International Workshop on Reducing Vulnerability of Agriculture and Forestry to Climate Variability and Climate Change

APN Project 2002-07

7 - 9 October 2002

Ljubliana, Slovenia

WORKSHOP REPORT

Organized by the World Meteorological Oranization and the APN Component by the National Institute of Water and Atmospheric Research
Co-Funded by the Asia-Pacific Network for Global Change Research

P O Box 109-695, Auckland, New Zealand
Tel + 64 9 375 2050 Fax + 64 9 375 2051

International Workshop on Reducing Vulnerability of Agriculture and Forestry to Climate Variability and Climate Change

7 – 9 October 2002

Ljubliana, Slovenia

Organized by the World Meteorological Organization with the National Institute of Water and Atmospheric Research (NIWA) Co-Funded by the Asia-Pacific Network for Global Change Research

NIWA, P O Box 109-695, Auckland, New Zealand
Tel + 64 9 375 2050 Fax + 64 9 375 2051

WORKSHOP REPORT

International Workshop on Reducing Vulnerability of Agriculture and Forestry to Climate Variability and Climate Change

The International Workshop was organized by the World Meteorological Organization, with the APN Component by the National Institute of Water and Atmospheric Research, Auckland, New Zealand from funding provided by the Asia-Pacific Network for Global Change Research.

Workshop Report:
Edited by Dr Jim Salinger and Dr M Sivakumar

International Workshop on Reducing Vulnerability of Agriculture and Forestry to Climate Variability and Climate Change

ABSTRACT

Senior experts in several fields prepared state-of-the art discussion papers to address the following objectives:

1. To review the latest assessments of the science of climate variability and climate change, and their likely impacts on agriculture and forestry in different agroecological regions during the 21st century;

2. To present the range of adaptation options for agriculture and forestry, including the use of technological advances such as use of climate forecasts, for reducing the vulnerability to climate variability and change;

3. To discuss the resources and strategies, including education and training, required for promotion of sustained efforts for reducing the vulnerability of agriculture and forestry to climate variability and climate change.

The participants at the workshop, drawn from both developed and developing countries, discussed various adaptation strategies to cope with climate variability and climate change in different agroecological regions of the world. The workshop was co-sponsored by APN, the World Meteorological Organization (WMO), UNEP, FAO, IGBP/START, USDA and CTA and provided a close linkage to the current global change research programmes being carried out by all these agencies. Recommendations from the workshop are being widely disseminated to policy makers around the world by WMO. The workshop papers are to be published in a special edition of *Climatic Change*.

Contents

1 Project Information

Principal Investigator:

Dr James Salinger
National Institute of Water and Atmospheric Research
P. O. Box 109 695
Newmarket, Auckland
NEW ZEALAND
Tel: + 64 9 375 2050
Fax: + 64 9 375 2051
e-mail: j.salinger@niwa.co.nz

APN Funding:

US$40,000

APN approved collaborating countries:

Australia, Bangladesh, China, Cook Islands, Fiji, India, Indonesia, Malaysia, Maldives, Mongolia, Nepal, New Zealand, Pakistan, Phillippines, Russia, Sri Lanka and Vietnam.

2 Introduction

Climate change and variability, drought and other climate-related extremes have a direct influence on the quantity and quality of agricultural production and in many cases, adversely affect it, especially in developing countries, where technology generation, innovation and adoption are too slow to counteract the adverse effects of varying environmental conditions. The interdisciplinary nature of these issues requires a long lasting and where possible more substantial role for agrometeorology in the efforts to promote sustainable agricultural development during the 21st Century. There is a need to develop locally agrometeorological adaptation strategies to increasing climate variability and climate change especially in vulnerable regions where food and fibre production is most sensitive and vulnerable to climatic fluctuations.

Because of uncertainties associated with regional projections of climate change, the IPCC has attempted to assess the vulnerability of natural and social systems to changes in climate, rather than attempt to provide quantitative predictions of the impacts of climate change at the regional level. The range of adaptation options for managed systems such as agriculture and forestry is generally increasing because of technological advances, thus opening the way for reducing the vulnerability of these systems to climate change. However, some regions of the world, particularly developing countries, have limited access to these technologies and appropriate information on how to implement them. Incorporation of climate change concerns into resource-use and development decisions and plans for regularly scheduled investments in infrastructure will facilitate adaptation.

The issues of climate variability and climate change need to be integrated into resource use and development decisions. Climate variability affects all economic sectors, but agricultural and forestry sectors are perhaps two of the most vulnerable and sensitive activities to such climate fluctuations. Many sectors are currently not optimally managed with respect to today's natural climate variability because of the nature of policies, practices and technologies currently in vogue. Decreasing the vulnerability of agriculture and forestry to natural climate variability through a more informed choice of policies, practices and technologies will, in many cases, reduce the long-term vulnerability of these systems to climate change. For example, the introduction of seasonal climate forecasts into management decisions can reduce the vulnerability of the agriculture to floods and droughts caused by the El Niño - Southern Oscillation (ENSO) phenomena.

The interdisciplinary nature of these issues requires a long lasting and where possible more substantial role for agrometeorology in the efforts to promote sustainable agricultural development during the 21st Century. There is a need to develop locally agrometeorological adaptation strategies to increasing climate variability and climate change especially in vulnerable regions where food and fibre production is most sensitive and vulnerable to climatic fluctuations.

It is with this background that WMO organized jointly with several co-sponsors, an International Workshop on Reducing Vulnerability of Agriculture and Forestry to Climate Variability and Climate Change. The workshop was held in October 2002 in Ljubliana, Slovenia, in conjunction with the 13th Session of the Commission for Agricultural Meteorology of WMO.

The objectives of the workshop were:

1. To review the latest assessments of the science of climate variability and climate change, and their likely impacts on agriculture and forestry in different agroecological regions during the 21st century;
2. To present the range of adaptation options for agriculture and forestry, including the use of technological advances such as use of climate forecasts, for reducing the vulnerability to climate variability and change;
3. To discuss the resources and strategies, including education and training, required for promotion of sustained efforts for reducing the vulnerability of agriculture and forestry to climate variability and climate change.

It is with this background that the World Meteorological Organization (WMO) organized the International Workshop on Reducing Vulnerability of Agriculture and Forestry to Climate Variability and Climate Change at the Cankarjev Dom in Ljubljana, Slovenia from 7 to 9 October 2002. The workshop was co-sponsored by the Asia-Pacific Network for Global Change Research (APN), the Canadian International Development Agency (CIDA), the Centre Technique de Coopération Agricole et Rurale – Technical Centre for Agricultural and Rural Co-operation (CTA), the Environmental Agency of the Republic of Slovenia, the Ministry of Agriculture, Forestry and Food of the Republic of Slovenia, the Ministry of Environment, Spatial Planning and Energy of the Republic of Slovenia, the Food and Agriculture Organization of the United Nations (FAO), the Fondazione per la Meteorologia Applicata (F.M.A.) and the Laboratory for Meteorology & Climatology (La.M.M.A.), the International START Secretariat (START), the Météo-France , the Ufficio Centrale di Ecologia Agraria (UCEA), the United Nations Environment Programme (UNEP), and the United States Department of Agriculture (USDA).

The Workshop was attended by 118 participants from 76 countries and two regional and international organizations (Annex I).

3 Activities Conducted

The format of the workshop was as follows:

1) Opening Session: Welcoming addresses from different sponsors of the workshop, and the Slovenian hosts.

2) Seven technical sessions covering different objectives of the workshop. In each session there were presentations by invited speakers, followed by comments from discussants from developing countries. These were on:

(i) Reducing vulnerability of agriculture and forestry to climate variability and climate change overview;
(ii) Impacts of climate variability in the tropics;
(iii) Impacts of climate variability in the temperate regions;
(iv) Reducing vulnerability to climate variability and climate change: adaptation and applications;
(v) Reducing vulnerability to climate variability and climate change: technology and strategies;
(vi) Reducing vulnerability to climate variability and climate change: communication, education and training;
(vii) Reducing vulnerability to climate variability and climate change: future research and applications.

3) A final session for discussion on the conclusions and recommendations of the workshop.

A copy of the programme for the workshop is contained in Appendix II.

4 Outcomes and Products

Summary of Workshop Sessions

SESSION 1: OPENING OF THE WORKSHOP

The session was chaired by Mr Ken Davidson, Director of the World Climate Programme (WCP) of WMO. Participants to the workshop were welcomed by Ms Andreja Čerček Hočevar, Director, Environmental Agency of the Republic of Slovenia. The three Convenors of the workshop: Dr R. P. Motha, President, Commission for Agricultural Meteorology (CAgM) of WMO, Dr M. J. Salinger, Senior Scientist, National Institute of Water and Atmospheric Research, Auckland, New Zealand and Dr M.V.K. Sivakumar, Chief, Agricultural Meteorology Division of WMO explained the background to the workshop including the initiative taken by CAgM to organize the workshop, the overall objectives and format of the workshop and thanked the different co-sponsors of the workshop. This was followed by short welcoming remarks on behalf of the co-sponsors by Dr M.J. Salinger, (APN), Mr B. Angle (CIDA), Dr M.V.K. Sivakumar (FAO), Dr G. Maracchi (FMA), Ms V. Pérarnaud (Météo-France), Dr M.V.K. Sivakumar (START), Dr D. Vento (UCEA) and Dr R.P. Motha (USDA). Mr Franc But, Honourable Minister of Agriculture, Forestry and Food of the Government of Slovenia opened the workshop.

SESSION 2: REDUCING VULNERABILITY OF AGRICULTURE AND FORESTRY TO CLIMATE VARIABILITY AND CLIMATE CHANGE: OVERVIEW

The session was chaired by Mr L.E. Akeh (Nigeria) who was assisted by Ms A. Susnik (Slovenia) as the rapporteur.

Paper: Overview - Climate variability and climate change: Past, present and future.

Dr M.J. Salinger, National Institute of Water and Atmospheric Research, Auckland, New Zealand

Summary:

Prior to the 20th century Northern Hemisphere temperatures have varied in the order of 0.5°C back to AD 1000. Various climate reconstructions indicate that slow cooling took place until the beginning of the 20th century. Subsequently, global-average surface air temperature increased by about 0.6°C with the 1990s being the warmest decade on record. The pattern of warming has been greatest over mid-latitude northern continents in the latter part of the century. At the same time the frequency of air frosts has decreased, and there has been a drying in the tropics and subtropics. The late 20th century changes have been attributed to global warming because of increases in atmospheric greenhouse gas concentrations due to human activities.

Underneath these trends is that of decadal scale variability in the Pacific basin at least induced by the Interdecadal Pacific Oscillation (IPO), which cause decadal changes in climate averages. On interannual timescales El Niño/Southern Oscillation (ENSO) causes much variability throughout many tropical and subtropical regions and some mid-latitude areas. The North Atlantic Oscillation (NAO) provides climate perturbations over Europe and northern Africa.

During the course of the 21st century globally averaged surface temperatures are very likely to increase by 2 to 4.5°C as greenhouse gas concentrations in the atmosphere increase. At the same time there will be changes in precipitation and climate extremes such as hot days, heavy rainfall and drought are expected to increase.

The combination of global warming, superimposed on decadal climate variability (IPO) and interannual fluctuations (ENSO, NAO) will lead to a century of increasing climate variability and change that will be unprecedented in the history of human settlement. Although the changes of the past and present have stressed food and fibre production at times, the 21st century changes will be extremely challenging to agriculture and forestry.

Discussion:

Mr. K. Bandara (Sri Lanka) started the discussion by presenting the impacts of climate change on agriculture in Sri Lanka. The agriculture in the coastal regions is very vulnerable to anticipated rising sea-level. The yield of high value crops in the upland regions of the country may decline due to increased nighttime temperatures. Also, rainfed and irrigated crops will require more water due to increased water demand from increased potential evaporation due to higher temperatures. Higher temperatures are likely to increase upland tea yields but at the expense of lower quality and lowland tea quality and yields will continue to decline.

Mr. Tan Lee Seng (Malaysia) presented the potential impacts of climate change on Malaysian agriculture. In Malaysia, climate scenarios show large temperatures increases in the future. He pointed out that agronomists are no longer interested in the average conditions (climate statistics) but they are interested in forecasts of likely future climate for planning purposes. He presented several strategies for adaptation to climate change including: developing plant varieties that are resilient to high temperatures and high water use efficiency; maximizing efficient usage of water and nutrient input; developing efficient post-harvest handling to reduce wastage; and formulate appropriate strategies in response to land use change.

During the open discussion, there was considerable talk on the enhanced frequency of extreme events with climate change. Although it is observed that rainfall intensity is increasing, it is necessary to analyse the historical data to evaluate if there is also an increase in the number of rainy days.

