SYMPOSIUM ON GLOBAL CLIMATE CHANGE: IMPERATIVES FOR AGRICULTURAL RESEARCH IN ASIA-PACIFIC

21-22 October 2008
Tsukuba, Japan

PROCEEDINGS

Organized by:
Asia-Pacific Association of Agricultural Research Institutions
Japan International Research Center for Agricultural Sciences

Co-sponsored by:
Global Forum of Agricultural Research
International Maize and Wheat Improvement Center
International Center for Agricultural Research in the Dry Areas
International Crops Research Institute for the Semi-Arid Tropics
The World Vegetable Center

GFAR CIMMYT ICARDA ICRISAT AVRDC The World Vegetable Center

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FOREWORD

Asia is the home for more than one half of the world population. It is estimated that by 2020, food grain requirement in Asia would be 30-50% more than the current demand. Alleviating poverty and attaining food security under in adverse environmental scenario due to global climate change and spiraling cost of inputs would be a major challenge to most countries in the Asia-Pacific region in the 21st century. It is with this background, adaptation to and mitigation of climatic change was identified as an important subject for deliberation by the members of APAARI during an earlier Expert Consultation on Research Need Assessment organized during late 2006 in Bangladesh. In view of IPCC report, threat of climate change is real and hence preparedness and reorientation of research agenda to address this concern emerges as a high priority.

Considering above objective, APAARI, in collaboration with JIRCAS, had recently organized a Symposium on 'Global Climate Change: Imperatives for Agricultural Research in Asia-Pacific' at Tsukuba, Japan on 21-22 October 2008, to develop a framework for reorientation of agricultural research to address climate change adaptation and mitigation in crops, livestock, fisheries and agro-forestry in Asia-Pacific region. The Symposium had Plenary sessions and Panel discussions to debate the key issues to develop appropriate recommendations for research to enhance adaptive capacity and mitigation potential of agriculture in the Asia-Pacific region while ensuring continued agricultural growth and development. 158 leading scientists from 30 countries representing CGIAR, ARIs, NARS, Civil Society and NGOs attended the meeting. In this report, we have tried to highlight the proceedings of all presentations, discussion and recommendations. A "Tsukuba Declaration on Adapting Agriculture to Climate Change" was also adopted during the Symposium; the text of which is also included. APAARI is hopeful that wider dissemination of these proceedings will assist various research organizations in the Asia-Pacific and other regions to reorient their research agenda for meeting the new but real challenge of climate change.

We are thankful to all the participants, special invitees as lead speakers and to JIRCAS, Japan for hosting the meeting. Support of GFAR, CIMMYT, ICARDA, ICRISAT and AVRDC for co-sponsoring the event is duly acknowledged.

(Raj Paroda)
Executive Secretary

ACRONYMS AND ABBREVIATIONS

AARINENA	Association of Agricultural Research Institutions in the Near and North Africa
ACIAR	Australian Centre for International Agricultural Research
APAARI	Asia-Pacific Association of Agricultural Research Institutions
ARD	Agricultural Research for Development
ARI	Advance Research Institute
ARI	Advanced Research Institution
AVRDC	Asian Vegetable Research and Development Center
BARC	Bangladesh Agricultural Research Council
BRS	Bureau of Rural Science
C/ha	Carbon per hectare
CARP	Sri Lanka Council for Agricultural Research
CDM	Clean Development Mechanism
CG	Consultative Group
CGIAR	Consultative Group on International Agricultural Research
CH_4	Methane
CIMMYT	International Maize and Wheat Improvement Center
CO_2	Carbon dioxide
CPRS	Carbon Pollution Reduction Scheme
CWANA	Central-West Asia and North Africa
ENSO	El-Niño Southern Oscillation
FFF	Federation of Free Farmers
GFAR	Global Forum on Agricultural Research
GHG	Green House Gases
HKH	Hindu Kush-Himalayan
IAC	Institut Agronomique Neo-Caledonien
IARI	Indian Agricultural Research Institute
ICAR	Indian Council of Agricultural Research
ICARDA	International Center for Agricultural Research in the Dry Areas
ICRAF	International Centre for Research in Agro-forestry
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IFAP	International Federation of Agricultural Producers
IPCC	Inter-Governmental Panel on Climate Change
IRRI	International Rice Research Institute
IWMI	International Water Management Institute
JIRCAS	Japan International Research Center for Agricultural Sciences
MARDI	Malaysian Agricultural Research and Development Institute
MDG	Millennium Development Goal
N_2O	Nitrogen dioxide
NARI	National Agricultural Research Institute
NARO	National Agriculture and Food Research Organization
NARS	National Agricultural Research System

NGO	Non-Government Organization
NIAES	National Institute of Agro-Environmental Sciences
NICS	National Institute of Crop Science
NIFTS	National Institute of Fruit Tree Science
ODA	Overseas Development Agency
PARC	Pakistan Agricultural Research Council
PCARRD	Philippine Council for Agriculture, Forestry and Natural Resources Research and Development
PNG	Papua New Guinea
R&D	Research and Development
UK	United Kingdom
UN	United Nations
USA	United States of America

I. RATIONALE AND OBJECTIVES

The fourth assessment report of the Inter-Governmental Panel on Climate Change (IPCC), released in 2007, has revealed that increases in the emission of green house gases (GHGs) have resulted in warming of the climate system by 0.74^0C between 1906 and 2005. It has further projected that temperature increase by the end of this century is likely to be in the range 2 to 4.5^0C. It is expected that future tropical cyclones will become more intense, with larger peak wind speeds and heavier precipitation. Himalayan glaciers and snow cover are projected to contract. It is also very likely that hot extremes, heat waves, and heavy precipitation events will continue to become more frequent. Increases in the amount of precipitation are expected more in high-latitudes, while decreases are likely in most sub-tropical regions. At the same time, the projected sea level rise by the end of this century is likely to be between 0.18 to 0.59 meters.

Such global climatic changes are affecting agriculture through their direct and indirect effects on crops, soils, livestock and pests, and hence the global food security. IPCC report has particularly indicated vulnerability of developing countries of the Asian region, especially its megadeltas to increasing climate change and variability due to its large population, predominance of agriculture, large climatic variability, and limited resources to adapt. There are likely to be negative effects on livestock productivity due to increased heat stress, lower pasture productivity, and increased risks of animal diseases. Increasing sea surface temperature and acidification are projected to lead to changes in marine species distribution and production.

Extreme events including floods, droughts, forest fires, and tropical cyclones have already increased in temperate and tropical Asia in the last few decades. Runoff and water availability are projected to decrease in the arid and semi-arid regions of Asia. Sea-level rise and an increase in the intensity of tropical cyclones is expected to displace tens of millions of people in the low-lying coastal areas of Asia; whereas increased intensity of rainfall would increase flood risks in temperate and tropical Asia.

Asia is the home for more than one half of the world population. The rapid and continuing increase in population implies increased demand for food. It is estimated that by 2020, food grain requirement in Asia would be almost 30-50% more than the current demand. This will have to be produced from the same or even shrinking land resource due to increasing competition for land and other resources by non-agricultural sector. Accordingly, the world food situation will be strongly dominated by the changes that would occur in Asia because of its huge population, changes in diet pattern and associated increased demand for food and feed.

Agriculture, consisting of cropland, pasture, and livestock production, contribute 13% of total anthropogenic greenhouse gas emissions. This does not include indirect sources relating to fertilizer and food processing industries. The agriculture sector therefore provides, in principle, a significant potential for greenhouse gas mitigation.

Alleviating poverty and attaining food security would be the major challenges to most countries in the Asia-Pacific region in the 21st century. Producing enough food for the increased population with reduced

resources in adverse environmental scenario would be a major challenging task for most developing nations. Concerted efforts would be needed to maximize food production, minimize environmental degradation and attain socio-economic development through reorientation of agricultural research that would comprehensively address all urgent concerns including adaptation to and mitigation of climatic change.

