than cleanup. Agricultural meteorology is not in a favorable position. The drivers of the European agriculture in the next decades will be the growing demand for safe and quality food, growing awareness for nutrition issues and healthy food, increased demand for renewable energy, and increased demand for biodegradable paper, fibre, and polymers. Europe needs the following especially in response to the 2003 heatwave: improved agrometeorological services for coping with drought, climate change, protecting the environment and biodiversity and for ensuring sustainable development; better mitigation and adaptation to the adverse effects of climate variability and climate change; and better recognition that drought is becoming a "normal" feature of many natural, economic, and soil environments.

Session 4: Agrometeorological risks and uncertainties – perspectives for farm applications

Dr. Eitzinger: "Weather and climate and optimization of farm technologies at different input levels".

Optimization of farm technologies interacts with complex factors and has to consider sustainability of crop production. Beyond the other functions, farm technology has to deal with the effective management of the main resources of agricultural production, which is soil, water, crop, and crop microclimate. There is

a strong demand in high and low input systems for optimized farm technologies in order to better manage natural resources and increase productivity of farming due to ongoing climate change and variability decreasing agricultural land and soil resources and increasing food demand in developing countries. There are many technologies available but care has to be taken for technology transfer, which should consider the farmers' socio-economic situation, knowledge and infrastructure, etc. Costly technology is appropriate for high input farming but for low input farming, traditional technologies should be considered, adapted or combined with new low cost technologies, with limiting the risk of implementation by external support.

Dr. Stigter: "Complying with farmers' conditions and needs using new weather and climate information approaches and technologies."

There are four policy issues to be used to differentiate between income groups of farmers with respect to services: mitigation practices; disaster preparedness; contingency planning and responses; disaster risk mainstreaming. There are difficulties found with policy options for structural preparedness for and rehabilitation from climate disasters, such as in well-selected agrometeorological services for such purposes, that are also common to recent tsunami disaster in Indonesia. Some studies from China indicate that rural people are heterogeneous in their education, income, occupation, and information demands. This diversity has not been genuinely identified, and their detailed priority information demands have not been properly revealed. Although information service systems have been shaped and established, the scientific and technological requirements of investigated farmer household have not been met yet. Studies from China indicate that traditional modes of information flow and communication skill occupy the main position. This is confirmed for many other developing countries. Therefore one must first discuss information demands in general and differentiated information demand and supply situations as well as information channels for four different income groups distinguished and the general implications of these findings for each group. the implications of these findings for information approaches and technologies with respect to these groups in China. Experiences from other developing countries are explained and stressed that WMO/CAGM should realize the above implications for the future of weather and climate information approaches and technologies in agriculture production.

Dr. Lee: "Information technology and decision support systems for on-farm applications to cope effectively with agrometeorological risks and uncertainties."

The risk and uncertainty in agriculture that includes hydrometeorological, geological, and biological hazards and along with environmental degradation was discussed. Some of the major gaps of decision-making support systems (DMSSs) as the following: data gaps, not learning from past hazards, inadequate access to information, insufficient multi-disciplinary and multi-agency coordination, inadequate communication systems, underdeveloped dissemination infrastructure and systems, and ineffective engagement of the media. The current phase of the World Agrometeorological Information Service (WAMIS) is a Web Portal and the proposed next phase of WAMIS is a GRID Portal. The AMBER model was described. Efforts should be made on data management systems and obtaining systematic environmental data for vulnerability analysis. There is a need for development of standards, protocols and procedures for exchange of data, bulletins, alerts, etc. for some of the hazards. The use new information and communication technologies in disseminating warnings are a useful advance for expanding the coverage and reducing time lags in warning dissemination. Sharing of resources between associated authorities and farming communities is necessary under limited resource.

Dr. Menzie: "Challenges to coping strategies with agrometeorological risks and uncertainties in South America".