SESSION 3: IMPACTS OF CLIMATE VARIABILITY IN THE TROPICS

The session was chaired by Dr G. Maracchi (Italy) who was assisted by Mr R. Stefanski (USA) as the rapporteur.

Paper: Impacts of present and future climate variability and change on agriculture and forestry in the arid and semi-arid tropics

M.V.K. Sivakumar, WMO, Geneva, Switzerland
O. Brunini, Center for Ecology and Biophysics, Campinas, Brazil
H. P. Das, India Meteorological Department, Pune, India

Summary:

The arid and semi-arid regions account for approximately 30% of the world total area and are inhabited by approximately 20% of the total world population. Issues of present and future climate variability and change on agriculture and forestry in the arid and semi-arid tropics of the world were examined and discussion under each of these issues had been presented separately for Asia, Africa and Latin America.

Several countries in tropical Asia have reported increasing surface temperature trends in recent decades. Although there is no definite trend discernible in the long-term mean for precipitation for the tropical Asian region, many countries have shown a decreasing trend in rainfall in the past three decades. African rainfall has changed substantially over the last 60 years and a number of theoretical, modeling and empirical analyses have suggested that noticeable changes in the frequency and intensity of extreme events, including floods may occur when there are only small changes in climate. Climate in Latin America is affected by the ENSO phases and there is a close relationship between the increase or decrease of rainfall depending upon the warm or cold phases of the phenomenon.

Over land regions of Asia the projected area-averaged annual mean warming is likely to be 1.6 ± 0.2^0C in the 2020s, 3.1 ± 0.3^0 C in the 2050s, and 4.6 ± 0.4^0C in the 2080s and models show high uncertainty in projections of future winter and summer precipitation. Future annual warming across Africa is projected to range from 0.2 °C per decade to more than 0.5 °C per decade while future changes in mean seasonal rainfall in Africa are less well defined. In Latin America, projections indicate a slight increase in temperature and changes in precipitation.

Impacts of climate variability and changes are discussed with suitable examples. Agricultural productivity in tropical Asia is sensitive not only to temperature increases but also to changes in the nature and characteristics of monsoon. Simulations of the impacts of climate change using crop

simulation models show that crop yield decreases due to climate change could have serious impacts on food security in tropical Asia. Climate change is likely to cause environmental and social stress in many of Asia's rangelands and drylands. In the arid and semi-arid tropics of Africa, which are already having difficulty coping with environmental stress, climate change resulting in increased frequencies of drought poses the greatest risk to agriculture. Impacts were described as those related to projected temperature increases, the possible consequences to water balance of the combination of enhanced temperatures and changes in precipitation and sensitivity of different crops/cropping systems to projected changes. In Latin America, agriculture and water resources are most affected through the impact of extreme temperatures (excessive heat, frost) and the changes in rainfall (droughts, flooding).

Adaptation potential in the arid and semi-arid tropics of Asia, Africa and Latin America was described using suitable examples. It is emphasized that approaches need to be prescriptive and dynamic, rather than descriptive and static.

Discussion:

There was an interesting open discussion following the paper on the vulnerability of arid and semi-arid regions to climate variability and climate change, especially in Africa. The need for more studies on the potential changes in rainfall distribution and the starting date of rainy season under the climate change scenarios was highlighted. One question dealt with GMOs in the developing world. Dr. Sivakumar responded that the developing world cannot ignore the issues of GMOs and research is needed to provide answers to many of the questions concerning possible impacts.

Paper: Impacts of present and future climate variability on agriculture and forestry in the sub-humid and humid tropics

Yanxia Zhao, Chunyi Wang, and Shili Wang, China Meteorological Administration, Beijing, China

Lourdes Tibig, Phillippine Atmospheric, Geophysical and Astronomical Services Administration, Quezon City, Philippines

Summary:

In the developing countries of the humid and sub-humid tropics, the current state of agriculture and forestry are characterized by stagnant yields, recurrent natural disasters, deforestation and land degradation, and poverty. Although there are different results from different studies, most assessments indicate that climate variability would have negative effects on agriculture and forestry in the humid and sub-humid tropics. Impacts of climate variability/change are expected to be greatest in the developing with current degradation of resources, poor access to technologies, and low investments in production. Cereal crop yields would decrease generally with even minimal increases in temperature. For commercial crops, extreme events such as cyclones, droughts and floods lead to larger damages than only changes of mean climate. Impacts of climate variability on livestock mainly include two aspects; impacts on animals such as increase of heat and disease stress-related death, and impacts on pasture. As to forestry, climate variability would have negative as well as some positive impacts on forests of humid and sub-humid tropics. However, in most tropical regions, the impacts of human activities such as deforestation will be more important than climate variability and climate change in determining natural forest cover.

Discussion:

D. Kashasha (Tanzania) presented an overview of several adaptation strategies from Tanzania. These include soil water conservation techniques (modern and traditional); harvesting rain water planting proper crop cultivars to fit increasingly shorter seasons; and better placement of irrigation. in better placed areas.

Nguyen van Viet (Vietnam) discussed climate change, variability, and strategies of sustainable development on agriculture in Vietnam. He concluded that temperatures are increasing, sunshine durations are decreasing and rainfall trends are varied across the regions. He provided the following adaptation strategies: selection of more CO2 efficient plants; changing planting dates; shifting to drought tolerant crops; and developing more irrigation systems.

W. Wigmore (Cook Islands) discussed the situation from the Cook Islands. He concluded that crops such as papaya, citrus, and vegetables, which are more climate sensitive, may be more affected by increasing temperature and rainfall. Any increase in sea level can dramatically affect the Cook Islands, which are only a few meters above sea level. They may experience greater flooding by seawater and can cause major damage of agricultural production. Tropical cyclones, prolonged drought periods, increased precipitation, and flooding of low-lying atoll islands most probably pose the greatest risk to agriculture and forestry.

SESSION 4: IMPACTS OF CLIMATE VARIABILITY IN THE TEMPERATE REGIONS

The session was chaired by Mr A. Harou (Canada) with Dr A. Kleschenko (Russian Federation) as the rapporteur.

Paper: Impacts of present and future climate variability on agriculture and forestry In the temperate regions: Europe

G. Maracchi, IATA-CNR, Florence, Italy
O. Sirotenko, ARRIAM, Obninsk, Russia
M. Bindi, IATA-CNR, Florence, Italy

Summary:

Agriculture and forestry will be particular sensitive to changes in mean climate and climate variability in the northern and southern regions of Europe. Agriculture may be positively affected by climate change in the northern areas through the introduction of new crop species and varieties, higher crop production and expansion of suitable areas for crop cultivation. The disadvantages may be determined by an increase in need for plant protection, risk of nutrient leaching and accelerated breakdown of soil organic matter. In Southern areas the benefits of the projected climate change will be limited, while the disadvantages will be predominant. The increased water use efficiency caused by increasing CO_2 will compensate for some of the negative effects of increasing water limitations and extreme weather events, but the lower harvestable yields, higher yield variability and a reduction in suitable areas of traditional crops are expected for these areas.

Forestry in the Mediterranean region may be mainly affected by increases in droughts and forest fires. In northern Europe, the increased precipitation is expected to be large enough to compensate the increased evapotranspiration. On the other hand, however, increased precipitation, cloudiness and rain days and the reduced duration of snow cover and soil frost may negatively affect forest work and timber logging determining lower profitability of forest production and a decrease in recreational possibilities. Adaptation management strategies should be introduced, as effective tools, to reduce the negative impacts of climate change on agriculture and forestry sectors.

Discussion:

A. Susnik (Slovenia) discussed the vulnerability assessment of Slovenian agriculture to climate variability and potential impacts of climate change. All global climate change scenarios predict increased temperatures and reduced precipitation across Slovenia. Currently, 15% of Slovenia suffers from soil moisture deficits. With a projected increase of evapotranspiration due to increased temperatures, potentially more of Slovenia will experience moisture deficits. Also, an increase in extreme weather events will also negatively impact Slovenian agriculture. Some positive effects of climate change include a prolonged growing season, an expansion of agricultural cultivation in the higher elevations, and more appropriate temperature conditions for temperature-sensitive crops. It has been assessed that the expected negative impacts will be more pronounced than the positive ones.

Paper: Impacts of present and future climate variability on agriculture and forestry in the temperate regions: North America

R. P. Motha, U.S. Department of Agriculture, Washington, DC, USA
W. Baier, Eastern Cereal and Oilseed Research Centre, Ottawa, Canada

Summary:

The potential impact of climate variability and climate change on agricultural production in the United States and Canada varies generally by latitude. Largest reductions are projected in southern crop areas due to increased temperatures and reduced water availability. A longer growing season and projected increases in CO_2 may enhance crop yields in northern growing areas. Major factors in these scenarios analyses are increased drought tendencies and more extreme weather events, both of which are detrimental to agriculture. Increasing competition for water between agriculture and non-agricultural users also focuses attention on water management issues.

Agriculture is also sensitive to greenhouse gases. Forests and soils are natural sinks for CO_2. Removal of forests and changes in land use, associated with the conversion from rural to urban domains, alters these natural sinks. Agricultural livestock and rice cultivation are leading contributors to methane emission into the atmosphere. The application of fertilizers is also a significant contributor to nitrous oxide emission into the atmosphere. Thus, agriculture can play an important role in managing the sources and sinks of greenhouse gases. Forest and land management can be effective tools in mitigating the greenhouse effect.

Discussion:

R. Guerreiro (Portugal) presented a brief description of the climate in Mainland Portugal and trends in the last decades. A warming trend is verified since 1976. Since this year there is also a significant difference in precipitation trends between seasons, with a systematic reduction of spring precipitation all over the country. Climate data shows an increase in the frequency or intensity of extreme events: heavy precipitation events and severe and extreme droughts, particularly in the southern regions. Climate change scenarios for Mainland Portugal project a significant warming in the 21st century which leads to a faster phenological development of crops, an increase in water demand and a higher incidence of pests and diseases. A projected decrease in spring precipitation will increase irrigation requirements and cause water stress in dryland crops. A lengthening of the forest fires season is expected. Adaptation strategies and mitigation measures are presented.

Paper: Assessing the consequences of climate change for food and forest resources: View from the IPCC

W. Easterling, Pennsylvania State University, University Park, US
M. Apps, Natural Resources Canada, Victoria, Canada

Summary:

Important findings on the consequences of climate change for agriculture and forestry from the recently completed Third Assessment Report (TAR) of the Intergovernmental Panel on Climate Change (IPCC) are reviewed, with emphasis on new knowledge that emerged since the Second Assessment Report (SAR). The State-Pressure-Response-Adaptation model is used to organize the review. The major findings are that constant or declining food prices are expected for at least the next 25 years, although food security problems will persist in many developing countries as such countries deal with persistent population increases, political crisis, poor resource endowments, and steady environmental degradation. Confidence in this projection declines farther out into the 21st century. Although deforestation rates may have decreased since the early 1990s, degradation with a loss of forest productivity and biomass has occurred at large spatial scales as a result of fragmentation, non-sustainable practices and infrastructure development.

According to United Nations estimates, approximately 23% of all forest and agricultural lands were classified as degraded over the period since World War II. At a worldwide scale, global change pressures (climate change, land-use practices and changes in atmospheric chemistry) are increasingly affecting the supply of goods and services from forests. The most realistic experiments to date indicate that C_3 agricultural crops particularly respond favorably to increased atmospheric CO_2 concentrations (e.g., wheat yield increases by an average of 28%), although extrapolation of experimental results to real world production remains problematic. Moreover, little is known of crop response to elevated CO_2 in the tropics, as most of the research has been conducted in the mid-latitudes. Research suggests that for some crops, for example rice, CO_2 benefits may decline quickly as temperatures warm beyond optimum photosynthetic levels. However, crop plant growth may benefit relatively more from CO_2 enrichment in drought conditions than in wet conditions.

