Workshop on Climate-Smart Agriculture in Asia: Research and Development Priorities

Proceedings and Recommendations

Bangkok, Thailand
11-12 April, 2012

Organizers

Asia-Pacific Association of Agricultural Research Institutions (APAARI)

CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS)

World Meteorological Organization (WMO)

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APAARI (Asia-Pacific Association of Agricultural Research Institutions) is a regional association that aims to promote the development of National Agricultural Research Systems (NARS) in the Asia-pacific region through inter-regional and inter-institutional cooperation. The overall objectives of the Association are to foster the development of agricultural research in the Asia-Pacific region so as to : promote the exchange of scientific and technical information, encourage collaborative research, promote human resource development, build up organizational and management capabilities of member institutions and strengthen cross-linkages and networking among diverse stakeholders. To meet these needs, APAARI undertakes the following activities: i) convenes General Assembly once in two years, holds regular Executive Committee meetings yearly and organizes consultations, workshops, trainings, etc., ii) collects, collates and disseminates research findings, iii) maintains links with other fora in the region and outside through meetings/ participations and information exchange, and iv) promotes need based collaboration in research projects among member institutions, analyzing priorities and focusing on regional agricultural development. For details, please visit: *www.apaari.org.*

CCAFS, the CGIAR Research Program on Climate Change, Agriculture and Food Security, is a strategic partnership of the Consortium of International Agricultural Research Centers and the Earth System Science Partnership (ESSP). The Program's Lead Center is the International Center for Tropical Agriculture (CIAT). The program is funded by bilateral and multilateral donor agencies, and is staffed by people based at leading research institutions worldwide. The CCAFS addresses the increasing challenge of global warming and declining food security on agricultural practices, policies and measures through a strategic collaboration between the CGIAR and ESSP. The CCAFS is collaborating with all 15 CGIAR research centers as well as with the other CGIAR thematic research programs. For details, please visit: *www.ccafs.org.*

WMO, the World Meteorological Organization (WMO), is the UN system's authoritative voice on the state and behaviour of the Earth's atmosphere, its interaction with the oceans, the climate it produces and the resulting distribution of water resources. Established in 1950, WMO became the specialized agency of the United Nations in 1951 for meteorology (weather and climate), operational hydrology and related geophysical sciences. The WMO promotes cooperation in the establishment of networks for making meteorological, climatological, hydrological and geophysical observations, as well as the exchange, processing and standardization of related data, and assists technology transfer, training and research. It also fosters collaboration between the National Meteorological and Hydrological Services of its members and furthers the application of meteorology to public weather services, agriculture, aviation, shipping, the environment, water issues and the mitigation of the impacts of natural disasters. For details, please visit: *www.wmo.int.*

UNDP, the United Nations Development Program, is an organization advocating for change and connecting countries to knowledge, experience and resources to help people build a better life. Since 1966, the UNDP has been partnering with people at all levels of society to help build nations that can withstand crisis and drive and sustain the kind of growth that improves the quality of life for everyone. The UNDP works in four main areas: poverty reduction and achieving the Millennium Development Goals (MDGs); democratic governance; crisis prevention and recovery; environment and sustainable development. For details, please visit: *www.undp.org.*

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Foreword

South and Southeast Asian regions are home to more than 30 per cent of the world's population; half the world's poor and malnourished. Agriculture plays a critical role in terms of employment and livelihood security for a large majority of people in most countries of the region. The region is prone to climatic extremes, which regularly impact agricultural production and farmers' livelihood. In the last decade, these regions have witnessed considerable increase in the number of floods, droughts, some of the most devastating cyclones in recorded history; and water, soil and land resources continue to decline. Climate change is further projected to cause 10-40 per cent loss in crop production in the region by the end of the century. The increased climatic variability in future would further increase production variability. Agriculture, forestry and land use change account for 30 per cent of greenhouse gas emissions. Producing enough food for the increasing population in a background of reducing resources in a changing climate scenario, while minimizing environmental degradation, is a challenging task.

A few regional conferences were held during the last few years to identify the priorities for adaptation and mitigation to climate change. Several options were identified and are being implemented to build climate-smart agriculture but there are still considerable technology and knowledge gaps and much more scope for partnering and policy reform. APAARI, CCAFS, WMO and UNDP jointly organized a meeting in Bangkok on 11-12 April, 2012 to review best practices and technologies being used to make agriculture climate smart, to identify gaps in solutions available and prioritize research and development needed to fill the gaps, and to agree on a plan to address gaps and link knowledge with policy actions at the local/ national/regional level to make agriculture climate smart. The workshop was attended by Asia's leading climate specialists, agricultural scientists, government representatives and development organizations, and several global experts. This publication contains the proceedings and key recommendations of the workshop.

It is our expectation that climate-smart agriculture will receive high priority in future research and development agenda. We are, therefore, sure that the stakeholders of agriculture including National Agricultural Research and Extension Systems in South and Southeast Asia will take full advantage of these recommendations. It is also expected that this publication will be of immense use to the planners, administrators, scientists, farmers, and other stakeholders for ensuring climate-smart agriculture in Asia.