It is with this background, adaptation to and mitigation of climatic change was identified as an important subject by the members of APAARI during an earlier Expert Consultation on Research Need Assessment organized during late 2006. Accordingly, APAARI in collaboration with JIRCAS organized a Symposium to develop required framework for reorientation of agricultural research to address specific issues related to the climate change adaptation and mitigation in crops, livestock, fisheries and agro-forestry. The symposium had plenary sessions and panel discussions to debate the key issues and to develop appropriate recommendations for research to enhance adaptive capacity and mitigation potential of agriculture in Asia-Pacific region while ensuring continued agricultural growth and development. This Symposium was held at JIRCAS, Tsukuba, Japan on 21-22 October 2008 and was co-sponsored by GFAR, CIMMYT, ICARDA, ICRISAT and AVRDC. The specific objectives of this meeting were:

1. To review the current state of understanding of the climate change and to assess its impacts on agriculture in Asia-Pacific region.
2. To understand and analyze the available scientific, technological, and policy options in the region for adaptation and mitigation to climatic change and their possible implications in agriculture.
3. To identify short-, medium-, and long-term research priorities that would ensure enhanced adaptation and mitigation in agriculture

II. INAUGURAL SESSION

Dr. Ghodake, Chairman of APAARI and Dr. Iiyama, President of JIRCAS chaired this session. They, on behalf of their respective organizations, and all representatives of the Conference co-sponsors including AVRDC, CIMMYT, ICARDA, ICRISAT, GFAR and CGIAR Science Council offered their welcome statements.

APAARI

Dr. Ghodake, Chairman of APAARI welcomed all delegates and thanked Dr. Kenji Iiyama, President, JIRCAS as well as the Government of Japan for hosting the symposium in Tsukuba. He noted that the recent Inter-Governmental Panel on Climate Change (IPCC) report has particularly indicated vulnerability of developing countries in the Asian region, especially its mega-deltas to increasing climate change due to its large population, predominance of agriculture, large climatic variability, and limited resources to adapt. Runoff and water availability are projected to decrease in the arid and semi-arid regions of Asia. Sea-level rise and an increase in the intensity of tropical cyclones are expected to displace millions of people in the low-lying coastal areas of Asia. He highlighted that alleviating poverty and attaining food security with reduced resources in such an adverse environmental scenario is a major challenge to most of the Asian countries. Focused efforts are needed to maximize food production, minimize environmental degradation

and attain socio-economic development. That would need a reorientation of agricultural research to comprehensively address all concerns relating to mitigation and adaptation to climatic change together with other development goals and it is hoped that the deliberations of this Symposium will lead to some specific recommendations for implementation by all concerned in the region.

JIRCAS

Dr. Iiyama welcomed the delegates on behalf of JIRCAS and indicated that this Symposium will provide a valuable opportunity for agricultural research systems in the Asia-Pacific region to understand the current status on climate change and to set up their research priorities. He informed the delegates that Tsukuba, the Science City of Japan, is a world-leading scientific city with large research facilities. He hoped that this Symposium would further help all participants to obtain useful and significant information in promoting the cause of science. He further highlighted that climate change is a major area of interest to research organizations in Japan, especially to JIRCAS. Dr. Iiyama also expressed his satisfaction on organizing this important conference in Tsukuba.

GFAR

Dr. Holderness welcomed all the delegates on behalf of the Global Forum on Agricultural Research (GFAR). He emphasized that GFAR has always played a crucial role towards strengthening regional and international cooperation and has been involved in facilitating the debates on critical thematic areas around the world. Climate change is one such area, which has lately drawn considerable interest in all member countries, and he hoped that this conference would be able to provide clear directions on future areas of research for the Asia-Pacific countries. GFAR was pleased to co-sponsor this very important and timely event for which APAARI must be congratulated.

Science Council of CGIAR

Dr. Fischer welcomed the delegates on behalf of the Science Council and thanked the organizers for giving the Science Council an opportunity to attend the meeting and participate in the discussions. He mentioned that CGIAR is in the process of launching a Challenge Program on Climate Change and the deliberations of this conference will help set the priorities of the Challenge Program and its implementation in this region. He also emphasized on strengthening partnerships with Regional Fora in future for reorienting agricultural research agenda, including efforts on climate change.

CIMMYT

Dr. Ortiz of CIMMYT while welcoming the delegates highlighted research-for-development activities at CIMMYT that address adaptation and mitigation of climate change. These include screening maize, wheat, and triticale germplasm for adaptation to heat-prone environments. Identifying bio-nitrification inhibition in wild species that can be used for genetic enhancement of wheat breeding for heat- and drought-tolerant maize and wheat as well as for emerging crop pests as a result of climate change. CIMMYT also promotes conservation agriculture in maize- and wheat-cropping systems. Efforts are also being made on breeding crops with ability to perform under direct-seeding/zero-till, or bed-planting with lower input use.

ICARDA

Dr. van Ginkel of ICARDA also joined others in welcoming the delegates. He informed the delegates that ICARDA since its inception has been concerned with drought and heat tolerance in its mandated crops, two principal sources of stress in its global target regions, and the main climatic variables associated with global climate change. He mentioned the progress ICARDA has made in recent times in developing stress tolerant germplasm. He also indicated that ICARDA was looking forward to the deliberations of the Conference in order to have a clear understanding on the current status and future directions for orienting its research agenda for the region that APAARI addresses.

ICRISAT

Dr. Gowda of ICRISAT in his statement stressed that the rainfed farming systems of semi-arid tropics in Asia and sub-Saharan Africa are highly vulnerable to the effects of climate change. He mentioned that ICRISAT firmly believes that unless the livelihoods of vulnerable rural communities are made more resilient to current rainfall variability and climatic shocks, the challenge of adapting to future climate change will be quite daunting. The institute is convinced that improved livelihood resilience of risk-averse farmers, and concurrent investment by stakeholders, will be greatly enhanced through a quantification of temporal and spatial impact of climate risk. He also highlighted that ICRISAT is undertaking several projects that address coping strategies for current climate change and adapting to future climate, and evaluation of integrated climate risk management and carbon sequestration in a few countries of Asia and sub-Saharan Africa.

AVRDC

Dr. Keatinge of AVRDC stressed that his institute is well ahead of most other organizations in terms of developing heat tolerant germplasm as it has been tropicalizing temperate species for the last 25 years and heat tolerant genes have been incorporated into modern varieties. He further highlighted that climate change is likely to bring an intensification of already existing constraints to vegetable production as a result of changes in virus/disease/insect pressures. Storm intensities will increase under climate change scenarios and thus there is a need for greater investment in plant protection, research and to develop varieties that are able to avoid damage from flooding. He also suggested that instead of more conferences on climate change, time is ripe to have more action to accomplish research goals. He also called upon the donor agencies concerned about climate change to provide necessary investment support so as to ensure timely solutions to emerging problems.

Lead and Keynote Papers

Dr. Parry of the Imperial College, London reviewed the various scenarios of climate change and studies dealing with impacts of climate change on food systems. He concluded that climate change is likely to reduce potential agricultural output globally in the longer term, and increase risk of hunger. Adverse effects, regionally and near-term, are likely to be marked in the dry tropics and dry sub-tropics (e.g. especially in Africa and West and Central Asia). Most serious effects, sub-nationally, will probably be at the social and economic margins (where adaptive capacity is low). He also indicated that early mitigation is needed (with emissions peaking by c. 2015) so that adaptive capacity is not exceeded by subsequent large climate

changes. Emissions need to be cut by c. 80% (of 1990 levels) by 2050 to avoid serious damage. A combination of adaptation and mitigation is necessary, especially adaptation to increase resilience to climate change. These adaptation strategies could be technology (including crop breeding for new climates, e.g. drought-proofing; rural electrification), management (e.g. farming systems that use water more efficiently), or in the form of institutions (e.g. changes to market and tariff structure). Many adaptations can be 'win-win' (e.g. drought-proofing for present weather can increase resilience to effects of a long-term drying trend). Considering the high vulnerability of the poorest areas, small islands, low-lying coasts, and dry/semi-arid regions, he called upon all stakeholders to urgently foster adaptation in these regions.