The unambiguous separation of the relative influences of elevated ambient CO_2 levels, climate change responses, and direct human influences (such as present and historical land-use change) at the global and regional scales is still problematic. In some regions such as the temperate and boreal forests, climate change impacts, direct human interventions (including nitrogen-bearing pollution), and the legacy of past human activities (land-use change) appear to be more significant than CO2 fertilization effects. This subject is, however an area of continuing scientific debate, although there does appear to be consensus that any CO_2 fertilization effect will saturate (disappear) in the coming century. Modeling studies suggest that any warming above current temperatures will diminish crop yields in the tropics while up to 2-3° C of warming in the mid-latitudes may be tolerated by crops, especially if accompanied by increasing precipitation. Where direct human pressures do not mask them, there is increasing evidence of the impacts of climate change on forests associated with changes in natural disturbance regimes, growing season length, and local climatic extremes. Recent advances in modeling of vegetation response suggest that transient effects associated with dynamically responding ecosystems to climate change will increasingly dominate over the next century, and that during these changes the global forest resource is likely to be adversely effected. The ability of livestock producers to adapt their herds to the physiological stress of climate change is not well known, in part because of the general lack of experimentation and simulations of livestock adaptation to climate change. Crop and livestock farmers who have sufficient access to

capital and technologies should be able to adapt their farming systems to climate change. Substantial changes in their mix of crops and livestock production may be necessary, however, as considerable costs could be involved in this process as learning and gaining experience with different crops or if irrigation becomes necessary. Impacts of climate change on agriculture after adaptation are estimated to result in small percentage changes in overall global income. Nations with large resource endowments (i.e., developed countries) will fare better in adapting to climate change than those with poor resource endowments (i.e., developing countries and countries in transition, especially in the tropics and subtropics) will fare worse. Although local forest ecosystems will be highly affected, with potentially significant local economic impacts, it is believed that, at regional and global scales, the global supply of timber and non-wood goods and services will adapt through changes in the global market place. However, there will be regional shifts in market share associated with changes in forest productivity with climate change: in contrast to the findings of the SAR, recent studies suggest that the changes will favour producers in developing countries, possibly at the expense of temperate and boreal suppliers. Based on the accumulated evidence of modeling studies, a global temperature rise of greater than 2.5°C is likely to reverse the trend of falling real food prices. This would greatly stress food security in many developing countries.

Discussion:

M. Pintar (Slovenia) discussed global climate change research in Slovenia. Given projected increases in temperatures and reductions in precipitation, studies suggest that there will be an earlier start of vegetation period for one week in springtime and one week extension in fall. Results showed that the precipitation occurred in bigger rainfall events – thus sufficiently filling the gaps of water storage capacity. Therefore a projected 10% decrease in overall precipitation had little or none influence on the water balance of the soil profile. However, results from the worst case scenario showed that the water depletion would occur sooner and therefore the irrigation period would start sooner.

D. Azzaya (Mongolia) discussed climate change impacts on pasture and animal husbandry in Mongolia. Modeling results indicate that the overall peak biomass would decrease by 2070 and livestock grazing time and daily weight would decrease. The potential livestock carrying capacity of rangeland would increase nearly 10% from current levels in 2039 but then decline 15% from current levels in 2069. Also many adaptation measures were mentioned.

SESSION 5: REDUCING VULNERABILITY TO CLIMATE VARIABILITY AND CLIMATE CHANGE: ADAPTATIONS AND APPLICATIONS

Dr H.P. Das (India) chaired the session and he was assisted by Mr Lee Seng Tan (Malaysia) as the rapporteur.

Paper: Achieving adequate adaptation in agriculture

I. Burton, Meteorological Services of Canada, Ontario, Canada
B. Lim, United Nations Development Programme, New York, USA

Summary:

Scientists and economic experts participating in the IPCC scientific synthesis appear confident that global agricultural production can be maintained in the face of climate change. Research has shown that the adverse effects of climate change on agricultural production are likely to be felt more in the lower latitude countries even though the amount of temperature change there is projected to be less than in higher latitudes. Mostly it is because of a lower adaptive capacity in socio-economic systems. In the face of great uncertainties that agriculture faces from changes in technology, economic and social forces, we have little or no understanding of what the added stress of climate change will do. What can and will be done to adapt to changes is less and less in the hands of the farmers themselves, and more and more dependent upon agri-business, and the global political economy. There is currently much excitement about the improvements being made in seasonal forecasting, but these advances in technology will not be sufficient to deal with the new threats of climate change.

Adaptation should be view as a broad concept involving choices at national and international levels as well as local. Adaptation involves more than measures, it is also a matter for national agricultural and development policy. Under the UN Framework Convention very little attention has been given to technical adaptation. The debate has centered on the need for technology transfer but adaptation technology has been virtually ignored in the rush to promote tech-transfer for greenhouse gas emission reductions.

National agricultural policy is developed in the context of local risks, needs, and capacities, as well as international markets, tariffs, subsidies and trade agreements. Stakeholder participation in policy development is frequently recommended as a measure that can help to reduce the distance between national policy processes and the farm and community level.

The fact that agriculture can be described on the one hand as highly adaptable and resilient, and on the other as resistant to change, is related to the diffusion and success of technical innovations at the farm level. Successful adaptation over decades and centuries at this level goes a long way towards explaining the confidence now being expressed in the ability of agriculture to cope with the potential impacts of climate change. On the other hand there are concerns that the modernization of agriculture is having serious environmental and social consequences.

The evidence so far seems to suggest that the prospects at the global level are good, but that severe local and regional disruptions and inequalities are possible, even likely. This diagnosis suggests the need to pay more attention to national policy and global negotiations in order to alleviate inequalities between and within nations. From the perspective of climate change and development the place where local and global converge is at the level of national policy.

Some new approaches to national policy for climate change adaptation are now being developed and applied. These include the National Adaptation Programmes of Action (NAPAs) agreed of the Conference of the Parties to the Framework Convention on Climate Change (COP 7). The Adaptation Policy Framework (APF) now being elaborated builds upon past work and experience and is being developed by UNDP at a generic level. The World Health Organization is developing a set of guidelines for the assessment of adaptation to climate change in the health sector. Perhaps a similar activity led by WMO with partners such as FAO and CGIAR would be timely.

Discussion:

W. Easterling (USA) stressed that adaptation must be directed to a number of factors, not just climate change. Maladaptive policy can be risky and costly. One should not use only one model.

Tan Lee Seng (Malaysia) proposed alternative adaptive measures from agricultural researchers from Malaysia.

A. Popova (Bulgaria) discussed some the research underway in Bulgaria regarding water supply treatments of maize and compared rainfed, irrigation, and fertilizer treatments to maize.

Paper: The development of seasonal and inter-annual climate forecasting
M. Harrison, United Kingdom Met Office, London, UK

Summary:

In general, seasonal to interannual prediction uses knowledge of sea surface temperature anomalies on which to base a forecast of temperature and rainfall conditions in teleconnected parts of the globe. A review of modern short-range climate forecasting is given by using the history of the ENSO as the prime example. There are two types of models used in long-range prediction which are empirical models and computer-based models of the ocean and/or atmosphere. In all cases the objective is to produce a prediction of the average climatic conditions throughout a season across a region measuring several hundred kilometres along each side. For agriculture, rainfall is a major concern but it is variable in both space and time and many applications are more sensitive to the timing and amounts of rainfall through a season than they are to the total amount. The paper illustrates the some of problems of using seasonal forecasts operationally from the experience of forecasts for southern Africa during the 1997/98 El Niño. There is a also a robust discussion of the following topics: the current status of the seasonal forecasting, the problems with comparing different forecasts schemes (skill scores), forecast interpretation, applications, and the future. One conclusion is that downscaling does not improve the accuracy of the forecast and the author recommends that more research needs to done on improving methods for forecast validation, verification, and interpretation, and that optimal strategies be devised through more pilot projects.

Discussion:

Nguyen Van Viet (Vietnam) discussed how Vietnam uses ENSO forecasts for potential impact on the agricultural sector. He concluded that rice yields have more correlation to the MEI rather to the SOI.

Antoyo Setyadipratiko (Indonesia) discussed the role of the Meteorological and Geophysical Agency for Disaster preparedness in Indonesia.

Paper: Seasonal and inter-annual climate forecasting: The new tool for increasing preparedness to climate variability and change in agricultural planning an operations
H. Meinke, Department of Primary Industries, Toowoomba, Australia
R. Stone, Department of Primary Industries, Toowoomba, Australia

Summary:

Climate variability and change affects us all. Within agricultural systems, seasonal climate forecasting can increase preparedness and lead to better social, economic and environmental outcomes. However, climate forecasting is not the panacea to all our problems in agriculture. Instead, it is one of many risk management tools that sometimes play an important role. To understand **when** to use this tool **where** and **how** is a complex and multi-dimensional problem. To do this effectively, a participatory, cross-disciplinary research approach that brings together institutions (partnerships), disciplines (ie. climate science, agricultural systems science and rural sociology) and people (scientist, policy makers and direct beneficiaries) as equal partners to reap the benefits from climate forecasting was suggested. Climate science can provide insights into climatic processes, agricultural systems science can translate these insights into technically possible solutions (management options) and rural sociology can help to determine the options that are most feasible or desirable from a socio-economic perspective. Any scientific breakthroughs in climate forecasting capabilities are much more likely to have an immediate and positive impact if they are conducted and delivered within such a framework.

While knowledge and understanding of the socio-economic circumstances is important and must be taken into account, the general approach of integrated systems science is generic and applicable in developed as well as in developing countries. Examples on how contextualised forecasting can deliver benefits across the value chain and indicate areas that require improvement were given. The need to better understand temporal and spatial scale variability was highlighted and it was argued that only a probabilistic approach to outcome dissemination should be considered. We demonstrated how knowledge of climatic variability, its frequencies, causes and consequence can lead to better decisions in agriculture regardless of geographical location and socio-economic conditions.

Discussion:

A. Porteous (New Zealand) informed that the farmers in New Zealand adapt to climate variability, motivated by economics, need to minimize risks, maximize climate resources, search for climate niches and innovate for excellence.

P. Goolaup (Mauritius) emphasized the need to use forecasts to influence decision making with clear focus on specific requirements.

S. McGree (Fiji) discussed the two tools, the SOI and RAINMAN, used in the Fiji Met Office to forecast seasonal rainfall.

Paper: Climate, Communications, and Innovative Technologies: Potential Impacts and Sustainability of New Radio and Internet Linkages in Rural African Communities

M.S. Boulahya, ACMAD, Niamey, Niger
M.S. Cerda, Institute of International Education
M. Pratt, University of Wisconsin-Madison and USAID, Madison, USA
K. Sponberg, Office of Global Programs

Summary:

Communicating drought information to remote rural populations is a major challenge for drought monitoring and prediction in Africa. Without access to reliable communication networks, the vast majority of Africa’s farmers and herders are cut off from the scientific and technological advances that support agricultural decision-making in other parts of the world. The African Centre of Meteorological Applications for Development (ACMAD) worked with herders and farmers to design the RANET system. Named for its innovative linkage of radio and Internet, RANET brings new communications and information technologies together with the oral traditions of Africa to deliver scientific drought information over a distributed network owned and managed by local communities.

RANET combines data from global climate data banks in the U.S., seasonal rainfall predictions from the international scientific community, data and forecasts generated in Africa, along with food security and agricultural information, to disseminate a comprehensive information package via a network of digital satellite, receiving stations, computers, radio, and oral intermediaries. Prior to RANET, this information was rarely available outside of capital cities, and much of it never traveled far beyond the research centers where it originated. RANET depends on four critical steps to move information from capital cities to rural communities: information gathering and integration, satellite transmission, reception and interpretation, and dissemination.

RANET's main strengths and weaknesses are wrapped up in this way. Distributed control of the system at both national and local levels creates an empowering sense of ownership and responsibility. Decentralization permits the system to be readily adapted according to each country's and community's needs and capabilities, but it also leads to uneven results. The multiplicity of RANET partners bring a wealth of expertise and depth of support to the system, but the increasing coordination burden may result in diminishing returns, and spreading responsibility among too many organizations blurs accountability. The rapid spread of the system across and among countries is a testament to RANET's ability to serve rural populations; however, rapid and uncontrolled replication can lead to dangerous overextension. In the end, the strength of RANET's model for communication of drought monitoring and prediction information lies in its diversity and flexibility. As an open system that invites rural populations to participate, it offers tremendous returns to those who are willing to invest their energy and imagination.

Discussion:

D. Maiga (Mali) discussed the need to involve the NGOs and local people in the campaign to educate and communicate climate information to the farmers. Farmers can also be trained to be observers.

SESSION 6: REDUCING VULNERABILITY TO CLIMATE VARIABILITY AND CLIMATE CHANGE: TECHNOLOGY AND STRATEGIES

The session was chaired by Mr Russell Stringer (Australia) with Ms L. Tibig (Philippines) assisting him as the rapporteur.