Bruce Campbell
Director
CCAFS

Raj Paroda
Executive Secretary
APAARI

Acronyms and Abbreviations

ADB	Asian Development Bank
APAARI	Asia-Pacific Association of Agricultural Research Institutions
CARP	Council for Agricultural Research Policy
CCAFS	CGIAR Research Program on Climate Change, Agriculture and Food Security
CGIAR	Consultative Group of International Agricultural Research
CIAT	International Center for Tropical Agriculture
CIMMYT	International Maize and Wheat Improvement Center
CIRAD	Agricultural Research for Development
COP	Conference of Parties
CSA	Climate-Smart Agriculture
ESSP	Earth System Science Partnership
FAO	Food and Agricultural Organization
FAORAP	FAO Regional Office for Asia and the Pacific
GHGs	Greenhouse Gases
GIZ	Gesellschaftfür Internationale Zusammenarbeit
IAARD	Indonesian Agency for Agricultural Research and Development
ICAR	Indian Council of Agricultural Research
ICRAF	World Agroforestry Center
ICRISAT	International Crops Research Institute for the Semi-Arid-Tropics
ICT	Information and Communication Technology
IFPRI	International Food Policy Research Institute
ILRI	International Livestock Research Institute
IMD	India Meteorological Department
IRRI	International Rice Research Institute

IWMI	International Water Management Institute
JIRCAS	Japan International Research Center for Agricultural Sciences
MARD	Ministry of Agriculture and Rural Development
MARDI	Malaysian Agricultural Research and Development Institute
MDG	Millennium Development Goals
N2O	Nitrous Oxide
NAFRI	National Agriculture and Forestry Research Institute
NARC	Nepal Agricultural Research Council
NARES	National Agricultural Research and Extension Systems
NARO	National Agriculture and Food Research Organization
NARS	National Agricultural Research Systems
NGO	Non-Governmental Oraganization
NUE	Nitrogen Use Efficiency
PARC	Pakistan Agricultural Research Council
REDD	Reducing Emissions from Deforestation and Forest Degradation
UN	United Nations
UNDP	United Nations Development Program
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development
WMO	World Meteorological Organization

Workshop on Climate-Smart Agriculture in Asia: Research and Development Priorities

Introduction

South and Southeast Asian regions are home to more than 50 per cent of the world's poor and malnourished. Agriculture is the back-bone of most of these regions; with nearly 50 per cent of the population dependent on agriculture. Climate change in these regions is expected to reduce agriculture productivity by 10-50 per cent by 2050. In recent years, these regions have witnessed considerable increase in the number of floods, droughts and cyclones, and the water, soil and land resources continue to decline. The increased climatic variability in future would further increase production variability. Producing enough food for the increasing population in a background of decreasing resources and a changing climate scenario is a challenging task. Faced with growing problems of food security and climate change, agriculture must become more productive, more resilient and more climate-friendly. Drought and flood tolerant varieties of crops, adapted livestock and fish, weather forecasts, information and communication technology (ICT)-based agro-advisories, weather based insurance, water management practices, conservation tillage, soil and agroforestry for carbon sequestration, precision in the use of fertilizers, adapted mechanization, and seed and fodder banks are some of the best options and practices currently in use for climate change adaptation and mitigation. But, there are still considerable technology and knowledge gaps and there is enough scope for partnering and policy reforms to expedite the process of adoption of climate-smart agriculture (CSA) i.e. agriculture that sustainably increases productivity, resilience (adaptation), reduces/ removes greenhouse gases (mitigation) and enhances achievement of national food security and development goals (FAO).

In order to address the challenges of climate change, a global program "Climate Change, Agriculture and Food Security (CCAFS)" was recently launched by the Consultative Group on International Agricultural Research (CGIAR) to bring together the world's best researchers in agricultural science, development research and climate science. Asia-Pacific Association of Agricultural Research Institutions (APAARI) promotes agricultural research for development in the Asia-Pacific region by facilitating through novel partnerships among NARS and other related organizations to contribute to sustainable improvement in the productivity of agricultural systems. APAARI in collaboration with Japan International Research Center for Agricultural Sciences (JIRCAS) organized a "Symposium on Global Climate Change: Imperatives for Agricultural Research in Asia-Pacific" at Tsukuba, Japan from 21-22 October, 2008 which led to the "Tsukuba Declaration" emphasizing the need for greater and continued focus on adaptation and mitigation research and policy interface in agriculture in the Asia-Pacific region. World Meteorological Organization (WMO) also organized a workshop in 2008 at Dhaka, Bangladesh to review the impacts of climate change in South Asia and to develop future research priorities.

The heads of agricultural research organizations of South and Southeast Asian countries, negotiators from the South and Southeast Asian countries responsible for discussion on adaptation and mitigation in agriculture in the United Nations Framework Convention on Climate Change (UNFCCC), chiefs of the meteorology departments of South and Southeast Asian countries, regional and global agriculture and climate change experts, CGIAR climate change scientists and regional and global development organizations met in Bangkok on 11-12 April, 2012 to build on the momentum created by the earlier meetings and expand discussions on climate-smart agricultural research and development to the whole of South Asia and Southeast Asia. The meeting took stock of activities underway to build climate-smart agriculture since the last regional meeting nearly 5 years ago. The workshop had the following specific objectives:

- To review the best practices and technologies being used to make agriculture climate-smart
- To review the latest knowledge of impacts of climate change on agriculture
- To identify the gaps in solutions available and prioritize research and development needed to fill these gaps
- To agree on the plan to address the gaps and link knowledge with policy actions at the local/national/regional levels to make agriculture climate-smart

The workshop was structured in four major technical sessions: i) Climate services in agriculture, ii) Agriculture in UNFCCC: Durban and beyond, iii) Parallel group discussions to identify 5 key priorities, and iv) Current state of research and development on climate-smart agriculture. These major technical sessions were divided into smaller sessions and in total there were 11 sessions. All presentations in the sessions were followed by in-depth discussions. This report provides the outcomes of deliberations and key recommendations for implementation by the scientific community and policy planners.