Risk and uncertainty affects every aspect of the agricultural commodity marketing system – from producers to the final consumer. Weather-related yield and price risk translates into income risk in agricultural markets around the world. Accurate, timely, consistent, objective, and widely available information including analysis of the impacts of weather on crop production is required for economic enterprises to make optimal business decisions. Some of the methods used at USDA to assess impacts of weather-related risk and uncertainty on global crop production is a first step toward estimating global supply and demand for commodities. More timely and accurate estimates result when multiple agrometeorological analytical techniques are employed to evaluate the impact of seasonal weather conditions on crops. Employing such techniques leads to more efficient markets and improves business enterprise decision-making at all levels of the marketing chain.

Session 5: Coping Strategies with Agrometeorological Risks and Uncertainties

Dr. Tibig: "Coping Strategies with Agrometeorological Risks and Uncertainties for Crop Yield."

Several strategies that started with the use of optimal and sustainable use of resources were discussed. One example of this is through crop diversification that matches the physiological requirements of crops with specific micro-environment; meets domestic consumption requirements, can reduce income risk; and improve aggregate production. Another strategy is the change in cultural practices/improved farming practices that can provide adjustments in agricultural inputs; integrate crops with trees/aquaculture/ livestock; and use of farming systems like organic/precision farming. The strategy of modifying resource potential, including controlled micro-climates through field afforestation (windbreaks) and changes in the location of crops was described. Local indigenous knowledge systems/networks are another strategy that use farmer-developed techniques developed from years of observations, experiments and experiences. Access to extension services permits adapting cropping systems to a wider range of climatic regions. A few technological innovations include direct rice seeding, raised cropping beds (as used in Pakistan and India) and integrated weed management. Specific examples of coping strategies in Canada, United States, Peru, Bolivia, Senegal, Uganda, and several countries in Asia were discussed. Some strategies from the Philippines including crop rotation can be used to suppress weeds, pathogens and insect pests; using cover crops in orchards/vineyards that can buffer the system against pest infestations by increasing beneficial insect populations; and using pest-resistant crops when chosen carefully are tolerant of existing soil and site conditions.

Dr Maracchi : by Dr. Orlandini) "Water Management in a semi-arid region: An analogue algorithm approach for rainfall seasonal forecasting."

This paper is based on recent research in seasonal forecasting methods for West Africa (Sahel) based on new insights into the physical mechanisms of the African Monsoon and the role of sea-surface temperature (SSTs) in precipitation. The forecasting system uses standardized anomalies (SSTA) obtained by subtracting the 1979-2003 SST average and division by 1979-2003 SST standard deviation. The standardized change rates are used to determine the difference between current and previous standardized SSTA for the considered month. Several related activities about in this work includes the setting up a map server-based data dissemination tool for end-users (<http://www.ibimet.cnr.it/Case/sahel/>) which can allow browsing of available maps. He also stated that simple extraction of data will be available for end-users applications in agrometeorology, risk management, and hydrology and that spatial downscaling techniques have been developed. The improvement of

seasonal forecasts in the Sahel region, especially for agrometeorological applications, should include a full comprehension of physical mechanism and the present spatial resolution should be improved in order to obtain a useful geographical information input for agrometeorological models.

Dr. Ramakrishna "Water management and water use efficiency."

India's share of various global resources is the following: 16% of world's human resources, 2.5% of land, 4 % of the water, and 15% of livestock. In India, despite a large area under irrigation, stress during crop growth is unavoidable. Several water management related problems in rainfed areas include extreme spatial and temporal variability in rainfall and evaporative demand is higher than rainfall during greater part of the year. The evolution of watershed concept in India from a topdown approach with a bio-physical emphasis in the 1980s to a participatory approach with bio-physical and socio-economic aspects in the 1990s to a livelihoods approach with an integrated watershed in 2000. Integrated watershed management strategies such as efficient management of natural resources; coordination of policies, programmes and activities; promotion of community participation, and sustainable rural livelihoods are important. Components of rainwater management in rainfed areas include: *in-situ* conservation (off-season land treatment, conservation furrows, ridges and furrows system, cover cropping, micro-catchments, i.e.); grade line bunds; drainage line treatments; water harvesting; and groundwater recharge. Issues of participatory ground water evaluation include policy and social implications leading to efficient water management, the supply and demand of groundwater and their associated management strategies, and finally the issue of climate change.