Paper: Using traditional methods and indigenous technologies for coping with climate variability

C. Stigter, University of Wageningen, Wageningen, Netherlands
Z. Dawei, China Agricultural University, Beijing, China
M. Xurong, Chinese Academy of Agricultural Sciences, Beijing, China
L. Onyewoto, Forestry Research Institute of Nigeria, Kano, Nigeria

Summary:

In agrometeorology and management of meteorology related natural resources, many traditional methods and indigenous technologies are still in use or being revived for managing low external inputs sustainable agriculture (LEISA) under conditions of (increasing) climate variability. An introduction was given on the context in which the use of such methods and technologoes must be seen to operate. Options that LEISA farmers have were reviewed, distinguishing parameters and related phenomena that should be more thoroughly dealt with, based on the role these phenomena play as limiting factors

in agricultural production and the expectations on their variabilities. Subsequently, local case studies were given as examples of preparedness strategies in the fields of coping with (i) variable water/moisture flows, including mechanical impacts of rain and/or hail, (ii) variable temperature and heat flows, including fires, and (iii) fitting cropping periods to the varying seasons, everywhere including related phenomena as appropriate. The paper ended with a series of important additional considerations without which the indicated strategies cannot be successful on a larger scale and in the long run.

Discussion:

H. P. Das (India) discussed that farmers can cope with water scarcity in arid/semi-arid areas by using traditional indigenous water harvesting techniques. These traditional techniques include building local stone dams, tapping spring water using bamboo, and shallow wells.

R. Regmi (Nepal) discussed climate change research in Nepal.

During the open discussion, it was mentioned that promoting traditional methods to reduce emissions from agricultural activities should be of secondary importance. Inappropriate techniques such as those on water management rice paddies should be addressed and avoided. Also, agrometeorologists should be able to improve on existing systems such as the use of traditional information (almanacs) in determining scheduling activities such as almanacs, since there has been insufficient study on the indicators of climate variability and how farmers use them.

Paper: Management strategies with particular emphasis on carbon sequestration to mitigate greenhouse gas emissions from agroecosystems

R. Desjardins, W. Smith, B. Grant, C. Campbell, H. Janzen, and R. Riznek,
Agriculture and Agri-Food Canada, Ottawa, Canada

Summary:

Carbon sequestration in agricultural soils is frequently promoted as a practical solution to slow down the rate of increase of CO_2 in the atmosphere. There is a need to improve our understanding on how land management practices affect exchange processes that lead to N_2O emissions, CH_4 absorption and net removal of atmospheric CO_2. The magnitude of the impact of management practices such as no-tillage, summer fallow, introduction of forages into crop rotations, conversion of croplands to grasslands, nutrient addition via fertilization as a means to increase C sequestration in agricultural soils was reviewed. Using CENTURY (a C model) and DNDC (a N model) simulations for five locations across Canada were carried out, for a 30-year time period, examining the potential trade-off between C sequestration and increased N_2O emissions. These simulations showed that the conversion of croplands to grasslands resulted in the largest reduction in net GHG emissions, while nutrient additions via fertilizers resulted in a small increase GHG emissions. The CENTURY model was also used to demonstrate that climate variations during the last 25 years could account for a change of 6% in the soil C at a site in Alberta, Canada.

Discussion:

H. P. Das (India) discussed carbon sequestration in Indian agro-ecosystems. The reversion of marginal agricultural land to forests (including shelterbelts and plantations), grasslands and wetlands represents a potential for C sequestration. Rate of C accumulation in reverted agricultural soils varies greatly depending on climate and soil conditions, the vegetation type established and the degree of the management. In India, historical losses of C observed in many soils are due, in part, to low production levels, erosion, inadequate fertilization, removal of crop residues and intensive tillage. Improved management of drained croplands, through conversion to conservation tillage and/or management of sub-surface drainage to keep soil moisture levels high, can increase soil organic carbon. Soil carbon sequestration can be further increased when cover crops are used in combination with conservation tillage and planting of perennial grasses and legumes.

During the open discussion, several points were raised. Soil respiration and modificaton of surface properties (albedo) have not been considered in the carbon study. Methods on soil carbon sequestration just presented are in keeping with the traditional technologies presented by the first speaker. In temperate countries, there is an advantage of the elimination of summer fallow. However, for developing countries, no tillage is a "win-win" solution. There could also be ways of reducing methane from rice production in tropical/subtropical regions.

SESSION 7: REDUCING VULNERABILITY TO CLIMATE VARIABILITY AND CLIMATE CHANGE: COMMUNICATION, EDUCATION, AND TRAINING

The session was chaired by Mr F. Lucio (Mozambique) who was assisted by Mr G. Garcia (Ecuador) as the rapporteur.

Paper: Role of education and training in agricultural meteorology to reduce vulnerability to climate variability
S. Walker, University of the Free State, Bloemfontein, South Africa

Summary:

Agricultural meteorologists are concerned with many operational aspects of the effects of climate on livestock and crop production. For them to continue to make a contribution to the economy of a country they must continually sharpen their skills and remain updated on the latest information available. Training should include a variety of skills including transferable skills (e.g. communication, numeracy), professional skills (including cognitive skills) and information technology skills. Problem-based learning can be used to promote critical thinking, decision making and analytical skills. More use should be made of Computer Aided Learning for agricultural meteorologists' in-service training. In particularly the Internet or CDs could be used to disseminate specific recently developed techniques and applications to improve the understanding of the variability in the climate and its effect on agricultural production. Examples that can address the vulnerability of farmers include crop-climate matching, the use of indices, crop modelling and risk assessment together with seasonal outlooks. A strategy needs to be formulated to address these needs and implement changes in the education and training of agricultural meteorologists.

Discussion:

S. Gachara (Kenya) discussed the need to create for education programs for the farmer community.

Byong-Lyol Lee (Republic of Korea) responded to Dr Walker's paper by discussing the need to form a network for filling the gap between state-of-art development and operational use. This can be done by the establishment of a Regional Meteorological Training Center (RMTC). He provided examples of such work being developed in the Republic of Korea. He also stressed agro-meteorologists need to enhance their IT skills because of increasing demands on climate and agronomic data for climate analysis at the regional scale, the inevitable use of computer technologies such as simulation models and GIS, and the need for agro-meteorological information sharing among countries for sustainable agriculture.

Barnabas Chipindu (Zimbabwe) provided information on opportunities to obtain Master of Science degrees in agricultural meteorology from the University of Zimbabwe. Scholarships were avaiable from Belgium and South Africa.

SESSION 8: REDUCING VULNERABILITY TO CLIMATE VARIABILITY AND CLIMATE CHANGE: FUTURE RESEARCH AND APPILCATIONS

Dr Zoltan Dunkel (Hungary) chaired the session and he was assisted by Dr Byong-Lyol Lee (Republic of Korea) as the rapporteur.

Paper: Agrometeorological research and applications needed to prepare agriculture and forestry adapt to 21st century climate change

V. Pérarnaud, Météo-France, Toulouse, France
B. Seguin, INRA, Avignon, France
E. Malezieux, CIRAD-DS, Montpellier, France
M. Deque, Météo-France, Toulouse, France
D. Loustau, INRA, Gazinet, France

Summary:

The adaptation of agriculture and forestry to the climate of the twenty-first century supposes that research projects will be conducted in cooperative actions between meteorologists, agronomists, pedologists, hydrologists, and modellers. To prepare for it, it is appropriate first of all to study the variations in the climate of the past using extensive, homogenised series of data (meteorological, phenological, etc.). General circulation models constitute the basic tool for forecasting the future climate. They may still be improved, and the regionalization techniques used for downscaling climate predictions could also be made more efficient. The crop simulation models using input data from the general circulation models applied at the regional level ought to be the favoured tools which allow the extrapolation of the major trends on yield, consumption of water, fertiliser, pesticides, the environment and rural development. For this, they have to be validated according to the available agronomical data, particularly the available phenological series on cultivated crops. In addition, a climatic change would have a certain impact on crop diseases and parasites, as well as on weeds. Very few studies have been carried out in this field. It is also necessary to quantify the stocks and fluxes of carbon in the large forest ecosystems, simulate their future, and assess the vulnerability of the various forest species. This is all the more important in that some choices of species must be made in the course of the next ten years in plantations which will experience the climate of the end of the twenty-first century. More broadly speaking, we shall have not only to try hard to research new agricultural and forestry practices which will reduce greenhouse gas emissions by agriculture and / or promote the storage of carbon, but it will also be indispensable to prepare the adaptation of numerous rural communities for the climatic changes (particularly those in the South countries, which are often under threat) by coming up with a series of new environmental management practices suited to the new climatic order.

Discussion:

L. Kaife-Bogataj (Slovenia) provided an overview of agriculture, climate change, and research needs relating to mountainous areas. The delicate agricultural balance with fragile mountain environments would be disrupted by climate changes, creating the potential for complete disruption of mountain communities, especially in the developing world. The issues that need to addressed in mountainous areas are improving and strengthening agrometeorological networks, improving downscaling techniques, identifying hazard-prone that are most vulnerable to natural hazards, fine tuning agrometeorological modelling, and research to protect the quality and supply of freshwater resources. There is a need for more international research cooperation which should contribute not only to the scientific understanding of the ongoing processes of climate change, but in the end to suggestions for action to preserve the ability of mountain agriculture to sustainably provide the goods and services on which humanity has come dependent.

S. Shami (Pakistan) discussed how plant growth is extremely vulnerable to weather & climate variability and the importance of heat units and chilling degrees days. Degree day units can be used in the long range planning of agriculture systems by designing irrigation schemes, choosing land use and farming patterns, and anticipating disease threats. Also, a close collaboration should exist between plant physiologist and agrometeorologists to exchange their research on the physiology of plant and agrometeorological forecast of phonological events.

SESSION 9: WORKSHOP RECOMMENDATIONS

Paper: Reducing vulnerability to climate variability and climate change in the 21st century: workshop summary and recommendations

M.J. Salinger, National Institute of Water and Atmospheric Research, Auckland, New Zealand
M.V.K. Sivakumar, WMO, Geneva, Switzerland
R. P. Motha, U.S. Department of Agriculture, Washington, DC, USA

Summary:

Global surface average temperature and sea level are projected to rise under all IPCC scenarios. At the same time climate variability is expected to continue on seasonal to interannual and decadal time scales owing to natural variability induced by such factors as ENSO events and the Interedecadal Pacific Oscillation. These will promote increasingly stronger impacts on agriculture and forestry.

Whether or not there will be significant climate change, this inherent climatic variability makes adaptation unavoidable. These are embedded on other land use issues of sustainability and retaining land productivity. Changes in erosion, degradation and environmental quality also require consideration. Improved management strategies though will be vital for coping with projected climate change during the 21st century. General overall adaptation and mitigation strategies include:

1. Standardization of crop models is required, with more studies on the rainy season commencement and rainfall distribution.
2. Changes in agronomic practices, such as earlier plant dates or cultivar substitution or microclimate modification to cool then environment are required.
3. Development of physiological based animal models with well developed climate components are needed urgently to cover gaps in knowledge and for future projections.
4. Improvement of carbon sequestration from agriculture and forestry by adopting permanent land cover, utilizing conservation tillage, reducing fallow land in summer, incorporating rotations of forage and improving nutrient management with fertilizers.

Adaptation strategies recommended for the tropics include:

1. Improved monitoring of crops and climate for management purposes.
2. Implementation of sustainable agriculture and forestry practices with the utilization of efficient water conservation strategies.
3. Development of innovative new technologies alongside traditional methods, and seeking active participation of local communities.

For temperate regions, the following adaptation and mitigation strategies were recommended:

1. Earlier planting and sowing of crops as temperatures increase. This will utilize the higher temperatures earlier in the growing season and result in conserving soil moisture.
2. Earlier planting with the use of long season cultivars to increase crop yields in regions with adequate soil moisture and low risk of heat stress.
3. The introduction of changed land allocation so as to stabilize production, conserve soil moisture with the use of shorter crop rotations and routine crop thinning in areas that experience higher precipitation, and reduction of drought during dry periods.
4. Reducing the impacts of drought and erosion with larger forestry plantation planting, later thinning and planting shelterbelts.
5. Application of integrated pest management techniques.
6. Prevention of overgrazing of grasslands to improve soil carbon levels, and inclusion of summer fallow areas to reduce emissions of nitrous oxide.
7. Introduction of reduced tillage intensity and summer fallow areas, improved manure management and feed rations with improved drainage and irrigation will all contribute to less emissions of carbon dioxide, methane and nitrous oxide.

Agronomic adaptation has been found to be very effective in mild-latitude developed countries, and less effective in lower latitude developing countries. With increasing climate change and variability though a wide range of adaptation strategies will be essential.