Inaugural Session

The workshop started with the welcome and initial remarks by Dr. Raj Paroda, Executive Secretary, APAARI. Outlining the importance and necessity of the workshop, Dr. Paroda highlighted that climate change will pose a serious challenge to food security in the South Asian region. For ensuring food security both in the short and long-term and making agriculture sustainable and climate-resilient, appropriate adaptation and mitigation strategies have to be developed. The challenges are further exacerbated with the depleting water resources, vulnerability of soil to degradation and indiscriminate and imbalanced use of external production inputs. This will lead to lower farm profit, making farming unattractive and unsustainable in the region. Dr. Paroda further emphasized that adaptation to climate change in agriculture is the key to face the future challenges. However, mitigation should also be addressed as there are co-benefits owing to adaption and mitigation supplementing each other. He observed that farmers of Asia have evolved many coping mechanisms over the years, but these have fallen short of an effective response strategy in dealing with recurrent and intense forms of extreme events on the one hand and gradual changes in climate parameters including rise in surface temperatures, changes in rainfall patterns, increase in evapo-transpiration rates and degrading soil moisture conditions on the other. The need of the hour is, therefore, to synergise modern agriculture

research with the indigenous wisdom of the farmers to enhance the resilience of agriculture to climate change. To start with, traditional knowledge bases should be documented and validated. To cope with the negative impacts of climate change and climatic variability, the focus should be on adaptation to help small and marginal farmers in the developing countries for their sustainable livelihood security. A comprehensive and integrated strategy should be developed by identifying and transferring appropriate technologies for climate-resilient agriculture. Efforts should be intensified to develop stress-tolerant varieties suitable for different agro-climatic zones. Tools of new sciences, microbial genetics, terrestrial and marine genetic resources should be exploited to develop designer crops for climatic stress tolerance. There is a need to revisit the regulatory mechanism with regard to genetically modified crops, particularly in the context of changing climate. There is a large gap between potential and actual yields obtained by farmers. This gap must be bridged by enhancing the use of inputs and their use-efficiency. Dr. Paroda emphasized that integrated farming system, conservation agriculture, agroforestry, organic farming practices and watershed development programs should be promoted in large scale to enhance livelihood security and income of farmers.

In his welcome and initial remarks, Dr. B. Campbell, CCAFS outlined the role of climate-smart agriculture in the international negotiations and opportunities in the face of emerging challenges. He felt that business as usual in our globally inter-connected food system will not bring us food security and environmental sustainability and the window of opportunity to avert a humanitarian, environmental and climate crisis is rapidly closing. He informed that agriculture is now on the agenda for a decision in Doha at the Conference of Parties (COP 18) and suggested that a work program should be developed to demonstrate the win-wins for adaptation and mitigation; ensure that food security is not compromised by mitigation and adaptation efforts; and provide scientific basis to guide policy making by identifying the best practices and specific technologies that need incentives. He concluded that agriculture needs serious consideration in the international negotiations. The opportunities lie in identifying the key win-win technologies/practices/policies, tools for decision-making and opportunities to revitalize the agriculture sector all over the world, particularly the South and Southeast Asian regions.

Dr. P.K. Aggarwal, CCAFS summarized the outcome of the past key regional conferences on climate change organized by WMO (Dhaka; August, 2008), APAARI/JIRCAS (Tsukuba; October, 2008) and CCAFS (Delhi; November, 2010). Adaptation to climate change, managing current climatic risks, mitigation in agriculture and engaging policy makers and other stakeholders were the major themes of these conferences. However, he observed that though several opportunities for interventions were identified over time, progress is limited in many cases and many organizations are working for the same goal; often competing with each other. He suggested that there is a great need for synergy, collaboration, cooperation and strong advocacy among the organizations.

The Chief Guest, Mr. J. Lengoasa, World Meteorological Organization, in his inaugural address observed that the agriculture sector, in a broad sense, covering cropping, livestock, fisheries, forestry, and rural land and water management, is both a bearer of the burden of a changing climate and its impacts and a contributor of global climate change. In the South Asian countries, large populations of people depend on semi-subsistence agriculture for their livelihoods. The rainfall in the semi-arid and sub-humid regions of South Asia is highly variable and influences the agricultural productivity of millions of small farms. Farming practices in these regions have

developed as a response to such climatic risks. Hence, any changes in the current climate will further enhance the risk to agricultural productivity and the survival of the large populations in South Asia. He lauded the role of the organizers and felt that partnership among different disciplines (nutrition - health, risk management - financial sector, incentives - economics, policy interface - politics, water management, etc.) is extremely important. He emphasized the need to extend the dialogue beyond the traditional disciplines to ensure a better understanding of the Earth System, the changes it is going through, and the impacts on the civilization. He observed that some specific options have already been identified, tested and documented for climate change mitigation and adaptation for agriculture sector, such as good agriculture practices; sustainable land and forest management; changing varieties; more efficient water use; altering the timing or location of cropping activities; improving the effectiveness of pest, disease and weed management practices; and making better use of seasonal climate forecasts to reduce production risks. These options have substantial potential and if these are widely adopted, they could offset negative impacts from climate change and take advantage of positive impacts. To cope with climate change more effectively in South Asia, it is necessary to identify integrated adaptation and mitigation options (win-win options) suitable for local circumstances, to formulate and implement cross-sector framework for the wide range of agro-ecosystems through comprehensive and integrated approach, and to enable a favourable policy environment for the implementation of the framework.