Dr. Horie of NARO, Japan stressed that global climate change is likely to exacerbate food security and livelihoods in Asia, unless effective adaptation strategies are developed. He argued that adoption of altered genotypes and cropping seasons is the most basic measure for reducing risks of crop damages due to increased abiotic and biotic stresses. This adaptation requires genotypes to safely complete their life cycles under given climatic conditions. Especially, crop resistance to environmental stresses at reproductive development stage is important for successful adaptation, because a short-term stress in this stage is critical as has been noticed in case of pollen fertility in rice in Japan. He highlighted that resource management is another measure for agricultural adaptation to global climate change. This includes water and nutrient management technologies for their efficient use, such as mulching, field incorporations of clay-rich soils and organic materials, micro and drip trickle irrigations, and application of controlled-release fertilizers. He further stressed that when negative effects of global climate change exceed the adaptative capacities, altered crop species and cropping systems may be required such as replacement of C_3 crops with C_4 species and change from double rice cropping systems to upland-lowland rotation systems to save water and reduce insect and disease damages. Developing new genotypes with much higher resistances to biotic and abiotic stresses by marker-assisted methods and gene transformation technologies as well as by traditional breeding methods will also be an important adaptation strategy. Other important technologies specifically needed for agricultural adaptation are information technologies for monitoring and prediction of climate effects on agro-ecosystems; agricultural hazard maps; early warning of biotic and abiotic stresses; and for decision support for adaptive management.

Dr. Lal of Ohio State University discussed GHG mitigation potential and opportunities in agriculture. He indicated that mitigation options involve choice of land use and soil/crop management practices, which would either reduce emissions or sequester emissions. Emission reduction strategies include avoiding deforestation, reducing soil erosion, minimizing losses of fertilizers and pesticides, and making soil a net sink for atmospheric Carbon-di-oxide (CO_2) and Methane (CH_4). Most agricultural soils have lost 30 to 50 t C/ha due to past land use and management based on extractive farming practices. Restoration of degraded/desertified soils by afforestation and reforestation, improving degraded pastures, rehabilitating polluted/contaminated soils, and adopting recommended soil and crop management practices such as no-till farming with crop residue mulch and cover cropping, integrated nutrient management along with judicious use of fertilizers including slow release formulations, conserving water in the root zone, and adopting complex cropping and farming systems can create positive nutrient balance. He showed that the potential of carbon sequestration in terrestrial ecosystems is about 1 Gt/yr on agricultural soils. In addition to mitigating climate change, soil carbon sequestration is also essential to advancing food security. He concluded that carbon sequestration is a truly win-win situation, and a bridge to the future until low-carbon or no-carbon fuel sources take effect.

Dr. Wheeler of the University of Reading, UK discussed various tools and techniques for adaptation and mitigation research on crops comprising of plant experiments and simulation modelling. He illustrated that different plant experiment techniques ranging from those that use plant growth chambers to impose tightly controlled differences in climate to those in near-field conditions that more closely match some aspects of projected climate changes. The latter include Free-Air CO_2 Enrichment rings for the study of responses to CO_2 and drought, temperature gradient tunnels for CO_2 and temperature and open-top chambers for CO_2 or ozone studies. He cautioned, however, that none of these experiment systems entirely simulate all components of a changed climate, but meta-analyses of many of these studies can provide a broad consensus of impacts of climate change that potentially can offer adaptation options. Plant experiments to study possible mitigation options from agricultural systems may include the measurement of methane emissions from paddy rice soils with treatments such as altered water management, different soil organic matter content or rice cultivars that may result in lower methane emissions. Also, results from such crop plant experiments are used extensively to develop, evaluate and parameterize crop simulation models. He also highlighted that assessments of the impacts of and adaptation to climate change involve a climate model and a crop or agricultural system model.

At the conclusion of the Session, the Chairman thanked the speakers for their thought provoking presentations and felt that there could not have better speakers for this opening session. He also thanked the speakers for setting the stage for further discussions on adaptation and mitigation. He also noted that there were a large number of options available for enhancing our adaptive capacity and mitigation potential. Their applicability and cost effectiveness in different ecological environments of Asia-Pacific would need to be critically evaluated. He further emphasized that climate change is real and would require concerted efforts by various research organizations to address emerging challenges in the region.

TECHNICAL SESSION I : RESEARCH STRATEGIES AT NATIONAL LEVEL: SELECTED COUNTRY REPORTS

Dr. Rahman of MARDI, Malaysia and Dr. Rajapakse of CARP, Sri Lanka, Chaired the session. Six country reports were presented in the session. The main theme was to review the progress made, and future priorities in the area of climate change and agriculture in respect of a few selected national agricultural research systems in the Asia-Pacific region.

Dr. Sims of the BRS, Australia summarized Australian research strategies in agriculture in relation to climate change. He stressed that Australian agriculture operates within one of the most variable climates in the world and consequently farmers have developed highly resilient and adaptive production systems. This variability in the climate has always posed a risk to the nation's agricultural industries and changing climatic trends are likely to create new and additional risks. Dr. Sims informed that Australia is introducing a major new initiative aimed at mitigating its greenhouse gas emissions through a trading scheme. This scheme, called the Carbon Pollution Reduction Scheme (CPRS), won't initially include direct agricultural emissions but agriculture will be exposed to the CPRS through increased cost of inputs such as energy, fertilizer and transport. There may be some opportunities for the agricultural sector to provide offsets through sequestration. Examples of practical mitigation at an enterprise scale might include increasing the efficiency of nitrogenous fertilizer use, reducing fuel consumption, upgrading to energy-efficient equipment and

increasing feed-use efficiency in ruminant livestock. He further indicated that in this changing climate, Australia's primary industries face challenges of physical impacts (e.g. changing rainfall patterns), social impacts (e.g. changes to farm business structures, community demographics, health and wellbeing) and economic impacts (e.g. changing productivity levels and markets). To support the adaptation and adjustment to climate change within the agriculture sector, the priorities of the Australian Government is to increase industries' productivity, and innovations and improve biosecurity through effective quarantine systems.

Dr. Aggarwal of IARI, New Delhi discussed the implications of global climate change for Indian agriculture. He summarized that recent IPCC report and several other studies indicate a probability of 10-40% loss in crop production in India and other countries of South Asia by 2080-2100 due to increase in temperature and decrease in irrigation water. India could lose 4-5 million tons wheat production with every rise of 1°C temperature throughout the growing period even after considering incorporation of carbon in the soil. Droughts, floods, tropical cyclones, heavy precipitation events, hot extremes, and heat waves are known to negatively impact agricultural production, and farmers' livelihood in the region. The projected increase in these events will result in greater instability in food production and threaten livelihood security of farmers. He indicated that increased production variability could perhaps be the most significant impact of global impact change on India. He stressed that producing enough food for meeting the increasing demand against the background of reducing resources in a changing climate scenario, while also minimizing further environmental degradation, is a challenging task. This would require increased adaptation and mitigation research, capacity building, changes in policies, regional cooperation, and support of global adaptation and mitigation funds and other resources. Simple adaptations such as change in planting dates and crop varieties could help in reducing impacts of climate change to some extent. Additional strategies for increasing India's adaptive capacity include bridging existing yield gaps to augment production, development of adverse climate tolerant genotypes and alternative land use, assisting farmers in coping with current climatic risks through providing weather linked value-added advisory services to farmers for crop/weather insurance, and improved land and water use management and policies.