5 Outputs and Products

Outputs and products from this workshop:

- Capacity building of APN scientists to learn about the range of adaptation options for agriculture and forestry, including the use of technological advances, for reducing the vulnerability of the agroecosystems in the APN countries to climate variability and climate change and apply them in their projects
- Participation of the scientists from the APN countries to interact with the experts presenting state-of-the-art papers in the workshop and also with scientists from other regions participating in the workshop.
- A summary report of the workshop including the conclusions and recommendations in the six working languages of the World Meteorological Organization. Copies of this report will be distributed disseminated widely to all policy-makers in their networks. In addition, copies of the report will be made available at the sessions of the Conference of Parties (COP) of UNFCCC, UNCCD and CBD.
- Provided participants with a CD-RoM containing all workshop presentations.
- All keynote papers are currently being edited for punlication in a special volume of the international journal *Climatic Change*.

6 Conclusions

The International Workshop on Reducing Vulnerability of Agriculture and Forestry to Climate Variability and Climate Change took place at the Cankarjev Dom in Ljubljana, Slovenia from 7 to 9 October 2002. The workshop was organized by the World Meteorological Organization (WMO) and the Environmental Agency of the Republic of Slovenia and was co-sponsored by a number of national, regional, and international organizations. The Workshop was attended by 118 participants from 76 countries and two regional and international organizations who expressed their sincere appreciation to the Government of the Republic of Slovenia for hosting the Workshop.

The workshop addressed a range of important issues relating to climate variability, climate change, agriculture, and forestry including:

(i) The state of agriculture and forestry related to current and future climate variability and climate change;

(ii) The state of agroclimatological and agrometeorological information, including seasonal to interannual climate forecasts;

(iii) The potential adaptation strategies for agriculture and forestry to changing climate conditions and other pressures;

There is evidence that global warming over the last millennium has already resulted in increased global average annual temperature and changes in rainfall, with the 1990s being likely the warmest decade in the Northern Hemisphere at least. During the past century, changes in temperature patterns have had a direct impact on the number of frost days and the length of growing seasons with significant implications for agriculture and forestry. Land cover changes, changes in global ocean circulation and sea surface temperature patterns, and changes in the composition of the global atmosphere are leading to changes in rainfall. These changes may be more pronounced in the Tropics. For example, crop varieties grown in the Sahel may not be able to withstand the projected warming trends and will certainly be at risk due to projected lower amounts of rainfall as well.

Seasonal to inter-annual climate forecasts will definitely improve in the future with a better understanding of dynamic relationships. However, the main issue at present is how to make better use of the existing information and dispersion of knowledge to the farm level. The Regional Climate Outlook Forums now offer an opportunity to focus on these regional and local issues. Ensemble predictions appear to show the most promise, but the spatial scales need to become smaller in order to promote field applications of these forecasts. Pilot projects demonstrating the application of such information should be implemented. Direct participation by the farming communities in these pilot projects will be essential to determine the actual value of forecasts and to identify the specific user needs. Old (radio) and new (internet) communication techniques, when adapted to local applications, may assist in the dissemination of useful information to the farmers and decision makers.

Some farming systems with an inherent resilience may adapt more readily to climate pressures, making long term adjustments to varying and changing conditions. Other systems will need interventions for adaptation that should be more strongly supported by agrometeorological services for agricultural producers. This applies, among others, to systems where pests and diseases play an important role. To that end, as Mr. Franc But, the Honourable Minister of Agriculture, Forestry and Food of the Republic of Slovenia indicated at the opening of the Workshop, “Scientists have to guide policy makers in fostering an environment in which adaptation strategies can be effected." There is a clear need for integrating preparedness for climate variability and climate change.

In developed countries, higher trend yields, but with greater annual fluctuations and changes in cropping patterns and crop calendars can be expected with changing climate scenarios. Shifts in projected cropping patterns can be disruptive to rural societies in general. However, developed countries have the technology to adapt more readily to the projected climate changes. In many developing countries, the present conditions of agriculture and forestry are already marginal, due to degradation of natural resources, the use of inappropriate technologies and other stresses. For these reasons, the ability to adapt will be more difficult in the tropics and subtropics and in countries in transition.

Food security will remain a problem in many developing countries. Nevertheless, there are many examples of traditional knowledge, indigenous technologies and local innovations that can be used effectively as a foundation for improved farming systems. Before developing adaptation strategies, it is essential to learn from the actual difficulties faced by farmers to cope with risk management at the farm level. Agrometeorologists must play an important role in assisting farmers with the development of feasible strategies to adapt to climate variability and climate change. Agrometeorologists should also advise national policy makers on the urgent need to cope with the vulnerabilities of agriculture and forestry to climate variability and climate change. Adaptation to the adverse effects of climate variability and climate change is of high priority for nearly all countries, but developing countries are particularly vulnerable. Effective measures to cope with vulnerability and adaptation need to be developed at all levels. Capacity building must be integrated into adaptation measures for sustainable agricultural development strategies.

Consequently, the workshop urges all nations to consider the recommendations that address management practices, mitigation measures, and adaptation strategies to cope with the increasing vulnerability of agriculture to a rapidly changing climate. Furthermore, the workshop noted that its recommendations can not be universally applied. Nations must develop strategies that effectively focus on specific regional issues to promote sustainable development.

7 Future Directions

The recommendations of the workshop provide direct input for the WMO Commission for Agricultural Meteorology's workplan for 2003 – 2007. Three expert teams were formed with the following Terms of Reference.

1. Expert Team on Impact of Climate Change/Variability on Medium- to Long-Range Predictions for Agriculture

(a) To appraise and report on current capabilities in the analyses of climate change/variability and long-range prediction studies, specifically as they relate to and affect agriculture, rangelands, forestry and fisheries at the national and regional levels;

(b) To produce a review on the current status of methodologies for the presentation of seasonal to interannual prediction products and applications to the agricultural end user;

(c) To review the availability and suitability of software packages for the calculation of appropriate seasonal climate variability indices for agricultural applications;

(d) To make recommendations on research and development activities needed to improve the technology for the benefit of agriculture, rangelands, forestry and fisheries.

2. Exeprt Team on Contribution of Agriculture to the State of Climate

(a) To review estimates of greenhouse gas emissions from agroecosystems as well as recommend best management practices to reduce greenhouse gas emissions from agroecosystems;

(b) To assess the feedback mechanisms from human activities in agriculture, rangelands, forests and fisheries that may influence weather and climate at the local, national, regional and global levels;

(c) To document both positive and negative influences of agriculture on weather and climate systems;

(d) To investigate and report on how alterations or trends in national, regional and global agriculture will contribute to variations in the state of weather and climate systems;

(e) To develop guidelines for increasing awareness within farming communities of adaptation/mitigation strategies to address climate change issues;

(f) To make recommendations on research and development activities needed to better understand the contribution of agriculture, rangeland, forestry and fishery activities to the state of climate.

3. Expert Team on Reduction of the Impact of Natural Disasters and Mitigation of Extreme Events in Agriculture, Rangelands, Forestry and Fisheries

(a) To develop a list of requirements quantifying observational data needs, analytical tools, and information delivery mechanisms to facilitate greater early detection of extreme events to help mitigate their impacts on agriculture, rangelands, forestry and fisheries;

(b) To document national, regional, and global quidelines for awareness of potential natural disasters, and to make recommendations for early alert monitoring;

(c) To study prototype examples at the national level on how agrometeorological information is being used operationally to reduce the impact of natural disasters and extreme events, and compile a survey to be prepared for the Member countries;

(d) To make recommendations on research and development activities needed to better understand the potential risks to agriculture, rangelands, forestry and fisheries from natural disasters and extreme events.

APPENDIX 1: AGENGA

INTERNATIONAL WORKSHOP ON REDUCING VULNERABILITY OF AGRICULTURE AND FORESTRY TO CLIMATE VARIABILITY AND CLIMATE CHANGE

7-9 October 2002
Cankarjev Dom, Cultural and Congress Centre
Ljubljana, Slovenia

Provisional Programme

SUNDAY, 6 OCTOBER 2002

Participants arrive in Ljubljana

MONDAY, 7 OCTOBER 2002

08:30-09:30 hrs Registration at the **Cultural and Congress Centre**

SESSION 1
OPENING OF THE WORKSHOP
(*Chairman: K. Davidson)*

09:30 hrs Welcome

Andreja Čerček Hočevar
Director
Environmental Agency of the Republic of Slovenia

09:35 hrs Welcome from Convenors

R. P. Motha
President
Commission for Agricultural Meteorology
World Meteorological Organization

M. J. Salinger
Senior Scientist
National Institute of Water and Atmospheric Research
Auckland, New Zealand

M.V.K. Sivakumar
Chief
Agricultural Meteorology Division
World Climate Programme Department
World Meteorological Organization

09:55 hrs Welcome from co-sponsors

M. Salinger, APN
B. Angle, CIDA
R. Gommes, FAO
G. Maracchi, FMA
V. Perarnard, Météo-France
M.V.K. Sivakumar, START
D. Vento, UCEA
UNEP

R. Motha, USDA

10:30 hrs Workshop opening
Franc But, MA
Honourable Minister of Agriculture, Forestry and Food
Government of Slovenia

10:45 hrs Group Photo

10:50 hrs Tea/Coffee Break

SESSION 2
REDUCING VULNERABILITY OF AGRICULTURE AND FORESTRY TO CLIMATE VARIABILITY AND CLIMATE CHANGE: OVERVIEW
(*Chairman: L.E. Akeh Rapporteur: I. Matajc)*

11:15 hrs **Overview - Climate variability and climate change: Past, present and future**
M.J. Salinger, National Institute of Water and Atmospheric Research, Auckland, New Zealand

11:40 hrs Discussant 1
Discussant 2
Discussant 3

11:55 hrs General Discussion

12:15 hrs Lunch

SESSION 3
IMPACTS OF CLIMATE VARIABILITY IN THE TROPICS
(*Chairman: G. Maracchi Rapporteur: P. Doraiswamy)*

14:00 hrs **Impacts of present and future climate variability on agriculture and forestry in the arid and semi-arid tropics**

M.V.K. Sivakumar, WMO, Geneva, Switzerland
O. Brunini, **Center for Ecology and Biophysics, Campinas, Brazil**
H. P. Das, India Meteorological Department, Pune, India

14:25 hrs Discussant 1
Discussant 2
Discussant 3

14:40 hrs General Discussion

15:00 hrs **Impacts of present and future climate variability on agriculture and forestry in the sub-humid and humid tropics**
Yanxia Zhao, Chunyi Wang, and Shili Wang, China Meteorological Administration, Beijing, China
Lourdes Tibig, Phillippine Atmospheric, Geophysical and Astronomical Services Administration, Quezon City, Phllippines

15:25 hrs Discussant 1
Discussant 2
Discussant 3

15:40 hrs General Discussion

16:00 hrs Tea/Coffee Break

SESSION 4
IMPACTS OF CLIMATE VARIABILITY IN THE TEMPERATE REGIONS
(*Chairman: A. Harou* *Rapporteur: A. Kleschenko)*

16:30 hrs **Impacts of present and future climate variability on agriculture and forestry in the temperate regions: Europe**
G. Maracchi, IATA-CNR, Florence, Italy
O. Sirotenko, ARRIAM, Obninsk, Russia
M. Bindi, IATA-CNR, Florence, Italy

16:55 hrs Discussant 1
Discussant 2
Discussant 3

17:10 hrs General Discussion

17:30 hrs Adjournment

TUESDAY, 8 OCTOBER 2002

SESSION 4
IMPACTS OF CLIMATE VARIABILITY IN THE TEMPERATE REGIONS (Contd.)