He concluded by saying that weather and climate information is of critical importance in the decision making process for agriculture, water resources management, and environmental conservation. The diversity of climate, soils, and hydrological regimes in different countries makes this research challenging but also provides the opportunity to both agricultural researchers and meteorologists to make a substantial contribution in the identification of solutions. He assured that the WMO and the National Meteorological and Hydrological Services in Asia stand ready to contribute to the discussions and in planning the future research and development agenda for South and Southeast Asia.

Mr. Man Ho So, FAO, the Chairman of the Session, observed that climate change could pose a serious threat to the agricultural productivity and food security of the world, particularly the South Asian nations. He congratulated the organizers, namely, APAARI, CCAFS, WMO and UNDP in organizing this important Workshop. He also lauded the efforts being made by the national and international organizations in developing adaption and mitigation strategies in agriculture. He observed that to overcome the challenges of current and future climatic risks, there is a need to intensify the efforts to develop climate-smart agriculture. He outlined the role being played by the FAO in this direction and wished the Workshop a great success.

Technical Sessions

Technical Session 1: Climate Services to Agriculture, Adaptation to Progressive Climate Change and Mitigation in Agriculture

Chair: *Dr. P. Faylon*

Rapporteur: *Dr. J.C. Dagar*

Dr. Shiva Kumar, WMO made a presentation on climate services in agriculture and observed that global availability of food has increased with time, however, the number of hungry and

malnourished still remains large and climatic risks are increasing. He highlighted that water for agriculture is crucial and the need for efficient climate services for the agriculture sector is greater than ever before. He also highlighted the goal of Global Framework for Climate Services to enable better management of the risks of climate variability and change and adaptation to climate change at all levels, through development and incorporation of science-based climate information and prediction into planning, policy and practice. The key elements for climate services are acquisition and wider dissemination of data and products, advancing knowledge base for adaptation, assisting farmers in coping with current climatic risks, assisting in the intensification of food production systems, enabling institutions and policy support and partnerships and capacity enhancement.

Dr. Takeshi Horie, National Agriculture and Food Research Organization (NARO), Japan talked about adaptation to progressive climate change in Asian agriculture and observed that even without climate change, agriculture in many Asian countries is facing difficult situations for sustaining future food security and livelihoods. He cautioned that without adequate adaptation to climate change, food insecurity and loss of livelihood are likely to be exacerbated in Asia. He concluded that there are many pathways for adaptation of Asian agriculture to progressive climate change such as altered genotypes, cropping seasons and systems; better management of resources, insect-pests and diseases; breeding of stress resistant genotypes; infrastructure development; capacity building; and policy making. The most important for adaptation of Asian agriculture to progressive climate change is the strategy and technology development and dissemination for much better adaptation of agriculture to the current environment. There is a need for an efficient information system to monitor and predict climate change effects on agro-ecosystems, develop agricultural hazard maps, and provide early warning for biotic and abiotic stresses and decision support for adaptive management.

Dr. Peter Grace, Queensland University of Technology, Brisbane, Australia made a presentation on GHGs mitigation in agriculture. He identified various sources and sinks of Greenhouse Gases (GHGs) in agriculture and observed that soil carbon sequestration potential is low in Asia. However, increased nitrogen use efficiency (NUE) will reduce nitrous oxide (N_2O) emissions, mid-season drainage and reduced organic matter inputs will mitigate methane (CH_4) emissions from rice, improved forage quality and grain feeding will reduce CH_4 emissions from livestock and soil carbon increases will indirectly influence NUE and soil structure (reducing N_2O). He concluded that mitigation must be in synchrony with productivity/profitability and must be geographically targeted (e.g. climate $\times$ soil $\times$ practice).

Technical Session 2: Agriculture in the UNFCCC

Chair: *Dr. N. van Bo*

Rapporteur: *Dr. P. Kristjanson*

Dr. B. Campbell, CCAFS made a presentation on agriculture in the UNFCCC: Durban and beyond. He highlighted the role of climate-smart agriculture, agriculture in the international negotiations and opportunities in the face of the challenges. He observed that besides increasing productivity to achieve national food security and development goals, agriculture has to enhance the resilience through various adaptation measures and reduce the emission of greenhouse gases. He concluded that agriculture needs serious consideration in the international negotiations and

observed that there are many opportunities and we need to identify key win-win technologies/ practices/policies and also tools for decision-making to harness the opportunities to revitalize the agriculture sector.

This lead presentation was followed by remarks from Md. Sohrab Ali, Bangaldesh; Dr. B.M.U.D. Basnayeke, Sri Lanka; Dr. K.P. Sharma, Nepal; Dr. S.D. Attri, India; Dr. N. Sharma, Nepal and Dr. A. dePinto, IFPRI. They highlighted the trends and impacts of climate change on agriculture in the regional, national and global perspectives. It came out quite clearly that though climate change has a global dimension but different regions will be affected differently. Therefore, region and location-specific adaptation and mitigation strategies have to be developed to deal with the adverse impacts of climate change. The remarks were followed by a general discussion in which several speakers expressed their opinion about how the future discussions should be shaped and focussed in the UNFCC to make agriculture climate resilient.