Dr. Tusneem of Planning Commission, Pakistan and Ex-Chairman, PARC reported that the research on climate change in Pakistan is in its early stages with initial focus on studies relating to the potential impact of climate change on agriculture production and water resources. Several projects have been initiated in collaboration with international institutions to assess the impact of climate change on water resources, rainfall, temperature and crop yields. Also, an inventory of glaciers and glacial lakes in the HKH region of Pakistan has been completed and a Global Change Impact Study Center established to undertake research on the impacts of climate change in a systematic manner. Initial results of these studies suggest that the global climate change leads to: (i) variation in temperature, monsoon timing and intensity; (ii) length of crops' growing season due to higher temperature and reduced water availability; alter the stages of plant growth with accelerated growth early in the season affecting the quantity and quality of biomass; (iii) increased infestation of pests and diseases; and (iv) spatial shifts in traditional areas of specific agricultural crops. A rise in temperature and reduction in rainfall could increase the net irrigation water requirement of crops, especially wheat crop thereby forcing farmers to make changes in cropping patterns to adjust to climate change. He further stressed that the global warming may lead to climatic extremes during summer as well as winter and the increase in CO_2 concentration which in turn may lead to changes in land use systems.

Dr. Yagi of NIAES, Japan summarized the research strategies for mitigation and adaptation of climate change in agriculture sector of Japan. Japanese government has revised the Kyoto Protocol Target

Achievement Plan in March 2008, in which options for mitigating GHG emissions from agriculture are included. He showed results of a long-term experiment in a typical soil cropping system, which demonstrated that soil carbon stock increased through organic matter application such as compost. Using such long-term data, Japanese scientists have developed a soil carbon model to predict its dynamics in future. He also informed that field experiments conducted in agricultural lands and animal industry at various sites in Japan have demonstrated promising options to mitigate GHG emissions. These options include composting rice straw, improving mid-season drainage from rice cultivation, fertilizer management in upland fields, and diet management for animals. Options such as improved mid-season drainage by keeping fields non-flooded for different periods in rice cultivation led to reduced methane emission and are now in the extension stage. He highlighted that free-air CO_2 enrichment studies have shown a modest yield enhancement of 14% for rice in Japan. Extreme temperature events during the critical period for reproductive development increased floret sterility and thereby reduced grain yield substantially. He also showed that early signs of climate change impacts are now visible in Japan in terms of fruit quality. It is predicted that the favorable regions to cultivate apples and Satsuma mandarins will gradually move northward due to global warming. Horticultural crops are likely to be more sensitive to global warming than other agricultural crops. A recent survey has elucidated many effects of global warming, such as changes in the length of crop-growing periods, reduction in the feed intake and feeding efficiency of livestock, and reductions in the yields of wheat, barley, vegetables, flowers, milk, and eggs.

Dr. Faylon of PCARRD, Philippine presented the country status paper for Philippines where climate-related disasters such as droughts, forest fires, landslides and floods frequently impact agriculture, forestry and natural resources. He showed that severe droughts in 1997 and 1998 affected 960,000 hectares of agricultural lands resulting in damage estimated at P12 billion. Total fisheries production dropped 10.2% - a lost value of P7.2 billion. On the other extreme, from 2000 to mid-2008, tropical cyclones have resulted in damage averaging about P4 billion annually. To address these specific impacts, PCARRD is developing agricultural and natural resources management systems adapted to climate change. In the long run, these will contribute to minimizing GHG emission from agriculture and forestry activities. PCARRD has also identified priority areas for developing measures to help the sector become more resilient to climate extremes. These include determining local vulnerabilities to extreme climate; developing more efficient and effective disaster/hazard management; appropriate water and soil/watershed conservation; enhancing indigenous genetic conservation, integrated pest management; enhancing carbon sequestration and GHG emission reduction; developing new biofuels, and formulating science-based policies relating to global climate change.

Dr. Ghodake of NARI presented the paper on behalf of Dr. J.S. Bailey. He gave an account of the multidisciplinary research strategy to mitigate the impacts of climate change on agricultural production in Papua New Guinea (PNG). He showed that historically, agriculture has proved to be fairly adaptive to changing environmental conditions, but this may not hold true in the future global climate change scenario. PNG is affected not only by global warming and the rising sea levels, but also vulnerable to extremes in rainfall intensity linked to the El Niño Southern Oscillation (ENSO). The most widespread food shortages in PNG have resulted from severe drought conditions brought on by strong El Niños. Interspersed with these events have been excess rainfall conditions, linked to La Niña events, which have been almost equally detrimental to crop production, since excessively wet conditions prevent sweet potato, (PNG's staple food crop) from producing tubers and trigger fungal diseases. The threat posed by diseases is particularly serious

because of the narrow genetic base of PNG's sweet potato germplasm, and the risk that local varieties would be unable to cope with increased disease pressure under warmer/moister conditions. In response to the threat of climate change, PNG has taken up several projects including development of a drought forecasting and early warning system, diversification of genotypes and cropping systems, selection and breeding of crop varieties with tolerance to biotic and abiotic stresses, addressing the problem of heightened pest and disease outbreaks, and provision of water supply to sustain crop production in a scenario of recurring El Niño-induced drought events.

This technical session provided excellent insight and clear ideas of the progress made by various NARS in the area of climate change, current and future research priorities of the representative countries from three sub-regions of the Asia-Pacific (South Asia, South East Asia and Pacific). Several recommendations emerged from the presentations and the discussions that followed. These are summarized in the section dealing with Plenary Session. One clear message emerged that each national program has to reorient its research agenda for adaptation and mitigation of climate change and evolve strategies to address these on priority.

TECHNICAL SESSION II : RESEARCH STRATEGIES AT INTERNATIONAL LEVEL

Dr. Mennesson of IAC, New Caledonia and Dr. Hearn of ACIAR, Australia Chaired the session. The main theme was to review the progress made, and future priorities in the area of climate change and agriculture in respect of various CGIAR institutions currently engaged in the Asia-Pacific region. Eight leading scientists from CGIAR Centers and a senior representative of the Science Council presented papers in this session.

Dr. Keatinge of AVRDC, Chinese Taipei, indicated that high temperature, drought and limited water resources, salinity, pests and diseases all affect vegetable productivity. He indicated that to develop climate-responsive vegetables, AVRDC has broadened its focus to include adaptation research on crop production systems. In the last 25 years more than 100 heat tolerant tomato lines have been distributed to different countries. Using molecular markers, screening for heat and drought tolerance is now being accelerated and superior alleles from wild species for improving heat tolerance can be efficiently identified and introgressed into breeding programs to develop not only high yielding but also drought and heat tolerant cultivars. He indicated that production of sweet pepper in the lowland tropics is possible only with heat-tolerant varieties. These lines have been identified from evaluations conducted at AVRDC under high temperatures in recent years and are now being distributed to cooperators in Africa and Southeast Asia. Production strategies including efficient use of irrigation water through drip irrigation; grafting of tomato on egg plant root stock to increase flood and disease tolerance; use of mulches, shelters and raised beds help to conserve soil moisture, and to prevent soil degradation as well as protect vegetables from heavy rains, high temperatures, and flooding. In addition, soil amendments to improve soil fertility help in better nutrient uptake and thus help in addressing the potential impacts of climate change.

Dr. Ortiz of CIMMYT, Mexico highlighted the work being done at his Center in collaboration with its partners to mitigate the impacts of climate change in the developing countries. Improved maize cultivars that tolerate drought, heat, and low soil fertility have been developed that will help farmers in stress-prone areas to obtain better harvests under dry conditions and higher temperatures. The Center has also developed wheat lines that are better at using available water to produce more grain. He showed that experimental cultivars

derived from crosses between wheat and goat grass, one of wheat's wild relatives, produced up to 30% more grain than their parents, in tests over two years under dryland conditions. They are being used in breeding programs worldwide, and their derivatives are being released to farmers in China and highland Ecuador. CIMMYT scientists are also testing new sources of drought tolerance from gene bank collections and other wheat or grass species, including wheat landraces grown for centuries under dry conditions. He further expressed that CIMMYT has studied and fostered testing and adoption by farmers of various resource conserving practices to save food production costs and resources, and maintain or improve soil quality. He illustrated that building on linkages within the center's global maize and wheat nursery systems and geographic information system capacity and partnerships, it will be possible to form networks that allow researchers to follow and anticipate the movement of pathogens, pests, and invasive species and share the information with relevant stakeholders. He concluded that the security and quality of life of affluent nations are closely tied to conditions and events in the developing world and hence we need to have a global effort to combat the impacts of climate change.