08:30 hrs **Impacts of present and future climate variability on agriculture and forestry in the temperate regions: North America**
R. P. Motha, U.S. Department of Agriculture, Washington, DC, USA
W. Baier, Eastern Cereal and Oilseed Research Centre, Ottawa, Canada

08:55 hrs Discussant 1
Discussant 2
Discussant 3

09:10 hrs General Discussion

09:30 hrs **Global warming in the 21st century: impacts on agricultural and forestry ecosystems**
W. Easterling, Pennsylvania State University, University Park, US
M. Apps

09:55 hrs Discussant 1
Discussant 2
Discussant 3

10:10 hrs General Discussion

10:30 hrs Tea/Coffee Break

SESSION 5
REDUCING VULNERABILITY TO CLIMATE VARIABILITY AND CLIMATE CHANGE: ADAPTATIONS AND APPLICATIONS
(*Chairman: H.P. Das* *Rapporteur: Lee Seng Tan)*

11:00 hrs **Achieving adequate adaptation in agriculture**

I. Burton, Meteorological Services of Canada, Ontario, Canada

B. Lim, United Nations Development Programme, New York, USA

11:25 hrs Discussant 1
Discussant 2
Discussant 3

11:40 hrs General Discussion

12:00 hrs Lunch

14:00 hrs **The development of seasonal and inter-annual climate forecasting**
M. Harrison, United Kingdom Met Office, London, UK

14:25 hrs Discussant 1
Discussant 2
Discussant 3

14:40 hrs General Discussion

15:00 hrs **Seasonal and inter-annual climate forecasting: the new tool for increasing preparedness to climate variability and change in agricultural planning and operations**
H. Meinke, Department of Primary Industries, Toowoomba, Australia
R. Stone, Department of Primary Industries, Toowoomba, Australia

15:25 hrs Discussant 1
Discussant 2
Discussant 3

15:40 hrs General Discussion

16:00 hrs Tea/Coffee Break

16:30 hrs **Tomorrow's Forests: Adapting to a changing climate**
I. Burton, Meteorological Services of Canada, Downsview, Canada
D. MacIver, Meteorological Services of Canada, Downsview, Canada
E. Wheaton, Saskatchewan Research Council, Saskatoon, Canada

16:55 hrs Discussant 1
Discussant 2
Discussant 3

17:10 hrs General Discussion

17:30 hrs Adjournment

WEDNESDAY, 9 OCTOBER 2002

SESSION 6
REDUCING VULNERABILITY TO CLIMATE VARIABILITY AND CLIMATE CHANGE: TECHNOLOGY AND STRATEGIES
(*Chairman: R. Stringer* *Rapporteur: R. Frutos)*

08:30 hrs **Using traditional methods and indigenous technologies for coping with climate variability**
C. Stigter, University of Wageningen, Wageningen, Netherlands
Z. Dawei, China Agricultural University, Beijing, China
M. Xurong, Chinese Academy of Agricultural Sciences, Beijing, China
L. Onyewoto, Forestry Research Institute of Nigeria, Kano, Nigeria

08:55 hrs Discussant 1
Discussant 2
Discussant 3

09:10 hrs General Discussion

09:30 hrs **Management strategies with particular emphasis on carbon sequestration to mitigate greenhouse gas emissions from agroecosystems**
R. Desjardins, W. Smith, B. Grant, C. Campbell, H. Janzen, and R. Riznek, Agriculture and Agri-Food Canada, Ottawa, Canada

09:55 hrs Discussant 1
Discussant 2
Discussant 3

10:10 hrs General Discussion

10:30 hrs Tea/Coffee Break

SESSION 7
REDUCING VULNERABILITY TO CLIMATE VARIABILITY AND CLIMATE CHANGE: COMMUNICATION, EDUCATION, AND TRAINING
(*Chairman: R. Muchinda* *Rapporteur: M. Carvajal)*

11:00 hrs **Climate, Communications, and Innovative Technologies: Potential Impacts and Sustainability of New Radio and Internet Linkages in Rural African Communities**
M.S. Boulahya, ACMAD, Niamey, Niger
M.S. Cerda, Institute of International Education
M. Pratt, University of Wisconsin-Madison and USAID, Madison, USA
K. Sponberg, Office of Global Programs

11:25 hrs Discussant 1
Discussant 2
Discussant 3

11:40 hrs General Discussion

12:00 hrs Lunch

14:00 hrs **Role of education and training in agricultural meteorology to reduce vulnerability to climate variability**
S. Walker, University of the Free State, Bloemfontein, South Africa

14:25 hrs Discussant 1
Discussant 2
Discussant 3

14:40 hrs General Discussion

SESSION 8
REDUCING VULNERABILITY TO CLIMATE VARIABILITY AND CLIMATE CHANGE: FUTURE RESEARCH AND APPILCATIONS
(*Chairman: Z. Dunkel* *Rapporteur: Shili Wang)*

15:00 hrs **Agrometeorological research and applications needed to prepare agriculture and forestry adapt to 21st century climate change**
V. Perarnaud, Météo-France, Toulouse, France
B. Seguin, INRA, Avignon, France
E. Malezieux, CIRAD-DS, Montpellier, France
M. Deque, Météo-France, Toulouse, France
D. Loustau, INRA, Gazinet, France

15:25 hrs Discussant 1
Discussant 2
Discussant 3

15:40 hrs General Discussion

16:00 hrs Tea/Coffee Break

SESSION 9
WORKSHOP RECOMMENDATIONS

16:30 hrs **Reducing vulnerability of agriculture and forestry to climate variability and change in the 21st century: workshop summary and recommendations**
M.J. Salinger, National Institute of Water and Atmospheric Research, Auckland, New Zealand
M.V.K. Sivakumar, WMO, Geneva, Switzerland
R. P. Motha, U.S. Department of Agriculture, Washington, DC, USA

17:00 hrs Discussion

SESSION 10
WORKSHOP CLOSURE

17:30 hrs Workshop Declaration
C.J. Stigter
University of Wageningen, Wageningen, Netherlands

17:40 hrs Vote of Thanks on Behalf of Co-convenors
M.V.K. Sivakumar, WMO, Geneva, Switzerland

17:50 hrs Workshop closure

APPENDIX 2. LIST OF PARTICIPANTS

Albania

Petrit **Zorba**

Chief
Agrometeorological Section
Hydrometeorological Institute
Dr. Durresit
Z.P. 219
TIRANA
Tel. 355 42 22439
Fax 355 42 29317/23518
Email aspetalr@yahoo.com

Armenia

Valentina **Grigoryan**

Head of International cooperation department
Department of Hydrometeorology
ARMHYDROMET
54 Leo Str.
375002 YEREVAN
Tel. 3741 532001
Fax 3741 533575
Email armhydromet@meteo.am

Australia

Holger **Meinke**

Principal Scientist
Research Unit (APSRU-DPI)
Australian Agricultural Production Systems
P.O. Box 102
TOOWOOMBA Q4350
Tel. 61 7 46881378
Fax 61 7 46881193
Email holger.meinke@dpi.qld.gov.au

Russell **Stringer**

Surface Based Observations
Observations and Engineering Branch
Bureau of Meteorology
GPO Box 1289K
MELBOURNE VIC 3001
Tel. 61 3 9669 4225
Fax 61 3 9669 4695
Email r.stringer@bom.gov.au

Bangladesh

Asadur **Rahman**

Assistant Director
Bangladesh Meteorological Department
Agargaon
DHAKA 1207
Tel. 880 2 811 6634
Fax 880 2 811 8230
Email bmddhaka@bttb.net

Belarus

Victor **Melnik**

Head of Planning Section
Department of Hydrometeorology
State Committee for Hydrometeorology
16, Komsomolskaya Street
220050 MINSK
Tel. 37 517 223 5362
Fax 37 517 223 5663
Email depmet@bg.mecom.ru

Bolivia

Edgar **Imaña-Maldonado**

Ministerio de Desarrollo sostenible y planificacíon
Servicio Nacional de Meteorología e Hidrología
Calle Reyes Ortiz No. 41
Piso 3
Casilla Correo 10993
LA PAZ
Tel. 591 2 326165/355824
Fax 591 2 392413
Email edgaimana@hotmail. com
Agromet@entelnet.bo

Bosnia and Herzegovina

Sabina **Hodžić**

Head of the Applied Meteorology

Tel. 387 33 276717
Fax 387 33 276701
Email fmzbih@net.ba
fnizbih@net.ba

Brazil

Orivaldo **Brunini** Director

Center of Ecophysiology and Biophysics
Agronomic Institute
Av. Barao de Itapura No. 1481
13020-902 CAMPINAS
Tel. 55 19 2415188
Fax 55 19 2425230
Email brunini@cec.iac.br

Expedito **Rebello**

Chief
Division of Agrometeorology
Instituto Nacional de Meteorologia
Eixo Monumental Via S-1 Setor Sudoeste
BRASILIA-DF 70680-900
Tel. 5561 344 9944
Fax 5561 344 0700
Email rebello@inmet.gov.br

Bulgaria

Zornitsa **Popova**

Senior Scientific Researcher
N. Poushkarov
Institute of Soil Science
7 Shosse Bankya Str.
SOFIA 1080 00359
Tel. 2 24 77 98 00359
Fax 2 24 89 37
Email zornitsa@techno-link.com

Cape Verde

Maria A. **Martins**

Director, Department of Agrometeorology
Institut Nat. de la météorologie et de la géophysique
Morro Curral Espargos
BP 76
ILHA DO SAL
Tel. 238 617891
Fax 238 411294
Email snmg.dgc@cvtelecom.cv

Canada

Ian **Burton**

Environmental Adaptation Research Group
Meteorological Service of Canada
4905 Dufferin Street
DOWNSVIEW ONT M3H 5T4
Tel. 1 416 739 4314
Fax 1 416 739 4297
Email ian.Burton@ec.gc.ca

Raymond **Desjardins**

Research Scientist
Neatby Bldg. Research Branch
Agriculture and Agri-food Canada
Central Experimental Farm
960 Carling Avenue
OTTAWA Ontario K1A 0C6
Tel1 613 7591522
Fax1 613 7591432
Email desjardins@em.agr.ca
desjardins@agr.ga.ca

Abdoulaye **Harou**

Senior Sector Development Specialist
Meteorological Service of Canada
Environment Canada
10 Wellington, 4th Floor
HULL, QUEBEC K1A OH3
Tel 819 997 3845
Fax 819 994 8864
Email abdoulaye.harou@ec.gc.ca

Bruce **Angle**

Senior Advisor
Meteorological Service of Canada
Environment Canada
10 Wellington, 4th Floor
HULL, QUEBEC K1A OH3
Tel. 819 997 3844
Fax 819 994 8854
Email bruce.angle@ec.gc.ca

Central African Republic

Martin **Tomou**

Chef Service Agrométéorologie et Climatologie
Direction de la Météorologie
BP 941
BANGUI
Tel. 236 610636
Fax 236 610636

Chile

Miguel **Egaña**

Agrometeorologist
Direccíon Meteorologica de Chile
Casilla 63 Correo
Aeropuerto Internacional
SANTIAGO
Tel. 56 2 6763431
Fax 56 2 6019590
Email megana@meteorologos.cl

China

Yanxia **Zhao**

Associate Professor
Chinese Academy of Meteorological Sciences
China Meteorological Administration
No. 46 Zhongguancun Nandajie
100081 BEIJING
Tel. 86 010 68409525
Fax 86 010 62174797
Email zyx@cams.cma.gov.cn

Cook Islands

William **Wigmore**

Director of Research
Totokoitu Research Station
P.O. Box 96
RAROTONGA
Tel. 682 26 720
Fax 682 21 881
Email cimoa@oyster.net.ck

Croatia

Drazen **Kaucic**

Higher adviser
Meteorological and Hydrological Service
Gric 3
10000 ZAGREB
Tel.
Fax 385 1 4565759
Email kaucic@cirus.dhz.hr

Czech Republic

Jaroslav **Roznovský**

Head of Branch
Czech Hydrometeorological Institute
Kroftova 43
616 67 BRNO
Tel. 00420 5 41421020
Fax 00420 5 41421019
Email roznovksy@chmi.cz

Jiři **Nekovář**

Agrometeorologist - Phenologist
Czech Hydrometeorological Institute
Na Šabatce 17
Komorany
CZ-14306 PRAGUE 4
Tel. 00420 244 03 22 61
Fax 00420 244 03 21 28
Email jiri.nekovar@chmi.cz

Ecuador

Gustavo ***García***

Director de Meteorología
Instituto Nacional de Meteorología e Hidrología
INAMHI
Iñaquito 700 (N 36-14) y Corea
Casilla postal 16-310
QUITO
Tel. 2464 417
Fax 2433 934 / 2265 330
Email ggarciad@inamhi.gov.ec

Egypt

Mohamed **Dawod**

Director of Boundary Layer of Atmospheric Research Dept.
Egyptian Meteorological Authority
Koubry El-Quobba
PO Box 11784
CAIRO
Tel. 20 2 6820790
Fax 20 2 6849857
Email mo_dawod@hotmail.com

Fiji

Simon **McGree**

Acting Climate Applications & Developments Manager
Fiji Meteorological Service
Private Mail Bag NAP0351
NADI Airport
Tel. 6796 7 22500
Fax 6796 7 20430
Email Simon.McGree@met.gov.fj

Finland

Lea **Leskinen**
Senior Advisor
Finnish Meteorological Institute (FMI)
P.O. Box 503
00101 HELSINKI
Tel. 358 9 1929 3380
Fax 358 9 1929 3303
Email lea.leskinen@fmi.fi

France

Victorine **Pérarnaud**
Direction des Systèmes d'observation
Coordination Etude et Prospective
Météo-France
42 Avenue Coriolis
31057 TOULOUSE Cedex
Tel. 33 5 6107 9930
Fax 33 5 6107 8079
Email victorine.perarnaud@meteo.fr

Bernard **Seguin**
Director, Unit Agroclim
Institut national de la recherche agronomique (INRA)
Site Agroparc Domaine St Paul
F-84914 AVIGNON
Tel. 33 432 72 23 07
Fax 33 432 72 23 62
Email seguin@avignon.inra.fr