Technical Session 3a: Adaptation to Climate Change

Chair: *Dr. T. Horie*

Co-Chair: *Dr. C.L.L. Gowda*

In this session, the panellists Drs. D. Beare, M. McCartney, A.K. Joshi, K.T. Shongand Ms. Le Thi Thu Ha gave their opinion and identified key priorities for research and development for adaptation in agriculture in Asia. Several of the research priority areas identified in this session are identification of germplasm and development of varieties that meet the challenges of climate change i.e. stresses due to heat, drought, water logging, new diseases/insect-pests; changing time of cultivation, harvest and other management activities; improving the soil capacity through enhanced nutrition and soil moisture and preventing erosion; switching to cultivation that requires less water and resists heat, drought and incidence of insect-pests and diseases; encouraging afforestation in arid regions; gene discovery for traits of future use with breeder and researcher oriented data platform; durable resistance to insects, pests and diseases; sustainable crop based production systems that save precious inputs through efficient conservation technologies; crop diversification; resource conserving technologies; alternate land use system with agroforestry as integral part of farming system; improving water and fertilizer management and energy management in agriculture; better designed machinery, and conservation practices.

The panelists identified some key development areas which included ensuring faster adoption of new varieties through timely and adequate supply of high quality seed, together with other inputs in all growing regions; promoting water saving planting techniques (timely planting in residual soil moisture, post-sowing irrigation, zero tillage/raised bed); promoting diversification of crops and alternate crops; preparing farmers for coping with climate change through accelerated adoption of conservation agriculture, temperature buffering and water-saving technologies; and developing enhanced communication with farmers on climate change through use of modern information technologies.

Policy options were also identified during the group discussion session and included sustainable development goal with financial support and technical transfer to ensure equity and justice; enhancing research and development on climate, hydrological and integrated crop/biodiversity-climate models; research and development on planting techniques and crops resilient to severe

climate; better integrated land use, coastal, marine and water management; integrated cross sectors multi-hazards early warning approach, sea level rise and public health; effective stakeholders and communities participation; improving education and training of farmers and constructing or expanding food security programs.

Technical Session 3b: Mitigation in Agriculture

Chair: *Dr. A. de Pinto*

Co-Chair: *Dr. P. Grace*

The panelists in this session included Drs. V.P. Singh, J. Sander, A. de Pinto and P. Mehta. They suggested various priorities for GHG mitigation. Some of the key research areas for mitigation included improved water management to reduce methane emission from rice fields; improved nutrient management for reducing nitrous oxide emission; enhancing carbon sequestration in soil; developing feed and feeding practices that reduce greenhouse gas emission; and improved efficiency of water used for livestock and forage production.

Besides mitigation, the speakers also highlighted the need to study the impact of climate change (e.g. heat stress) on livestock diseases, decline in fertility, safeguarding public health by augmenting capacities to detect and control outbreaks of zoonotic diseases and designing institutional and market mechanisms that support the poorer livestock keepers, particularly women. Enhanced upstream watershed management to reduce erosion and enhanced water regulatory capacity in the upland areas and changing Asian canal systems to be more demand driven and accountable to farmers and increase energy efficiency of groundwater pumping will be essential since 60 per cent of food in South Asia comes from groundwater, which will be under growing threat due to climate change.

The speakers felt that adoption of climate-smart agricultural practices is hindered by investment barriers and risk (yields, prices). Hence, the identification of the correct financial mechanisms that promote adoption is of paramount importance. They stressed on the need to have proper crop modeling tools to keep track of GHGs. Similarly, proper modeling tools that allow robust scenario building are also of paramount importance for decision makers. There should be appropriate methods in place for risk sharing among the farmers, the private sector and the government. Crop insurance is probably not the answer, but some suitable measures need to be taken in that area given the increased incidences of flooding and drought in both South and Southeast Asia. They suggested to develop a comprehensive framework for the proper economic valuation of the services provided by agricultural systems: adaptation + mitigation + other ecosystem services.

Technical Session 4: Country Reports on Current State of Research and Development on Climate-Smart Agriculture

Chair: *Dr M. Shivkumar*

Rapporteur: *Dr. P.H. Zaidi*

In this Session, reports of different countries, namely, Bangladesh, India, Indonesia, Malaysia, Nepal, Pakistan, Philippines, Thailand and Vietnam were presented. In general, the speakers talked about the threats of climate change to agriculture in their respective countries and

also highlighted the major activities being undertaken by their respective governments. They also highlighted the various climate smart practices being promoted as well as the research and development needs. All the speakers unanimously, observed that the farmers in Asia are most vulnerable to climate change due to small holdings, subsistence and rain-fed agriculture. Adoption of climate-smart agriculture (CSA) technologies such as drought tolerant, submergence tolerant and disease resistant varieties of crops, etc. are increasing but lots need to be done. In all the countries, human resource capacity is to be strengthened to generate and promote CSA technologies to meet the emerging challenges of climate change. There is a need for higher investment on research and development with favorable policy and institutional mechanism to facilitate for CSA promotion to enhance food and nutrition security of the countries in the region. They also suggested that amalgamation of CSA with the rich indigenous knowledge and practices will enhance wide scale adoption of CSA.