Dr. Huda: "Examples of coping strategies with agrometeorological risks and uncertainties for integrated pest management."

An overview of the Australian climate and impact of its highly variable climate on industries, businesses and communities due to drought, storms and floods was given. The two climate-sensitive diseases of Australian crops of stripe rust of wheat and Sclerotinia rot of canola cause large economic losses. Farmers use climate information to assist with many decisions such as crop choice, choice of cultivar, fertilizer use, and irrigation scheduling. The indiscriminate use of pesticides is one major concern since it leads to resistance to pesticides and environmental pollution. One strategy to reduce the severity of pest and disease damage through reduce pesticide use is through Integrated Pest Management (IPM). Weather based pest / disease forecasting models can help provide advance information for need based crop protection by farmers and is a part of the broader IPM strategy. Various controls include predictive models, and trial results on Sclerotinia rot of canola. In deciding pest management strategy the specific disease, economics of application, and environmental impacts before applying fungicides and investigate other methods of control must be considered. Various frameworks related to climate/ weather and disease risks and the risk management cycle include policy - related strategies, aspects of managing crop diseases, needing collaborative approaches, reducing pesticide application, understanding the various macro and microclimates of disease and climate change effects on crop diseases.

Dr. Brunini: "Coping strategies with agrometeorological risks and uncertainties for drought: Examples from Brazil."

Various aspects of the Brazilian climate and the agrometeorology advisory system in the Brazilian state of Sao Paulo were described. This system uses several methodologies to assess precipitation anomaly and drought including meteorological indices such as the standardized precipitation index (SPI), Palmer Drought Severity Index adapted to the state of São Paulo, and the decile and quantile method. Agrometeorological indices include the actual evapotranspiration

standardized index (IPER), the Crop Moisture Index (CMI), crop development as a function of soil moisture, and soil water supply conditions and water stress on a crop. The IPER index developed used is based on the SPI methodology. It begins with the adjustment of the beta probability density function to the series of water balance in a ten days step and then cumulative probability of a given estimated value for ETR is calculated. The meteorological aspects of drought monitoring and prediction and agrometeorological aspects of drought in Brazil were discussed. Drought mitigation measures are not necessarily identical and must take into consideration the cultural aspects of the population, the climate regime, and the agricultural exploitation. The various indices have proven to be adequate for monitoring and mitigating the effects of drought, nevertheless, adjustments are necessary for the use of these indices for each region and crop. The drought phenomenon cannot be assessed and interpreted by only one field of expertise, but rather by a set of specialists and institutions. Furthermore, it is extremely important that researchers and specialist in the areas of agronomy, agrometeorology, meteorology, civil defense, agro extension service, and others, should be involved in the study of the drought phenomenon.

Dr. Wang: "Coping Strategies with desertification in China."

An overview of the issue of desertification in China was given which stressed that serious desertification has been threatening ecological security and sustainable socio-economic development in China. In 2004, the amount of land desertification in China was 27 percent across 18 provinces; the distribution of these lands can be specified by climate, type, and degree. The amount land desertification has very slightly decreased mainly due to reductions in land due to wind and water desertification. Wind erosion as the main factor affecting desertification in Northern China, with the various human activities can contribute to it: overgrazing, excess reclamation, excess firewood gathering, and irrational use of water resource. An overview of the desertification monitoring in China was given where national desertification surveys were carried out in 1994, 1999 and 2004. China monitors desertification at the national, provincial, and local level and there are various Chinese programs and practical aspects for converting cropland to forest/shrubbery, combating desertification, constructing shelterbelts, research on desertification development and combating in terms of meteorological conditions, monitoring to combating desertification of grassland, and the monitoring and predicting of dust storm in China. Global climate warming, and frequent and severe drought are existing facts, and future climate change will continue to influence desertification. There are still various human-driving factors leading to deteriorating vegetation in desert areas and the research on relationships between climate and occurrence, development of desertification as well as combating countermeasures should be carried out.

Dr. Brady: "Developing a Global Early Warning System for Wildland Fire."