Emmanuel **Cloppet**
Responsable de la Division agrométéorologie
Météo-France
42 Avenue Coriolis
31057 TOULOUSE Cedex
Tel. 33 5 6107 8381
Fax
Email emmanuel.cloppet@meteo.fr

Gambia

Momodou Pateh **Bah**
Meteo/Agrometeorological Officer
Department of Water Resources
7, Marina Parade
BANJUL
Tel. 220 228216 201559
Fax 220 225009
Email dwr@gamtel.gm

Georgia

Tamaz **Tourmanidze**
Vice-chairman of Georgia State Department of Hydrometeorology
State Department of Hydrometeorology of Georgia
150 pr. Davida Agmashenbeli
TBILISI
Tel. 380012 995 32 955321
Fax 995 32 955006
Email tourmanidze@yahoo.com

Ghana

Michael **Tanu**
Principal Meteorologist
Ghana Meteorological Services Department

P.O. Box LG 87
Legon
ACCRA
Tel. 233 21 7012519
Fax 233 21 511978
Email meteo@africaonline.com.gh

Guinea

Namory **Diakite**

Chef, Division de météorologie appliquée
Direction nationale de la météorologie
BP 566
CONAKRY
Tel. 224 45 48 15
Fax 224 41 35 77
Email metogui@sotelgui.net.gn

Guinea Bissau

Feliciana **Mendonça**

Serviciço Meteorologico National
Caixa Postal No. 75
1001 BISSAU
Tel. 245 212332
Fax
Email

Hungary

Zoltán **Dunkel**

Head of Division
Hungarian Meteorological Service
P.O. Box 38
H-1525 BUDAPEST
Tel. 36 1 3464664
Fax 36 1 3464665
Email dunkel.z@met.hu

India

Haripada P. **Das**

Director (Agrimet)
Office of Deputy Director General of Meteorology
(Agricultural Meteorology)
India Meteorological Department
Ganesh Khind Road
PUNE
Tel. 411005 91 20 325211 Ext. 320
Fax 91 20 5533201
Email hpd_ag@hotmail.com

Indonesia

Antoyo **Setyadipratikto**

Agrometeorologist
Bureau of Meteorology and Geophysics
Jl. Angkasa 1 N° 2
P.O. Box 3540 JKT
JAKARTA 10720
Tel. 62 21 4246321
Fax 62 21 4246703
Email antoyo_s@hotmail.com

Islamic Republic of Iran

Keivan **Noohi**

Meteorological Organization

P.O. Box 13185-461
TEHRAN
Tel. 9821 6025047
Fax 9821 6000417
Email intl-affairs@irimet.net

Hossein **Bariabarghouei**
Meteorological Organization
P.O. Box 13185-461
TEHRAN
Tel. 9821 6025047
Fax 9821 6000417
Email intl-affairs@irimet.net

Italy

Giampiero **Maracchi**
Director
National Research Council
Institute of Biometeorology
P.le delle Cascine, 18
I-50144 FIRENZE
Tel: 39 55 354895-7 / 39 335 439286
Fax: 39 55 350833
Email: maracchi@sunserver.iata.fi.cnr.it

Marco **Bindi**
Researcher, National Research Council
Institute of Agrometeorology and
Environmental Analysis for Agriculture
P.le delle Cascine, 18
I-50144 FIRENZE
Tel: 39 55 354895-7
Fax: 39 55 350833
Email: bindi@sunserver.iata.fi.cnr.it

Domenico **Vento**
General Coordinator of CLIMAGRI
Ufficio Centrale di Ecologia Agraria
Via del Caravita 7A
00186 ROMA
Tel. 669787558
Fax 669531237
Email dvento@ucea.it

Anna **Tritto**
Ufficio Centrale di Ecologia Agraria
Via del Caravita 7A
00186 ROMA
Tel. 669787558
Fax 669531237
Email atritto@ucea.it

Jordan

Fayez **Abdo**

Director, Agrometeorological Directorate
Jordan Meteorological Department
Amman Civil Airport
PO Box 341011
Amman 11134
Tel. 962 6 4892 408
Fax 962 6 4894 409
Email fzabdo@yahoo.com

Kazakstan

Lubov **Lebed**

Manager of the Group Agrometeorology
Subsidiary State Enterprise
Kazakh Scientific and Research Institute for Environment & Climate Monitoring
Pr. Seifulin, 597
480072 ALMATY
Tel. 7 3272 625793
Fax 7 3272 542270/542285
Email general@kniimosk.almaty.kz or llebed@softhome.net

Kenya

Stanslaus M. **Gachara**

Assistant Director Training
Kenya Meteorological Department
P.O. Box 30259
NAIROBI
Tel. 254 2 567880
Fax 254 2 567955
Email gachara@lion.meteo.go.ke

Korea, Republic of

Byong-Lyol **Lee**

Senior Scientist
National Center for Agrometeorology
Suwon Met. Office
208-16 Seodun-dong, Gwonson-gu
SUWON 441-856
Tel. 82 31 291 0170
Fax 82 31 291 0366
Email bllee@kma.go.kr

Kyrgyz Republic

Galina **Shiryaeva**

Engineer-agrometeorologist
Agency for Hydrometeorology
1, Kerimbekov Str.
BISHKEK 720017
Tel. 996 312 21 44 65
Fax 996 312 21 44 22
Email kgmeteo@kyrgyzmeteo.elcat.kg

Lesotho

Mokhele **Moeletsi**

Agrometeorologist
Lesotho Meteorological Services
P.O. Box 14515
MASERU
Tel. 266 22 324 374
Fax 266 22 324 374
Email moeletsi@lesmet.or.ls
mmoeletsi@hotmail.com

Libyan Arab Jamahiriya

Salah **Amar**

Head of Agrometeorological Unit
Libyan Meteorological Department
P.O. Box 5069
TRIPOLI
Tel. 218 21 3606655
Fax 218 21 360 66 55
Email salah_amar@hotmail.com

Fadla Alla **El Mansuri**

Libyan Meteorological Department
P.O. Box 352
DERNA
Tel. 081 634877
Fax 021 3606655

Macedonia, Republic of

Silvana **Stevkova**

Adviser for agrometeorology
Hydrometeorological Service
Skupi bb
1100 SKOPJE
Tel 389 2 397 004
Fax 389 2 397 118
Email silvanas@meteo.gov.mk

Nina **Aleksovska**

Head of Meteorological – Climatological Department
Hydrometeorological Service
Skupi BB
1100 SKOPJE
Tel. 389 2 397 004
Fax 389 2 397 118
Email naleksovka@meteo.gov.mk

Ilyn **Panov**

Dep. Director
Hydrometeorological Service
Skupi bb
1000 SKOPJE
Tel. 389 2 397 103
Fax 389 2 397 118
Email

Madagascar

Désiré **Randrianoro**

Chef de Division
Service de la météorologie
Direction générale de la météorologie et de l'hydrologie
BP 1254
ANTANANARIVO 101
Tel. 261 20 22 402 41
Fax 262 20 422 405 81
Email meteo@dts.mg

Malawi

Gray **Munthali**

Deputy Director
Meteorological Department
Ministry of Transport
Meteorological Services
P.O. Box 2
CHILEKA
Tel. 265 1 692 333
Fax 265 1 692 329
Email metdept@metmalawi.com

Malaysia

Lee Seng **Tan**

Director, Division of Agrometeorology
Malaysian Meteorological Service
Jalan Sultan
46667 PETALING JAYA
Selangor D.E.
Tel. 60 3 79678221
Fax 60 3 79563621
Email tls@kjc.gov.my

Maldives

Aslam **Rasheed**

Director General
Department of Meteorology
Orhaid Building
MALE
Tel. 960 337637 / 325766
Fax 960 320021
Email metmaldv@dhivehinet.net.mv

Mali

Djibrilla **Maiga**

Ingénieur principal en agrométéorologie
Direction nationale de la météorologie
BP 237
BAMAKO
Tel. 223 292101
Fax 223 292101
Email dnm@malinet.fr
djibamaigfr@yahoo.fr

Mauritania

Yelli **Gandega**

Chef, Service des Statistiques et Prévision
Direction de l'élevage et de l'agriculture
Ministère du Développement Rural et de l'Environnement
B.P. 620
NOUAKCHOTT
Tel. 222 631 9601
Fax 222 525 7879
Email ssp@toptechnology.mr
oasis@opt.mr

Mauritius

Premchand **Goolaup**

Agrometeorologist
Meteorological Services
St Paul Road
VACOAS
Tel. 230 6861031/32
Fax 230 6861033
Email meteo@intnet.mu

Mongolia

Dolgorsuren **Azzaya**

Director
Institute of Meteorology and Hydrology
Khydaldaany gudamj-5
ULAANBAATAR 210646
Tel. 976 11 326614
Fax 976 11 326614
Email azzaya23@yahoo.com

Morocco

Abdelaziz **El Ouali**

Chef de Service
Responsable du Programme AGROMETEO
Direction de la Météorologie Nationale
BP 8106
Casa-Oasis
CASABLANCA
Tel. 212 22 91 3803
Fax 212 22 91 3797
Email elouali@mtpnet.gov.ma

Mozambique

Filipe **Lúcio**

National Director
Instituto Nacional de Meteorología de Moçambique
Rua de Mukumbura 164
P.O. Box 256
MAPUTO
Tel. 258 1 493193
Fax 258 1 491150
Email flucio@inam.gov.mz

Moldova, Republic of

Tatiana **Mironova**

Chief of the Agrometeorological Forecasting Department
State Service Hydrometeo
Ministry of Ecology, Constructions & Territorial Development
193 Grenoble Str.
Chisinau 11D-2043
Tel. 373 2 773529
Fax 373 2 773636
Email berghi1976@hotmail.com

Nepal

Ramesh **Regmi**

Chief, Agrometeorology Section
Department of Hydrology & Meteorology
P.O. Box 406
Babar Mahal
KATHMANDU
Tel. 977 1 255920
Fax 977 1 254890
Email meteo@wlink.com.np

Netherlands

Cornelis **Stigter**

Chair of Meteorology and Air Quality
Guest scientist at Chair
Department of Environmental Sciences
Wageningen University & Research Centre
Duivendaal 2
6701 AP WAGENINGEN
Tel. 31 317 483332/345 502411(home)
Fax: 31 317 482811
Email: kees.stigter@wur.nl

New Zealand

James **Salinger**

Senior Climate Scientist
National Institute of Water
Atmospheric Research
P.O. Box 109-695
Newmarket
AUCKLAND
Tel. 64 9 3752053
Fax: 64 9 3752051
Email: j.salinger@niwa.cri.nz

Alan **Porteous**

Agricultural Climatologist
Climate Applications Group
National Institute of Water and Atmospheric Research
NIWA
P.O. Box 14901
WELLINGTON 6002
Tel. 64 4 3860300
Fax 64 4 3860341
Email a.porteous@niwa.co.nz

Niger

Assoumane **Bouba**

Chief, Climatology
Direction de la Météorologie Nationale
BP 218
Niamey
Tel. 227 73 21 60
Fax 227 73 38 37
Email assomane@yahoo.fr

Nigeria

Lihwu E. **Akeh**

Director General
Meteorological Services Department
P.M.B. 12542
LAGOS
Tel. 234 9 5232240
Fax 234 1 5238357
Email leakeh@yahoo.com

Modupe A. **Ogunwale**

Deputy-Director
Agricultural Meteorological Section
Nigerian Meteorological Services
Private Mail Bag 12542
LAGOS
Tel. 234 1 2633371
Fax 234 1 2636097
Email maogunwale@netscape.net

Pakistan

Saifullah **Shami**

Deputy Director Regional
Agrometeorological Centre
c/o Director Geophysical Centre
PO Box N° 2
QUETTA
Tel. 92 81 853034
Fax 92 81 853032
Email metq@qta.paknet.com.pk

Philippines

Lourdes **Tibig**

Chief
Climate Data Section
Section Climatology and Agrometeorology Branch
PAGASA
1424 Quezon Avenue
QUEZON CITY
Tel. 63 2 3733429
Fax 63 2 3733434
Email cab@philonline.com.ph AND
lvtibig@yahoo.com

Poland

Jan **Zielinski**
Director General
Institute of Meteorology and Water Management
61, Podlesna str.
01-673 WARSAW
Tel. 48 22 8341851
Fax 48 22 8341851
Email zielinski.jan@imgw.pl

Piotr **Kowalczak**
Branch Director
Institute of Meteorology and Water Management Ul.
Dabrowskiego 174/176
60-594 POZNAN
Tel. 48 61 8495160
Fax 48 61 8475 440
Email dyr_imgw@rose.man.poznan.pl