The speakers highlighted the National Action Plans for Climate Change in their respective countries. They presented the success stories for climate change adaptation and mitigation. Some of the success stories include: development of crop varieties adaptive to climate change, promotion of conservation agricultural practices, promotion of climate information through climate field school and other media, changing cropping calendar and integrated crop management. They also highlighted the strategies and innovative technologies to cope up with the impact of climate change in their respective countries. A brief report on issues presented for individual country is given below.

Bangladesh

Dr. Md. Sohrab Ali reported that climate change is now a reality and Bangladesh is one of the worst victims of the crisis. Uncertainty of weather conditions (e.g. erratic rainfall and natural calamities such as cyclones like AILA, SIDR) put huge pressure on national economy and unbearable hardship to the affected people. Along with increased temperature, uncertainty in rainfall and erratic weather conditions, saline water intrusion and land degradation are major threats of climate change to agriculture in the country. Water scarcity and also flooding are the other very crucial issues hurdling sustainable agriculture in Bangladesh, which has 57 trans-boundary rivers (54 with India, 3 with Myanmar). Regional cooperation, therefore, is essential for water resource management and equitable distribution of resources such as water. He suggested that due attention should be given to control the burgeoning population as that is creating pressure on the natural resources and is also a source of pollution and climate change.

India

Dr. J.C. Daggar talked about the projected impacts of climate change on Indian agriculture. He reported that the projections for 2020, 2050 and 2080 indicate an all-round warming over the Indian subcontinent. During 1901-2007, surface air temperature increased by 0.51°C and accelerated warming took place during 1971-2009. Mean temperature increased by 0.2°C per decade during 1971-2009 and there was greater rise in minimum temperature compared to maximum temperature. However, no significant change in monsoon rainfall at all India level was observed except some regional variations. Increase in rainfall in west coast, north Andhra Pradesh and north-west India and decreasing trend in east Madhya Pradesh and adjoining

areas were noticed. Extreme rainfall events are, however, increasing. Sea level in Indian Ocean has increased by 1.63 mm per year during 1993-2009. He suggested various mitigation and adaptation strategies such as crop diversification; resource conserving technologies; alternate land use system with agro-forestry as an integral part of farming system; improved water and fertilizer management; use of organic manure and crop residues; use of nitrification inhibitors such as neem-coated urea; improved fertilizer management practices and energy management in agriculture with better designed machinery and conservation practices. He outlined the various initiatives being taken by Govt. of India for climate change mitigation and adaptation. This includes National Action Plan on Climate Change and National Initiative on Climate Resilient Agriculture by the Indian Council of Agricultural Research (ICAR).

Indonesia

Dr. Astu Unadi reported that for Indonesia agriculture is very crucial as it contributes more than 30 per cent of the gross national product and is important for food security and job opportunity in the country. Expansion and intensification of agriculture is needed for food and energy security of the country. Agriculture in Indonesia mostly consists of rainfed and dryland farming, which are very vulnerable to the climate change and variability. The impact of climate change on agriculture could be direct as well as indirect, which will be manifested through increased temperature, shifting rainfall pattern, increased frequency of extreme climatic events and sea level rise. Several initiatives are in progress in the country for adaptation and mitigation of climate change. These include development of high yielding varieties of rice with potential for low GHG emission, tolerance to drought, flood and salinity with early maturity; introduction of climate field school; dynamic cropping calendar and innovative land management practices. The policy initiatives for climate change abatement include development of climate communication network in agriculture; programmes on climate change research consortium; law, regulation and policy reforms in agriculture; developing tools and guidance for climate resilience and follow-up and implementation of programmes of mitigation and adaptation.

Malaysia

Dr. Sharif Haron reported that the key trends on climate change and variability observed in Malaysia include longer dry season, increased frequency of drought, shorter rainy season but intense rain, increased annual rainfall by 10 per cent in the east coast and north-west of Peninsular region whereas decreased rainfall by 5 per cent in the central west region, increased mean air temperature by 1.2 to 1.4°C and emergence of new pests and diseases. He observed that new crop and water management strategies including development of short duration, drought and salinity tolerant varieties; aerobic rice; improving irrigation techniques to reduce water loss should be adopted to tackle the adverse impacts of climate change. For mitigation of GHG emission, he advocated the need of controlling burning of crop residues, precision farming, improved fertilizer management, changing sowing/planting time to match the rainfall distribution and development of new bio-fertilizers. The country has launched the National Action Plan on Climate Change in 2009 for mainstreaming climate change activities through wise management of resources and enhanced environmental conservation. Strengthening of institutional and implementation capacity would be essential to reduce negative impacts of climate change in the country.

Nepal

Dr. D.B. Gurung reported that increase in temperature had been about 0.04°C/year in Terai and 0.08°C/year in the high mountains of Nepal. Monsoon has been erratic in the country with late or early onset and decrease in number of rainy days. Too little or too much of rain is resulting in drought or flood resulting in severe losses to agricultural productivity. Number of rainy days with high intensity (>100 mm rain/per day) has been increasing in recent past. Soil moisture availability has been reduced resulting in early maturing of crop, crop failure and reduction in productivity. Extreme fog conditions and cold wave in the Terai region in winter are affecting winter crops in the country. He suggested to follow CSA which included multiple cropping (inter-cropping, mixed cropping, sequential cropping, relay cropping, agroforestry), terraced cultivation in hills, conservation of agro biodiversity (*in situ* and community gene bank), integration of legume in cropping system and utilization of plant and animal waste (crop residues, compost, FYM, biogas slurry) in agriculture. The practices such as organic and integrated farming system, farmers' managed irrigation system, crop residue mulching and indigenous knowledge should be promoted as a part of CSA. The Nepalese farmers are most vulnerable to climate change due to their smallholding and rainfed agriculture. However, the adoption of CSA technologies including drought, submergence and disease tolerant varieties of crops is increasing. He proposed that capacity of human resources in the country should be strengthened to generate and promote CSA technologies to confront the emerging challenges. There is a need of greater investment on research and development with favourable policy and institutional mechanisms to facilitate promotion of CSA to enhance food and nutritional security of the country. Amalgamation of CSA with the rich indigenous knowledge and practices will enhance wide scale adoption of CSA and help mitigating climate change in this Himalayan kingdom.