An overview of wildfire causes such as land-use fires, carelessness, arson, and natural wildfire was given. Some uncontrolled fires become large disastrous events that have large negative economic, social, and environmental impacts. The objectives of this project include developing an global early warning system (EWS) for predictions of up to 10 days of wildland fire danger; developing an information network to quickly disseminate these warnings to global to local communities; developing an historical record of regional and global fire danger information; designing and implementing a technology transfer program for global, regional, national, and local community applications. Fire danger is a general term used to describe conditions of the fire environment and fire danger rating as an assessment of the potential for a fire to start, spread and do damage. The operational implementation for a global EWS include: development of procedures within WMO's World Weather Watch to run the early warning system on a daily operational basis; analyze and produce fire danger assessments; analyze and produce forecasted fire

danger; disseminate early warning information through multiple channels; establish procedures with operating services to maintain and update the System as new tools and products are developed. The impacts of an EWS will provide local communities with an opportunity to mitigate fire damage by assessing the possibility of extreme behaviour and enabling appropriate fire prevention, detection, preparedness, and fire response plans, provide a globally robust operational early warning framework that will provide the foundation to build resource-sharing agreements between nations during times of extreme fire danger, and to develop local expertise and capacity building in wildland fire management for system sustainability through technology transfer and training. EWS case studies in Canada and Southeast Asia were described.

Special Session: Weather Risk Insurance for Agriculture - A Special Symposium

Dr. Sivakumar gave the welcome remarks for this session and reviewed the objectives of this workshop. Agriculture is the most weather-dependent sector, rainfed farming remains a risky business, natural disasters have a devastating effect on agricultural production, and extreme climate variability carries multi-dimensional impacts. Disaster risk management involves a wide range of decisions and actions and for the need for partnerships and coordination among different players (private, public, academia) involved in disaster and climate risk management. The WMO and NMHS have a role in assessing agrometeorological risks.

Mr. Hoeppe: "Scientific and Economic Rationale for Weather Risk Insurance for Agriculture."

A brief overview of Munich Re which is involved in underwriting wide range agricultural businesses including crops, hail, Multi-peril and named perils, livestock, aquaculture, and greenhouses, was given. There are several examples of increasing trends in natural disasters across the world and in India. Insurance and re-insurance companies have taken the scientific evidence of a link between global warming and tropical storms more seriously after recent increase of the number hurricanes in the North Atlantic. Several companies are working on SST and hurricane models to assess the risks. He then discussed some crop insurance products that include loss insurance (hail and named peril); yield guarantee insurance (based on regional average yield or individual historic yields); index insurance (meteorological triggers, area yield triggers, vegetation indices) and revenue insurance (covers yield and price elements for crops traded in existing commodity markets). Special circumstances exist in emerging markets such as dual agricultural structures, limited financial means of the government to support agricultural insurance programs, lack of insurance tradition and difficult access to insured farms. The Munich Climate Insurance Initiative (MCII) was discussed. Weather related catastrophes like storms, floods and droughts are increasing worldwide and that there is increasing evidence that global warming increases the hazard situation. Agriculture is especially vulnerable to the changing weather patterns and that proper insurance systems can help farmers to cope with the increasing volatility of their losses.

Mr. Hess: "Weather Derivatives for coping with Risks to Agricultural Production."

Weather insurance products are needed because they provide growth (access to finance, specialization, provides cost of risk to farmers) and equity (safety net and access to smallholders). Since weather impacts cause yield losses and emergency needs these kinds of products can be useful. The payout structure for a hypothetical rainfall contract depending on the rainfall for the period, different payment or non-payment is given was described. Several advantages of these kinds of weather

insurance products are that they offer superior risk protection, they overcome moral hazard and adverse selection problems, and they provide an accurate and sustainable index. The number and value of these products over the recent years has increased. The policy implications using these products include the need for clarity in regulations and communication with end-users, the integrity of weather data and indices, and the market linkages such as credit and inputs. A case study in Ethiopia where up to 5 million people of transient food insecure people may be lost under the current system shows that these products may be able to provide predictable funding to protect vulnerable people's livelihoods. In this case, the drought index accurately tracked agricultural season and the data was secured through the Ethiopian National Meteorological Agency. This pilot project demonstrated that it is possible to develop objective, timely and accurate indices for triggering drought response, it is feasible to use markets to finance drought risk in Ethiopia, and contingency plans can better be designed with predictable resources. An active role of agrometeorological service is important. Future plans of these efforts include developing products in new countries, developing products in relation to social protection and emergency finance, and incorporates satellite data sources.