Jerzy **Kozyra**
Research Assistant
Institute of Soil Science and Plant Cultivation in Pulawy
Department of Agrometeorology and Applied Informatics
Ul. Gzartoryskich 8
24-100 PULAWY
Tel. 48 81 88 63 421
Fax
Email kozyr@iung.pulawy.pl

Portugal

Rita **Guerreiro**
Head, Division of Agrometeorology
Institute of Meteorology
Rua e Aeroporto
1749-077 LISBOA
Tel. 351 21 8483961
Fax 351 21 8402370
Email rita.guerreiro@meteo.pt

Russian Federation

Alexander D. **Kleschenko**
Director
All-Russian Research Institute for Agricultural Meteorology
(ARRIAM)
Lenin Street, 82
Kaluga Region
249020 OBNINSK
Tel. 7 084 3944599 OR 7 084 3964706
Fax 7 084 3944388
Email cxm@meteo.ru
cxm@obninsk.ru

Oleg D. **Sirotenko**

Head of Department
All-Russian Research Institute for Agricultural Meteorology
(ARRIAM)
Lenin Street 82
Kaluga Region
249020 OBNINSK
Tel. 7 084 39 71471/31046
Fax 7 084 39 71446
Email adm@cxm.mskw.mecom.ru

Rwanda

Désiré **Disi**

Chef de Section d'agrométéorologie
Division de la Météorologie
Ministère des Travaux publics, transports et communications
PB 898
Kigali
Tel. 250 57 58 13
Fax 250 57 29 71
Email meteo@rwanda1.com

Slovenia

France **Batič**

University of Ljubljana
Biotechnical Faculty
Ljubljana
Tel. 386 1 423 11 61
Fax 386 1 423 10 88
Email france.batic@bf.uni-lj.si

Klemen **Bergant**

University of Ljubljana
Biotechnical Faculty
Jamnikarjeva 101
Ljubljana
Tel. 386 1 423 11 61
Fax 386 1 423 10 88
Email klemen.bergant@bf.uni-lj.si

Tanja **Cegnar**

Environmental Agency of the Republic of Slovenia
Ljubljana
Tel. 386 1 478 40 79
Fax 386 1 478 40 54
Email tanja.cegnar@rzs-hm.si

Janez **Čepljak**

Ministry of Agriculture, Forestry and Food
Ljubljana
Tel. 386 1 478 91 53
Fax 386 1 478 91 75
Email janez.cepljak@gov.si

Zalika **Črepinšek**

University of Ljubljana
Biotechnical Faculty
Jamnikarjeva 101
1000 Ljubljana
Tel. 386 1 423 11 61
Fax 386 1 423 10 88
Email zalika.crepinsek@bf.uni-lj.si

Matej **Gabrovec**

Anton Melik Geographical Institute
ZRC SAZV
Gosposka 13
Ljubljana
Tel. 386 1 470 63 64
Fax 386 1 425 77 93
Email matej@zrc-sazu.si

Andrej **Hočevar**

Retired Prof. in agrometeorology
Pod Topoli 82
Ljubljana
Tel. 041 841 754
Fax 01 2833 277
Email andrej.hocevar@bf.uni-lj.si

Ignac **Janžekovič**

Assistant Lecturer of Biology
Ignacij Janžekovič
Brstje 26b
2250 PTUJ
Tel. 386 2 25 05 800
Fax 386 2 229 60 71
Email ignac.janzekovic@uni-mb.si

Lučka **Kajfež-Bogataj**

University of Ljubljana
Biotechnical Faculty
Jamnikarjeva 101
1000 Ljubljana
Tel. 386 1 423 11 61
Fax 386 1 423 10 88
Email lucka.kajfez.bogataj@bf.uni-lj.si

Vlasta **Knapič**

Ministry of Agriculture, Forestry and Food
Administration for Plant Protection
Dunasska 58
1000 Ljubljana
Tel. 386 1 478 91 53
Fax 386 1 478 91 75
Email vlasta.knapic@gov.si

Matej **Knapič**

Institute of Hop Research and Brewing
Ljubljana
Tel. 386 3 712 16 36
Fax 386 3 712 16 20
Email matej.knapic@uni-lj.si

Brane **Matičič**	President Slovenian National Committee on Irrigation and Drainage – SINCID University of Ljubljana c/o IZVOR, Preradovičeva 44 1000 Ljubljana Tel. 386 1 2317 913 / 661 267 Fax 386 1 433 51 04 Email sdno-sincid@guest.arnes.si brane.maticic@guest.arnes.si
Marina **Pintar**	University of Ljubljana Biotechnical Faculty Ljubljana Tel. 386 1 423 11 61 Fax 386 1 423 10 88 Email marina.pintar@bf.uni-lj.si
Primož **Simončič**	Slovenian Forestry Institute Ljubljana Tel. 386 1 200 78 07 Fax 386 1 257 35 89 Email primoz.simoncic@gozdis.si
Andreja **Sušnik**	Environmental Agency of the Republic of Slovenia Vojkova 1b 1000 Slovenia Ljubljana Tel. 386 1 478 4073 Fax 386 1 478 4054 Email andreja.susnik@rzs-hm.si
Urša **Vilhar**	Večma pot 2 Slovenian Forestry Institute 1000 Ljubljana Tel. 386 1 200 78 00 Fax 386 1 257 35 89 Email ursa.vilhar@gozdis.si
Marko **Zmrzlak**	Institute of Hop Research and Brewing Ljubljana Tel. 386 3 712 16 16 Fax 386 3 712 16 20 Email marko.zmrzlak@guest.arnes.si
Vesna **Zupanc**	University of Ljubljana Biotechnical Faculty Ljubljana Tel. 386 1 423 11 61 Fax 386 1 423 10 88 Email vesna.zupanc@bf.uni-lj.si
Ana **Žust**	Environmental Agency of the Republic of Slovenia Vojkova 1B Ljubljana Tel. 386 1 478 40 74

Fax 386 1 478 40 54
Email ana.zust@rzs-hm.si

South Africa
Sue **Walker**
Professor of Agrometeorology
Department of Soil, Crop and Climate Sciences
University of the Free State
P.O. Box 339
BLOEMFONTEIN 9300
Tel. 27 51 401 2222
Fax 27 51 401 2212
Email walkers.sci@mail.uovs.ac.za

Sudan
Haroun **Abdalla**
Director of Research, Training & Information
Meteorological Authority
PO Box 574
Khartoum
Tel. 249 11 778837
Fax 249 11 771693
Email ersad@sudanmail.net

Sri Lanka
Abhayasingha **Bandara**
Deputy Director
Department of Meteorology
Bauddhaloka Mawatha
COLOMBO-7
Tel. 94 1 682041
Fax 94 1 698311
Email krabey@yahoo.com

Tanzania
Deusdedit **Kashasha**
Director of Research and Applied Meteorology
Tanzania Meteorological Agency
P.O. Box 3056
DAR ES SALAAM
Tel. 255 22 2134471
Fax 255 22 2110231
Email dkashasha@yahoo.co.uk

Tunisia
Hatem **Baccour**
Chef de Service de l'agrométéorologie
Institut National de la Météorologie
B.P. 156
TUNIS CARTHAGE 2035
Tel. 216 71 773 400
Fax 216 71 772 609
Email baccour@meteo.nat.tn

Turkey

Sakir **Soylu**

Head of Agricultural Meteorology & Climatological Observation Department
Turkish State Meteorological Service
Kutukcu Ali Bey Street 06120
Kalaba-Ankara
Tel. 90 312 360 8198
Fax 90 312 361 2371
Email ssoylu@meteor.gov.tr

Uganda

Paul **Isabirye**

Senior Meteorologist
Head Agrometeorology Unit
Uganda Department of Meteorology
P.O. Box 7025
KAMPALA
Tel. 256 41 251798
Fax 256 41 251797
Email meteoug@infocom.co.ug

Ukraine

Anatoliy **Prokopenko**

Deputy Head
Ukranian Hydrometeorological Centre
6, Zolotovoritska Str.
252601 KIEV 34
Tel. 380 44 2291890
Fax 380 44 2291080
Email prokopen@ukrweather.kiev.ua
kulbida@ukrweather.kiev.ua

United Kingdom of Great Britain & N. Ireland

Michael **Harrison**

Manager Environmental Stresses
Met Office
London Road
RG12 2SY BRACKNELL Berk.
Tel. 44 1344 856212
Fax 44 1344 854898
Email mike.harrison@metoffice.com

Ian **Barrie**

Head Agrometeorological Unit
Met Office
ADAS Woodthorne Wergs Road
WOLVERHAMPTON WV6 8TQ
Tel. 44 1902 693245
Fax 44 1902 743810
Email ian.barrie@adas.co.uk

United States of America

William **Easterling**

Professor
Department of Geography
The Pennsylvania State University
323 Walker Building
UNIVERSITY PARK PA 16802
Tel. 1 814 863 0291
Fax 1 814 863 7943
Email billeasterling@psu.edu

Raymond **Motha**

USDA Chief Meteorologist
USDA/OCE/WAOB
1400 Independence Ave, SW
Room 5143
WASHINGTON DC 20250
Tel.: 1 202 720 8671 (8651)
Fax: 1 202 720 4043
Email: rmotha@oce.usda.gov

Uzbekistan

Lidiya **Grom**

Chief Agrometeorological Forecasting Division
Hydrometeorological Centre of NMHS
72 K. Makhsumov Str.
700052 TASHKENT
Tel. 99871 1333941
Fax 99871 1333941
Email uzhymet@meteo.uz

Viet Nam, Socialist Republic of

Van Viet **Nguyen**

Director Center for Agro-Meteorological Research
Hydro-Meteorological Service
N° 4 Dang Thai Than str.
HA NOI
Tel. 84 4 8358626
Fax 84 4 8355993
Email agromviet@hn.vnn.vn

Zimbabwe

Isaac **Tarakidzwa**

Zimbabwe Meteorological Services
P.O. Box BE 150
Belvedere
HARARE
Tel. 263 4 778 173/4 or mobile 263 11 412548
Fax 263 4 778 161
Email itarakidzwa@weather.utande.co.zw

Barnabas **Chipindu**

Lecturer
Department of Physics
University of Zimbabwe
P.O. Box MP 167
Mount Pleasant
HARARE
Tel. 2634 303211/1926
Fax 2634 333407/333529
Email chipindu@science.uz.ac.zw

INTERNATIONAL INSTITUTIONS/ORGANIZATIONS

ACMAD Mohammed S. **Boulahya**
Director General
ACMAD
B.P. 13184
NIAMEY
Niger
Tel. 227 723160
Fax 227 723627
Email acmadem@acmad.ne
sd@acmad.ne

ICID
International Commission on Irrigation and Drainage

Brane **Maticic**
48 Nyaya Marg
Chanakyapuri
New Delhi 110 021
India
Tel. 91 611 6837
Fax 91 611 5962
Email icid@icid.org

WORLD METEOROLOGICAL ORGANIZATION

Ken **Davidson**
Director
World Climate Programme Department
Tel. 00 41 22 730 8377
Fax 00 41 22 730 8181
Email Davidson_K@gateway.wmo.ch

M.V.K. **Sivakumar**
Chief
Agricultural Meteorology Division
World Climate Programme Department
Tel. 00 41 22 730 8380
Fax 00 41 22 730 8181
Email Sivakumar_M@gateway.wmo.ch

Momadou **Saho**
Scientific Officer
Agricultural Meteorology Division
World Climate Programme Department
Tel. 00 41 22 730 8205
Fax 00 41 22 730 8181
Email Saho_M@gateway.wmo.ch

Robert **Stefanski**
Seconded Expert from USDA
Agricultural Meteorology Division
World Climate Programme Department
Tel. 00 41 22 730 8305
Fax 00 41 22 730 8181
Email Stefanski_R@gateway.wmo.ch

APPENDIX 3: FUNDING SOURCES PROVIDING CO-FUNDING

	Collaborator	Details of funds/commitment
1	WMO (World Meteorological Organization)	$ 50,000
2.	UNEP (United Nations Environment Programme)	$ 25,000
3.	FAO (Food and Agriculture Organization of the UN)	Support 3-4 participants from developing countries
4.	START (Global Change System for Analysis, Research and Training)	Support 4 participants from developing countries engaged in the CLIMAG Project
5.	USDA (United States Department of Agriculture)	$ 20,000
6.	CTA (Technical Centre for Agricultural and Rural Cooperation)	$ 25,000
7	ICARDA (International Center for Agricultural Research in the Dry Areas)	Support 3-4 participants from West Asia and North Africa