Pakistan

Dr. Nadeem Amjad reported that mean temperature in the country increased by 0.6 to 1.0°C. Rainfall decreased by 10-15% in the coastal/arid areas whereas it has increased by 18-32 per cent in the sub-humid to humid areas of the country. There has been 26-57 per cent increase in winter rains in sub-mountain, central and southern Punjab and north-eastern Balochistan; 0.5-0.7 per cent increase in solar radiation over southern half of the country; 1.2 mm/year rise in sea level; and there has been occurrence of 19 extreme climatic events (heavy rains causing floods, droughts, cyclones, heat waves) during 1992–2011. Agriculture sector is the most important sector in Pakistan as more than half of its population is directly associated with this sector. Climate change would have severe impacts on this sector. However, the country has taken several steps in mitigating and adapting to climate change. He suggested that CH_4 emission can be reduced through better soil and water management in rice fields, biogas generation from animal dung and concentrated feed blocks for livestock as supplement to CH_4-producing fodder material. The N_2O emission from croplands can be mitigated through better water management, integrated nutrient management and efficient N fertilization. The notable efforts for adaptation include development of short duration and drought, heat and disease resistant crop varieties; reducing water conveyance and application losses to account for water shortage due to climate change; lining of canals and distributaries; national water-course improvement program; laser land leveling and reduced or zero tillage.

Philippines

Dr. Patricio S. Faylon reported that in the Philippines, there is already a trend of increasing number of hot days and warm nights, but decreasing number of cold days and cool nights. According to the Philippine Atmospheric, Geographic and Astronomic Services Administration, there has been a general increase in observed minimum (0.89°C), maximum (0.35°C) and mean (0.61°C) annual temperature during 1951-2006. In most parts of the country, the intensity of rainfall is generally increasing. The same is true with the frequency of extreme daily rainfall as observed in Calapan and Laoag City in Luzon; Tacloban and Iloilo in Visayas. The number of tropical cyclones per year (average is 20) has been relatively the same but the intensity is increasing. The number of tropical cyclones with the maximum sustained winds of 150 km/hr and above has increased since 1971 to 2009. However, the country has taken a very proactive step in developing and promoting climate resilient technologies. Following the approval of the Climate Change Act in 2009, the National Framework Strategy on Climate Change was approved in 2010. It underscored the importance of enhanced vulnerability and adaptation assessments towards achieving its objective of building the adaptive capacity of communities and increasing the resilience of natural ecosystems to climate change. In the context of a risk resilient country, the National Climate Change Action Plan was formulated under the leadership of the Philippine Climate Change Commission.

Thailand

Dr. Praphan Prasertsak reported that annual rainfall and number of rainy days all over the country had not varied much during 1951-2009 but the drought prone area had extended. Average mean, maximum and minimum temperature showed increasing trend all over the country. The northeast part of Thailand is the most vulnerable region. He highlighted the perceptions of farmers towards climate change. Farmers feel that climate change adaptation options should include changing in cropping patterns and practices such as growing of drought resistant and early maturing varieties; growing of cash crops such as vegetables; shifting arable areas to more moist land to reduce risk; changing from transplanting to broadcasting of rice; crop diversification and soil improvement using organic matter amendment. Farmers also adopt coping practices such as construction of farm ponds and water sources in the villages; migration to cities for taking supplementary occupations as labourer; formation of self-help groups; getting loans and choice of improved water use systems such as drip irrigation. He suggested that the policy issues should include improvement of irrigation system; enhancing knowledge on climate variability; information and access to agricultural and environmental friendly technologies; reforestation and afforestation and creating opportunities to access credit and market for coping with the future climatic risks.

Vietnam

Dr. Le Thi Thu Ha informed that during 1958–2007, the annual temperature increased about 0.5-0.7°C. Temperature in the winter increased faster than the summer. Similarly, the temperature in the northern zone increased faster than the southern part. Average rainfall for the whole country has decreased by about 2 per cent during the period. In the recent years, there were more typhoons with higher intensity affecting agriculture in Vietnam. Typhoon track showed a tendency of moving southward and typhoon season tended to last longer. Sea level has risen about 3 mm/year during 1993-2008 and in the past 50 years, sea level at Hon Dau station

rose by about 20 cm. He observed that rising temperature can have tremendous impacts on agriculture. The increase of salinization due to rising sea level can also significantly reduce the area of agricultural land in the delta and coastal areas, especially the Mekong and Red River Delta. Increasing of natural disasters and extreme weather events such as droughts, floods in many areas may seriously affect crop productivity. He suggested some adaptation options including changing time of planting; improving soil moisture holding capacity to prevent erosion; switching to cultivation that requires less water and resist thermal, drought and pests incidences; development of new plant varieties tolerant to stresses; encouraging afforestation in arid regions; improving education and training of farmers; expanding food security programs and development of innovative policies that are effective and sustainable.