Dr. van Ginkel of ICARDA, Syria presented his paper addressing the various challenges of climate change in the dry areas, which cover 41% of the earth's surface, and are home to over 2 billion people and the majority of the world's poor. The food security of these people is aggravated by the fragile nature of environment and the impacts of climate change. He emphasized that improving food security and livelihoods of the resource poor in these areas requires an integrated approach based on crop and livestock improvement, natural resource management including that of rangelands, and development of policies and institutional capacity. Numerous case studies were illustrated to highlight the importance of an integrated approach in improving food security and livelihoods. He highlighted the past three decades of work by ICARDA with its NARS partners towards sustainable agricultural development in the dry areas, by increasing water productivity, crop production and improved livelihood options for resource-poor farmers. Working in collaboration with the Center, national programs have released nearly 850 improved varieties of wheat, barley, lentil, chickpea and faba bean adapted to the dry areas. The Center has introduced improved crop management methods including more efficient on-farm water management as well as conservation agriculture to increase rainwater infiltration, raise yields, reduce production costs and protect the soil. He further stressed that continued investment in agricultural research will be the key to improving food security, cutting food prices, and developing the capacities of national research centers to help farmers cope with climate change and called upon the national and international community for their full support.

Dr. Gowda of ICRISAT, Hyderabad, India presented the work being done at his institute on climate change. ICRISAT, with the help of partners, is working to better understand the global, national and regional impacts of climate change on agricultural production and resource management as well as developing mechanisms to better cope with the climate change effects in the semi-arid tropics of Africa and Asia. In short-to-medium term, ICRISAT is focusing on helping farmers and their support agents to cope better with current rainfall variability. Developing better forecasting methods, improved management practices and capacity enhancement of stakeholders is given priority for this. In the medium-term, priority strategies are to develop varieties of sorghum, pearl millet, pigeonpea, chickpea and groundnut with higher temperature tolerance, adapted to increased root stress due to drought, soil salinity, acidity, nutrient availability and flooding, and changed severity and distribution of pests and diseases. He suggested that a blend of adapted cultivars, improved natural resource management technologies, better forecasting methods, knowledge sharing, and market intelligence may help overcoming the climate change effects in agricultural production. He explained

that Asia and sub-Saharan Africa, which are already experiencing the adverse impacts of climate change, cannot afford to "wait and see" or follow the historic, unsustainable, carbon-intensive development path of industrialized countries. On the contrary, a concerted effort involving inter-disciplinary and inter-institutional approach is critical to meet the emerging challenge of climate change.

Dr. Wassmann of IRRI, Philippines gave an overview of research relating to interaction of rice production and global climate change conducted by IRRI and its national partners since 1991. He emphasized that among crops, rice in particular is a source of the greenhouse gas methane. IRRI's research on this aspect has initially focused on the in-situ quantification and up-scaling. Since all rice growing nations have signed the UN Framework Convention on Climate Change, the possible options for mitigating methane emissions from rice have gained more attention during the recent years. He also stressed that rice production will be affected by climate change unless preventive measures are taken to adjust rice production systems. He informed that recognizing the significance and urgency of the problem, IRRI has established the 'Rice and Climate Change Consortium' in 2007 as a platform to strengthen research jointly with the national research institutions on both short-term and long-term adaptations of rice production systems. The specific issues presently under investigation in this connection are improved tolerance to higher temperatures, intensification of rice production with higher resilience to more extreme events like droughts and submergence and expected sea level rise in Asian mega-deltas.

Dr. Noble of IWMI, Sri Lanka showed that the impacts of climate change on water – through rainfall, snowfall, soil moisture, river flow and groundwater recharge – will directly translate into impacts on food, livelihoods and ecosystems. In order to keep up with the increased food demand, 60 to 90% more water will be needed by agriculture. This raises significant concerns, since in many parts of the world agriculture is already affected by water scarcity and this will be exacerbated by climate change. He illustrated that in arid and semi-arid areas, the absolute amount of rain is expected to decrease due to climate change but variability will likely increase substantially leading to more short term droughts and crop losses. Flooding in paddy areas may increase which may prove to be beneficial because of increased water supply and fertile silt deposits. Many irrigation schemes, particularly the smaller village level ones that divert water directly from streams and rivers without water storage facilities, are vulnerable to changes in river flow in quantity and timing. Changes in rainfall quantities and intensity will affect natural groundwater recharge and therefore the millions of small holders depending on the groundwater economy in South Asia. He stressed that improved management of water resources will be a requirement in adapting to present and future climate variability and an obvious response to this in supply is to store water when it is abundant in order to use it during dry periods. Improving water productivity by deriving more value from water through higher yields, crop diversification, integrating livestock and fisheries is an important adaptations strategy. Management of trans-boundary Rivers is also important, as this requires cooperation between countries and understanding of flow variability and potential impacts of climate change. He further stressed that adaptation research closely links with identification of institutional frameworks required to support effective development and use of water, options to build ecosystem resilience to support long term agriculture and options to build societal resilience in response to climate change (such as drought early warning systems, insurance schemes and the transition of some people out of farming).

Dr. Wilkes presented ICRAF's research strategy on climate change and agroforestry which aims to improve the resilience of farming systems and livelihood strategies of small holder farmers to current climate variability

as well as long-term climate change, through the increased use of trees for intensification, diversification and buffering of farming systems. The research focuses on vulnerability assessments, the impact of climate change on Agroforestry systems, and synergies between climate change adaptation and mitigation. He highlighted that trees have important roles in reducing vulnerability, increasing resilience of farming systems and buffering households against climate related risks. He stressed that there is a great potential for Agroforestry to sequester atmospheric carbon, and thus to enhance livelihoods while mitigating climate change. He announced that ICRAF is developing tools for analyzing the relationships between land use change and climate change with a specific focus on changes in carbon stocks. Given the predicted scale of carbon markets, ICRAF is investing considerable effort in overcoming the main obstacles to the mobilization of carbon finance to scale up Agroforestry practices that facilitate adaptation to climate change, by developing tools and methods for measurement and monitoring of the carbon benefits of improved practices in agricultural landscapes, and by supporting institutional innovations to link small farmers to global carbon markets.

Dr. Fischer representing CGIAR's Science Council briefed the symposium participants on the recently approved new Challenge Program on "Climate Change, Agriculture and Food Security". He indicated that CGIAR Centers and their numerous National Agriculture Research System partners have been helping farmers cope with the effects of variable and severe weather for nearly three decades. They have generated a wealth of improved crop germplasm, knowledge, technologies, methods and policy analysis, which can lessen the vulnerability of rural people and regions through more sustainable management of crops, livestock, soils, water, forests, fisheries and biodiversity. CG Centers also undertake research to mitigate against GHGs particularly through policies on sustainable forestry, acquisition of carbon in tree and crop systems, and reduced N_2O and methane gas emissions. The Challenge Program has the objectives to close the critical gaps in knowledge on the nexus of food security, livelihood and environmental outcomes in the face of climate change, to develop and evaluate options for adapting to climate change, and to assist farmers, policy makers, researchers and donors to monitor, access and adjust their actions in response to climate change. The work in the initial phase will be at East Africa, West Africa and Indo-Gangetic Plains selected on the criteria of poverty and vulnerability, complimentary set of social, cultural and institutional contexts, complimentary climatic contexts with different temporal and spatial scales of climate variability and degree of predictability, and significant but contrasting climate-related problems and opportunities for intervention. Dr. Fischer concluded with an expectation that this new challenge program will help in addressing emerging issues associated with adaptation and possible mitigation of climate change through effective partnership of all stakeholders involved.

Similar to the previous session, this technical session also provided good insight into the progress made relating to research on climate change, current and future priorities of the concerned CG Centers in respect to adaptation and mitigation. A number of important recommendations emerged from the presentations and the discussion that followed in the session. A summary of this is provided under the Plenary Session in this report.