Mr. Pranav Prashad: "Weather Risk Insurance for coping with Risks to Agricultural Production."

A majority of the agricultural losses can be attributed to weather vagaries and that losses to drought are the greatest. Weather insurance is an insurance product based on a weather index and that financial protection is based on the performance of specified index in relation to a specified trigger. A detailed correlation analysis is carried on the weather impact on crop yields to arrive at compensation levels. Examples of weather indices include deficit/excess rainfall, extreme fluctuations of temperature, relative humidity and/or a combination of above. Some of the advantages of insurance based on weather indices are because these are a market-based alternative to traditional crop insurance, overcomes challenges of high monitoring and administrative cost, provides transparency, is objective and scientific, and is simple terms of insurance delivery. Examples of indices for wheat, apples, and oranges were given. These products provide cost effective distribution systems, are effectively administered, have easy accessibility, and provide quality service. Rural demand for products and services is no different from urban requirements provided and a focused approach along with appropriate regulation will help build a model which is viable, sustainable and scalable.

Session 6: Coping with Agrometeorological Risks and Uncertainties – Policies and Services

Dr. Stone: "Drought preparedness, drought contingency planning and farm risk management."

This rationale was undertaken in Australia since past attempts to manage droughts and their impacts have been ineffective, poorly coordinated, and untimely. Also, the ineffectiveness of the crisis management approach has led to increasing interest in the adoption of a more proactive risk-based management approach. Drought impact assessments must be made of the drought impact on the various water resources, economic sectors, population centers, and the environment. Different types of drought should be considered in the impact assessment studies and from this, drought risk assessment can be investigated through current meteorological data and other historical data in relation to climatic variation. These issues were elaborated on, using Australia as a case study and briefly described several tools and products such as the Australian National Agricultural Monitoring System (NAMS), US Drought Monitor, and "GrazeOn" an Australian tool to help pastoralists with risk management measures. Drought preparedness and contingency frameworks require various information to base decisions, what policies

and institutional arrangements are needed and the various risk management measures for decision makers. Case study examples of actions taken by decision makers were given. Contingency planning is especially important when dealing drought. In order for drought preparedness and contingency planning to be effective, many information sources and from diverse organizations are required and this information must be timely and reliable. Another factor to consider is that information policy aspects can easily lead to unnecessary complexities when different government agencies are involved at a national or local level.

Dr. Orlandini: "Using simulation modelling as a policy option in coping with agrometeorological risks and uncertainties."

The paper included an overview of the current state of the art of agrometeorological simulation modelling; application areas of worldwide simulation models; how these models are implemented; their aims and conditions of application; required data; constraints, uncertainties, and advantages of application. Currently there is an increasing need and possibility that these models can be developed and applied for crop and land management due to the following points: the widening of biological knowledge; the advances and development of computer science and telecommunications; the high level of energy and chemical inputs currently being used; the increased need for information concerning agricultural systems to improve planning and management; and finally the increasing possibility in using weather forecast data in these models. The application areas of these models are in crop protection (pathogens, insects, frosts), water balance and irrigation, crop growth and development, production and yield, soil erosion, and early warning systems. There are several economical and ecological benefits as result of using crop simulation modelling such as the reduction of chemical inputs in the ecosystem; soil fertility conservation; smaller amount of chemical residuals in food; work quality improvement; reduction in the development of resistant forms; safeguarding of natural predatory; and more acceptance of the farmers' work in public.

Dr. Motha: "Agrometeorological services to cope with risks and uncertainties."