TECHNICAL SESSION III : PANEL DISCUSSION ON ADAPTATION AND MITIGATION OPTIONS

Mr. Rashid of BARC, Bangladesh and Dr. Keatinge of AVRDC Chaired the session. The main theme was to discuss and finalize the key adaptation and mitigation strategies needed in various agricultural sectors in the Asia-Pacific region. Six Panelists were invited to present their views on strategies needed in crops, soils and fertilizers, capacity building, policy and social sciences, and also the regional and international cooperation.

Dr. Iwanaga of NICS, Japan argued that adaptation to climate change in farming systems is not likely to be an easy process. Many of the technological adaptation options are not farmer friendly; for example in Japan any change in planting date exposes crops to typhoons. The market price of adapted varieties is generally not adequate to encourage farmer to plant them. He suggested that adaptation strategies should be farmer driven and not technology driven because farmers, the key decision makers, may look at options differently.

Dr. Wassmann of IRRI, Philippines pleaded for documentation of success stories of adaptations. He stressed that International Agricultural Research Centers can provide generic strategies but in view of the large spatial and temporal variability in climate change, these strategies have to be site specific. He suggested greater cooperation among NARS, and between NARS and International Centers would be instrumental in targeting these adaptations.

Dr. Lal of Ohio State University indicated that increases in soil carbon pool improves soil quality and agronomic/biomass productivity; enhances water quality by reducing erosion and non-point source pollution; increases soil biodiversity; improves use efficiency of agronomic input and enhances the environment quality. Despite this, net carbon sequestration must also account for the hidden carbon costs of tillage, irrigation, fertilizers, pesticides and other energy-based input. Conversion of biomass carbon into humus also has additional nutrient requirements for N, P, S and others. He argued that undervaluing soil carbon, as is the case by trading carbon at <$10/t of carbon through voluntary market, is counter productive. The value of soil carbon for all ecosystem services is as much as $250/ton of carbon. Thus, farmers must be compensated appropriately and justly as an incentive to adopt restorative land use and recommended management practices.

Dr. Kobayashi of the University of Tokyo indicated that as climate changes farmers adapt to new climates. He demonstrated that apple-cultivating areas are likely to move within Japan as a consequence of increase in temperature. He also indicated that some change is already occurring in climate and as a result apple has become darker in colour. This may lead to changes in market strategies. He stressed that eradicating malnutrition should be the focus of adaptive strategies and for this he recommended global thinking but local action, and to connect well with the farmers and other stakeholders for food systems. He also drew the attention of delegates to increasing anthropogenic nitrous oxide emissions and surface ozone and their likely consequences on agriculture.

Dr. Holderness of GFAR discussed the role of regional and international cooperation in facilitating adaptation to climate change. He discussed that scientific knowledge is trusted and validated by its method where as local knowledge is holistic, trusted and validated by experience and culture. There is a need to link and

reconcile these knowledge bases for scientific development. He suggested that forums such as Global Forum on Agricultural Research comprising of farmers, civil society, NARS, private sector, international research centers, fundamental research institutes and donor organizations and its several regional fora are well placed to promote the desired collaboration/cooperation among various research stakeholders for increasing our adaptive and mitigation capacity to climate change.

Dr. Koyama of JIRCAS suggested that Asia Pacific region needs a suitable framework for adaptation to climate change. He reviewed various economic mechanisms such as CDM, insurance and climate change tax, currently available for adaptation and mitigation. He suggested evolving custom made incentives to internationalize positive and negative externalities and promotion of global agreement/commitment for research priorities. He called upon the scientists to develop mitigation and adaptation measures that should be in line with the mainstream research for development, and for their active participation in policy formation.

The presentations were followed by a lively discussion that led to the identification of several important recommendations. In particular, it was concluded that in order to enhance our adaptive capacity and mitigation potential in agriculture, research would need a more focused approach and a critical mass of well trained scientists. It was also concluded that agriculture has to be viewed as truly multifunctional, and the farmers need to be compensated for providing environmental services that could help mitigate adverse effects of climate change. It was also recognized that much more ARD initiatives will have to be intensified to address emerging challenges for which needed policy support and direction are critical.

PLENARY SESSION : CONFERENCE RECOMMENDATIONS AND ACTION PLAN

Dr. Paroda, Executive Secretary of APAARI and Dr. Holderness, Executive Secretary of GFAR co-Chaired the plenary session. In this session, Rapporteurs of the three technical sessions presented the key recommendations emerging from each session as under:

Technical Session I: Research Strategies at National Level: Selected Country Reports

- Producing enough food for meeting the increasing demand against the background of reducing resources in a changing climate scenario is a challenging task. This would require increased adaptation and mitigation research, capacity building, changes in policies, regional cooperation, and support of global adaptation and mitigation funds.
- Bridging crop yield gaps has been an important strategy for past growth in production in many developing countries of the Asia-Pacific. Most crops even today have considerable yield gaps. In several regions the current yield gaps are larger than the anticipated decline in productivity due to increased temperature and, therefore, bridging them would remain an important adaptation strategy for climate change.
- There is considerable interest in biofuel crops such as Jatropha in the Asia-Pacific region as an alternate source of energy. Their role in climate change mitigation is also being discussed. There is a need for science based evaluation of the realistic potential of biofuel crops, their input requirement, yield

potential over time in different agro-climatic regions and their true GHG mitigation/carbon sequestration potential in order to effectively guide government planners, farmers and other stakeholders.

- Given that most climate change scenarios indicate increased glacier melting and decreasing water availability in future, , R&D efforts should place particular emphasis on developing technologies to improve water productivity. In view of the potential role of fertilizers and manures in GHG emissions, an analysis of policies and practices should be undertaken to increase the overall nutrient use efficiency..
- Besides developing agronomic responses to help agriculture cope with climate change and/or mitigate its effects, complementary initiatives should be pursued to develop effective social and policy measures, such as crop insurance, that will help farmers and others stakeholders manage emerging risks and catastrophic climatic events.
- Carbon trading provides an avenue for the farmers to be compensated for their efforts to reduce green house emissions and contribute to carbon sequestration. However, workable ways to aggregate the relatively small contributions from small individual farms into economically sized and tradable units will need to be developed to minimize the transaction costs.

Technical Session II: Research Strategies at International Level

- CGIAR centers, and National Agriculture Research System have generated a wealth of improved crop germplasm, knowledge, technologies, methods and policy analysis, which have ensured global and regional food security. In the future, partnerships among NARS and CGIAR should be evolved to develop technologies that will help society to be more adaptive of climatic changes.
- Increasing climatic variability is likely to be the most important determinant of agriculture production in future. Short-term climatic stresses such as flooding, heat stress, and drought need urgent attention of crop improvement and management programs.
- Since future breakthroughs in research for increasing resilience of crops to climate change would require inter-disciplinary and international cooperation and collaboration, appropriate consortia of relevant institutes need to be established at an international level.
- Climate change coupled with increasing urbanization and industrialization would result in greater competition for water resources. Improving water productivity will be essential in all agro-ecosystems and for this several strategies are already available which need to be implemented.
- International centers must develop tools and technologies to facilitate access to carbon markets by the developing countries.

Technical Session III: Panel Discussion on Adaptation and Mitigation Options

- Farmers are continually making decisions with respect to their production systems that are multifaceted and have a direct bearing on their productivity. There is a need to ensure that the adaptation strategies proposed by researchers has relevance to farmers and their needs.

- In many parts of the world, there is a declining interest in youth to take up agriculture as a profession. Therefore, there is a need to enhance the profile of agricultural research and the importance of this sector in order to attract the best talents so as to sustain current and future food production. This needs to be done in a structured, collective and coordinated manner, towards which APAARI could play a significant role.
- There is a need for incentive based mechanisms that would promote C sequestration and the sustainable utilization of resources. Without clear incentives to farmers to get realistic returns, it will be difficult to promote C sequestration. Implementing this would require novel approaches to account for all carbon inputs and outputs, aggregating small farmers, and monitoring/regulating carbon budgets.
- There are limitations associated with several global mechanisms such as the CDM with respect to the inclusion of agricultural lands as potential beneficiaries that need to be addressed in the future. Further, there is a need to develop initiatives, frameworks and mechanisms that are specific for Asia based on demographic, economic, climate and social imperatives.
- Business as usual is not an option for the scientists engaged in agricultural research for development. There is a need for advocacy and a single voice. There is an urgency for inter-regional and global exchanges of knowledge and to take a more proactive approach in spreading the results of research to the end users.

The participants evinced keen interest and intensively discussed the recommendations of each session. Based on overall discussions, the Chairman Dr. Raj Paroda concluded that to meet future food production targets and to maintain environmental integrity, both adaptation and mitigation strategies would be required in the Asia-Pacific. He also emphasized the key messages emerging from the Symposium, especially that the impact of climate change is real and the time is ripe to act now and not just talk. Knowledge sharing at the regional level will be critical and inter-institutional collaboration will be needed to address both adaptation and mitigation to climate change. It will also be important that each region/country defines its own National Action Plan and the recommendations of this Symposium can be used to reorient the on-going efforts to combat adverse effects of climate change. APAARI would be happy to provide needed assistance to all member countries in developing National Action Plans. Co-Chairman also assured of needed support from GFAR and taking further the agenda of climate change in other regions as well.

At the end, participants decided to have the key messages coming out of the Symposium flagged in the form of a Declaration. Accordingly, the following "Tsukuba Declaration" was unanimously adopted:

Tsukuba Declaration on Adapting Agriculture to Climate Change

- We recognize that the Asia-Pacific region sustains almost half of the global people, with high rates of population growth and poverty. Agriculture continues to play a critical role in terms of employment and livelihood security in all countries of the region. At the same time, this region has the largest concentration of hungry and malnourished people in the world. Droughts, floods, heat waves and cyclones occur regularly. Climate change is likely to raise regional temperatures and lead to decline in fresh water availability, sea level rise, and glacial melting in the Himalayas. We recognize that the IPCC has considered the developing countries of the Asia-Pacific region, especially the mega-deltas of Asia as very vulnerable to climate change.

- Attainment of Millennium Development Goals (MDGs), particularly alleviating poverty, assuring food security and environmental sustainability against the background of declining natural resources, together with a changing climate scenario, presents a major challenge to most of the countries in the Asia-Pacific region during the 21st century.

- Water is a key constraint in the region for attaining food production targets and will remain so in future as well. Steps are, therefore, needed by all the stakeholders to prioritize enhancing water use efficiency. In addition, measures for water storage using proven approaches such as small on–farm ponds, large reservoirs, groundwater recharge and storage, and watershed approach managed by the farming communities require attention.

- We fully recognize that increasing food production locally will be the best option to reduce poor people's vulnerability to climate change variations. Available agricultural technologies can help increase the yield potential of crops that has not yet been tapped in many countries of the Asia-Pacific region. Hence, a concerted effort, backed by policy makers at the national level would be the key to enhance food security as well as ensuring agricultural sustainability.

- New genotypes tolerant to multiple stresses: drought, floods, heat, salinity, pests and diseases, will help further increase food production. This would require substantial breeding and biotechnology (including genetically modified varieties) related efforts based on collection, characterization, conservation and utilization of new genetic resources that have not been studied and used. CGIAR Centers, Advance Research Institutes (ARIs) and the National Agricultural Research Systems (NARS) of the region have a major role to play in this context. This will require substantial support in terms of institutional infrastructure, human resource capacity and the required political will to take up associated agricultural reforms. We, therefore, fervently call upon the national policy makers, overseas development agencies (ODA), other donor communities as well as the Private Sector to increase their funding support for agricultural research for development in the Asia-Pacific region.

- We also recognize that a reliable and timely early warning system of impending climatic risks could help determination of the potential food insecure areas and communities. Such a system could be based on using modern tools of information and space technologies and is especially critical for monitoring cyclones, floods, drought and the movements of insects and pathogens. Advanced Research Institution, such as JIRCAS, could take the lead in establishing an 'Advance Center for Agricultural Research and Information on Global Climate Change' for serving the Asia-Pacific region.

- The increasing probability of floods and droughts and other climatic uncertainties may seriously increase the vulnerability of resource-poor farmers of the Asia-Pacific region to global climate change. Policies and institutions are needed that assist in containing the risk and to provide protection against natural calamities, especially for the small farmers. Weather-crop/livestock insurance, coupled with standardized weather data collection, can greatly help in providing alternative options for adapting agriculture to increased climatic risks.

- Governments of the region should collaborate on priorities to secure effective adaptation and mitigation strategies and their effective implementation through creation of a regional fund for improving climatic

services and for effective implementation of weather related risk management programs. Active participation of young professionals is also called for.

- We do recognize that there are several possible approaches to enhance carbon sequestration in the soils of the Asia-Pacific region such as greater adoption of scientific soil and crop management practices, improving degraded lands, enhanced fertilizer use efficiency, and large scale adoption of conservation agriculture. To be effective, these would require simultaneously improved use of inputs such as fertilizers, crop residues, labor and time. This soil carbon sequestration has the added potential advantage of enhancing food security at the national/regional level. We do urge the global community to ensure appropriate pricing of soil carbon and related ecosystem/environmental services in order to motivate the small farmers to adopt new management practices that are linked to proper incentives and rewards.

- APAARI has been instrumental in stimulating regional cooperation for agricultural research in the Asia-Pacific. Global climate change and its implications for agriculture underline the need for such an organization to become even more active at this juncture. APAARI, in collaboration with its stakeholders, especially CGIAR Centers, ARIs, GFAR and other regional fora, should continue facilitating regional collaboration in a Consortium mode and take advantage of new initiatives such as Challenge Program on Climate Change for building required capability to adapt and mitigate the effects of climate change and ensure future sustainability of all concerned in the region.

APPENDIX I: PROGRAM

21st October, 2008

09:00 **Registration**

09:30 – 13:10 **INAUGURAL SESSION**

Chair: Raghunath D. Ghodake (Chairman, APAARI)
Co-Chair: Kenji Iiyama (President, JIRCAS)
Rapporteur: Mohammad A. Kamali Sarvestani, (AREEO, Iran)

09:30 – 09:45		Welcome Statements	Chairman, APAARI and President, JIRCAS	
09:45 – 10:15		Brief Statements	GFAR, Science Council of CGIAR, CIMMYT, ICARDA, ICRISAT, AVRDC	
10:15 – 10:55	K1	Keynote Lecture	Implications of Climate Change for Agriculture, Food Supply and Risk of Hunger	Martin Parry (Imperial College, London, UK)
10:55 – 11:20		Break (Tea/Coffee) and Group Photograph		
11:20 – 11:50	L1	Lead Paper	Adaptation Opportunities to Global Climate Change in Agriculture in Asia-Pacific	Takeshi Horie (NARO, Japan)
11:50 – 12:20	L2	Lead Paper	Mitigation Potential and Opportunities in Asia-Pacific	Rattan Lal (Ohio State Univ., USA)
12:20 – 12:50	L3	Lead Paper	Tools and Techniques for Adaptation and Mitigation Research	Tim Wheeler (Univ. of Reading, UK)
12:50 – 13:10			Question and Answer	
13:10 – 14:15		Lunch		

14:15 – 17:15 **TECHNICAL SESSION I: Research Strategies at National Level: Selected Country Reports**

Chair: Abd. Shukor bin Abd. Rahman (MARDI, Malaysia)
Co-Chair: Rohan Rajapakse (CARP, Sri Lanka)
Rapporteur: Raul Q. Montemayor (IFAP, Philippines)

14:15 – 14:35	SI-1	Australian Research Strategies: Agriculture and Climate Change	John P. Sims (BRS, Australia)
14:35 – 14:55	SI-2	Implications of Global Climate Change for Indian Agriculture	Pramod K. Aggarwal (IARI, India)
14:55 – 15:15	SI-3	Pakistan: Research on Impacts of Climate Change and Adaptation Strategies	Muhammad E. Tusneem (Planning Commission, Pakistan)
15:15 – 15:35	SI-4	Research Strategies for Mitigation and Adaptation of Climate Change in Agriculture Sector of Japan	Kazuyuki Yagi[1], Yasuhito Shirato[1], Toshihiro Hasegawa[1], Toshiaki Imagawa[1] and Toshihiko Sugiura[2] (1: NIAES, Japan & 2: NIFTS, Japan)
15:35 – 15:55		Break (Tea/Coffee)	