Natural disasters have been increasing in frequency and intensity over the past several decades, resulting in immense socio-economic damage and the loss of many human lives. Agrometeorological services have developed to promote economically viable and high quality production in a sustainable and environment-friendly manner by strengthening the nation's indigenous capabilities to provide relevant meteorological services to agriculture. Agrometeorological services need weather and climate data management systems, including products, analyses, forecasts, and interpretation. The United States and India are two examples of countries that have made extensive use of agrometeorological services. Strategies to improve agrometeorological services to cope with risks and uncertainties include: indigenous technical knowledge, agrometeorological characterization, response farming, technology transfer, and, monitoring and assessment. There must be a comprehensive approach to improve agrometeorological services to cope with risks and uncertainties. A blend of technology, including indigenous technical knowledge and modern technology (RS, GIS) with operational applications of agrometeorological indices is useful. Accurate and reliable weather and climate forecasts for agriculture and an information delivery system tailored to the needs of the appropriate user community are necessary. A risk management plan with preparedness as a key and mitigation measures are needed to reduce the impact of extreme events or natural disasters prior to their occurrence. Also, adaptation strategies to prepare for and minimize the potential impacts of natural disasters and climate extremes.

Workshop Recommendations

Drs Motha and Sivakumar provided a summary of the papers that were presented in each of the sessions. A list of recommendations from the discussions of each session were compiled and presented for further discussion. The broad categories of the recommendations were on risk management, risk management tools, research needs, policy issues, emphasis on user needs, communication, and marketing.

2.1 Some of the recommendations from the workshop included:

- Develop a pro-active risk-based management approach to deal with the adverse consequences of weather extremes and climate anomalies;
- Emphasize preparedness planning and improved early warning systems to lessen societal vulnerability to weather and climate risks;
- Provide accurate, timely, consistent, and widely-available information to optimize decisions relative to the risks and uncertainties within the global agricultural production and distribution system;
- Use of decision-support systems as risk management tools should be promoted as an effective means of providing output of integrated climate-agronomic information in the form of scenario analyses relating to impending risks that can be valuable to users;
- For medium and low input systems in the developing countries, crop or agro-ecosystem modeling should be used to guide general decision-making on a higher institutional or farm advising level;
- Current and future trends of simulation model outputs should be analyzed for sensitivity to climatic hazards of different agricultural systems and defining specific critical thresholds according to farming characteristics in agricultural areas.
- Climatic risk zoning could be used for quantifying climate-plant relationships and the risk of meteorological extremes in agricultural financing programs.
- Local indigenous knowledge has been blended with specific and important weather patterns in a cultural tradition in many poor, rural areas. Introducing new scientific-based weather/climate forecast services, which provide accurate and reliable outlooks into this cultural system may help farmers improve yields and cope with risks.
- The application of seasonal forecasts for crop management strategies, risk management planning, and national policy implications needs to be considered, as these outlooks become more accurate and reliable.
- Aspects of drought contingency planning, drought preparedness, and drought impact assistance policies need to be urgently considered as to their future effectiveness under long-term climate change.
- A scientific desertification monitoring and evaluation system involving all appropriate sectors including agriculture, forestry, water conservation, environmental protection, meteorological and natural resource conservation should be established.
- Develop clear and useful guidelines on the exact nature of agrometeorological products needed for local user communities
- Enhancements in communication channels for the improved dissemination of agricultural meteorological information must take into account the literacy levels of users, socio-economic conditions, level of technological development, and accessibility to improved technology and farming systems.
- Increased interdisciplinary collaboration between meteorologists, agronomists, and economists can improve the quality of information upon which agriculture-related businesses and agricultural policy-makers around the world depend.

Workshop Closure

2.2 Dr Sivakumar, on behalf of the Secretary-General of WMO, thanked all of the speakers and participants for attending the workshop and their active contribution to make this a successful workshop and gave thanks. Dr Srinivasan from the Department of Science and Technology (DST) gave his best wishes to the participant on behalf of the Government of India. Then the H.E. Kapil Sibal, the Honourable Minister of Science and Technology from the Government of India officially closed the workshop.

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