15:55 – 16:15	SI-5	Sustaining the Productivity and Competitiveness of the Agriculture, Forestry & Natural Resources Sector Amidst Global Climate Change: R&D Strategies of the Philippines	P.S. Faylon and Anthony C.T.M. Foronda (PCARRD, Philippines)
16:15 – 16:35	SI-6	A Multidisciplinary Research Strategy to Mitigate the Impacts of Climate Change on Agricultural Production in PNG	John S. Bailey and Raghunath D. Ghodake (NARI, Papua New Guinea)
16:35 – 17:05		General Discussion	
17:05 – 17:15		Concluding Remarks	Co-Chair/Chair
18:30	Reception		

22nd October, 2008

09:00 – 12:40 TECHNICAL SESSION II: Research Strategies at International Level

Chair: Thierry Mennesson (IAC, New Caledonia)
Co-Chair: Simon Hearn (ACIAR, Australia)
Rapporteur: Anil K. Bawa (ICAR, India)

09:00 – 09:20	SII-1	A Strategic Look to the Future for Vegetable Research: The World Vegetable Center and its Partners	John D.H. Keatinge, Dolores Ledesma, Jacqueline d'A. Hughes and Robert de la Peña (AVRDC)
09:20 – 09:40	SII-2	Climate Change and CIMMYT	Rodomiro Ortiz (CIMMYT)
09:40 – 10:00	SII-3	Climate Change and Challenges in the Dry Areas	Mahmoud Solh and Maarten van Ginkel (ICARDA)
10:00 – 10:20	SII-4	Coping with Climate Change in the Semi-Arid Tropics	C.L.L. Gowda, William D. Dar and A. Ashok Kumar (ICRISAT)
10:20 – 10:40	SII-5	Rice Production and Global Climate Change: Previous and Ongoing Research of the International Rice Research Institute	R. Wassmann and A. Dobermann (IRRI)
10:40 – 11:00	Break (Tea/Coffee)		
11:00 – 11:20	SII-6	Water and Climate Change Adaptation: The Key to Increasing Agricultural Productivity and Poverty Alleviation	Andrew D. Noble (IWMI)
11:20 – 11:40	SII-7	Agroforestry and Climate Change: ICRAF'S Research Strategy	Andreas Wilkes (ICRAF)
11:40 – 12:00	SII-8	Challenge Program on Climate Change	Kenneth S. Fischer (Science Council, CGIAR)
12:00 – 12:30		General Discussion	
12:30 – 12:40		Concluding Remarks	Co-Chair/Chair
12:40 – 13:50	Lunch		

13:50 – 16:00 **TECHNICAL SESSION III: Panel Discussion on Adaptation and Mitigation Options**

Chair: M. Harun-ur-Rashid (BARC, Bangladesh)
Co-Chair: John D.H. Keatinge (AVRDC)
Rapporteur: Andrew D. Noble (IWMI)

Crops	Masa Iwanaga (NARO, Japan)
Paddy	Reiner Wassmann (IRRI)
Soil and Fertilizers	Rattan Lal (Ohio State Univ., USA)
Capacity Building	Kazuhiko Kobayashi (Tokyo Univ., Japan)
Policy and Social Sciences	Osamu Koyama (JIRCAS, Japan)
Regional and International Cooperation	Mark Holderness (GFAR)
General Discussion	
Concluding Remarks	Co-Chair/Chair

16:00 – 16:20 Break (Tea/Coffee)

16:20 – 17:30 **PLENARY SESSION: Conference Recommendations and Action Plan**

Chair: Raj Paroda (APAARI)
Co-Chair: Mark Holderness (GFAR)
Rapporteur: C.L. Laxmipathi Gowda (ICRISAT)

16:20 – 17:10	Presentation of Session wise Recommendations and Adoption	
17:10 – 17:30	Concluding Remarks	Co-Chair/Chair

23rd October, 2008

08:45 – 13:30 **Short Tour of Research Institutes in Tsukuba**

08:45 – 09:00	Okura Frontier Hotel Tsukuba EPOCHAL
09:00 – 10:30	National Institute for Agro-Environmental Sciences
10:40 – 11:30	National Institute of Agrobiological Sciences - Genebank
11:40 – 12:10	Tsukuba Agriculture Research Gallery
12:25 – 13:30	Okura Frontier Hotel Tsukuba EPOCHAL
13:30	Tsukuba International Congress Center to Tsukuba Bus Center

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About 100 other participants attended locally from Agricultural Institutions in Japan.

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Anil K. BAWA holds a Doctorate degree in Botany from the University of Jodhpur (India) and is presently serving as a Principal Scientist in the Office of the Director General, Indian Council of Agricultural Research (ICAR), India. His expertise is in the field of Rangeland ecology. He has worked at the Central Arid Zone Research Institute, Jodhpur, Division of Environmental Sciences at the Indian Agricultural Research Institute, New Delhi, Policy and Perspective Planning unit of the ICAR and APAARI.

William D. DAR holds a PhD from Benguet State University, Benguet (Philippines). He is currently the Director General of the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), based at Hyderabad, India. He is also the Chair of the Committee on Science and Technology (CST) of the United Nations Convention to Combat Desertification (UNCCD) and a member of the UN Millennium Task Force on Hunger. He served as Presidential Adviser for Rural Development and Secretary of Agriculture in the Philippines.

Patricio S. FAYLON holds a Doctorate degree in Agriculture at the University of the Philippines, Los Banos. His fields of expertise include ruminant nutrition and physiology, meat processing, and forage and pasture. He has been the Executive Director of the Philippine Council for Agriculture, Forestry and Natural Resources Research and Development, Department of Science and Technology (PCARRD-DOST) since 1999.

Ken FISCHER holds a Doctorate degree in Agriculture Science from the University of Queensland (Australia) and is Professor Emeritus of that University. He is also a Member of the Science Council for the CGIAR. His expertise is in the area of adaptation of tropical crops to dryland agriculture. He has worked at various CGIAR centers including CIMMYT, IITA, IRRI and the World Fish Center.

Raghunath GHODAKE, the Chairman of APAARI and a member of the Steering Committee of the Global Forum on Agricultural Research (GFAR), holds both a Master's and a Doctorate degree in agricultural economics. He worked for ICRISAT from 1977-1985 and is the Director General of the National Agricultural Research Institute (NARI) in Papua New Guinea since 2003. This year, he was honored with the Order of Logohu Award by the Government of Papua New Guinea.

Maarten van GINKEL holds MSc and PhD degrees in plant pathology, plant breeding and genetics from Wageningen University, the Netherlands and Montana State University, Bozeman, Montana, USA. His practical expertise is in international bread wheat breeding. He worked at CIMMYT (in Turkey, Ethiopia and Mexico), and Australia (molecular plant breeding), and is currently Deputy Director General for Research at ICARDA.

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Simon HEARN is ACIAR's Senior Adviser. He has a PhD in Agricultural Economics from London University. Dr. Hearn has worked in agricultural and mining policy development and economic analysis, both nationally and internationally. His career to date has involved a number of senior research and senior executive positions, including one at the Australian Bureau of Agriculture and Resource Economics (ABARE); London University; Chief of Staff to the Minister for Employment and Education; and Managing Director of the Rural Industries Research and Development Corporation.

Mark HOLDERNESS holds a Doctorate degree in plant pathology from the University of Reading (UK). He worked for many years in plant pathology and IPM, then became increasingly involved in participatory research, learning and institutional reform. He worked for the Papua New Guinea Cocoa and Coconut Research Institute and then for CAB International, working in a wide range of tropical agricultural systems. He is now the Executive Secretary of the Global Forum on Agricultural Research.

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