Technical Session 5: Adapting to Current Weather Variability and Knowledge to Action and Policies for Climate-Smart Agriculture

Chair: *Dr. Raj Paroda*

Rapporteur: *Dr. M. Mc Cartney*

Two presentations were made in this session. Mr. J. Hansen, IRRI/CCAFS talked about adapting to current weather variability and Dr. P. Kristjanson, ICRAF/CCAFS presented her views on getting knowledge into action and policies for climate-smart agriculture. Mr. Hansen suggested several options for targeting emerging opportunities in designed diversification: index-based financial risk transfer; adaptive response to advance information, scalable and transferrable local traditional knowledge, food-system-level risk management; and supporting agricultural risk management through climate information and services. Dr. Kristjanson identified effective policies for climate-smart agriculture which included: food price policies, food buffer stocks; water pricing policies; agricultural input subsidies; payments/rewards for environmental services; export/import bans, restrictions and taxes on agricultural trade; regulations (e.g. on charcoal trading, forest management, grazing and water rules, etc); government investment in agricultural research and advisory services (new models, not the old 'top down' one); social safety nets and insurance and disaster risk management. She suggested to review the existing national policies related to agricultural sector development, food security and climate change (including bioenergy and Reducing Emissions from Deforestation and Forest Degradation (REDD), with analysis of the extent to which current policies are aligned or are in conflict with each other. She also talked about screening the existing national policy instruments and frameworks for consistency across the policy areas concerned to see how they might be usefully integrated to enhance effectiveness. Her other suggestions included identification of policy options that enable adoption of climate-smart practices, drawing on evidence/understanding of barriers to adoption, building capacity of policy makers and planners to formulate and coordinate coherent policies across multiple policy areas relating to climate-smart agriculture, including the use of integrated land-use planning, landscape and ecosystem approaches, and scenario simulation for different policy choices.

Technical Session 6a: Adapting to Current Weather Variability

Chair: *Dr. M. Sivakumar*

Co-Chair: *Mr. J. Hansen*

In this session, the panelists included Drs. K.D. Sharma, M. Rana Arif, S. Kinkgeo, Ms. J. Jutakorn,

and Mr. J.A. Weerawardena. They talked about climate-smart agriculture in Asia and suggested research and development priorities. Some of the priority areas identified during the session included salinity tolerant crop varieties and fish, alternating freshwater saline water cropping/fish systems (including the need for effective and timely drainage), farmscape engineering options, appropriate rainwater harvesting and irrigation technologies for consumption and irrigation, supporting finance and private sector engagement, seasonal forecasting and finding the proper proxies and forecasting high impact weather events.

The speakers observed that along with the research priorities, the development areas that need priority include conflict management through establishing transparent and equitable negotiations, strong community innovation and research culture by training, support and engagement particularly for tomorrow's farmers, improving the tank system, diverting the water flows in to dry areas and awareness programs on climate change for farmers and officers.

Technical Session 6b: Knowledge to Action and Policies for Climate-Smart Agriculture

Chair: *Dr. P.K. Joshi*

Co-Chair: *Dr. P. Kristjanson*

The panelists included Drs. P. Mehta, R. Lefroy, J.D. Samarsinghe, P.K. Joshi and K. Kamp. The speakers identified various research and development issues. Some of the research issues included documenting constraints for upscaling conservation agriculture technologies, targeting potential areas for climate-smart agriculture, extrapolating potential benefits on eco-region basis, development of more resilient farming systems for the known uncertainty of the current variable climate, use climate analogues (as future climate of one location could be the current climate in another location), and better quality and more accessible data, information, and knowledge.

The speakers strongly felt that development issues such as integrating climate-smart technologies with existing government programs, developing mega government schemes on climate-smart based technologies/interventions, institutional innovations to link climate-smart technologies with international programs and treaties, and favourable environment for private sector are the need of the hour for developing agriculture resilient to climate change.

Plenary Session : Reports from Group Discussions

Chair: *Dr. D.B. Gurung*

Co-Chair: *Dr. B. Campbell*

Facilitator: *Ms. H Leitch*

Each of the four thematic groups were asked to identify 5 priorities and the priorities identified by each of the thematic groups were reported to the plenary session. After the group presentations, the participants were invited to vote for their top 10 priorities. The voting process resulted in the identification of top 10 priorities for research and development. The key recommendations relating to research, development and policy aspects emerged to address these ten research and development priorities.

Concluding Session

Chair: *Dr. Raj Paroda*

Co-Chairs: *Dr. B. Campbell*
Dr. M. Sivakumar

At the Plenary Session, the identified research and development priorities for climate-smart agriculture were summarized by Ms. H. Leitch. The representatives of organizations that provided funding support gave their comments on the priority areas for research and development.

Mr. J. Zhang from the Asian Development Bank (ADB) felt that for Asia and the Pacific region, there are many constraints and food security is the key for sustainable growth. The ADB is supporting construction of rural roads, water management facilities, disaster response facilities, water and other natural resource management. Innovations addressing food-water-energy nexus and regional cooperation and integration are required to address various issues relating to climate-smart agriculture. The key areas of interventions should be climate resilient food value chains, rural market infrastructure, use of renewable energy and improving rural livelihoods. Multi-sector approach is needed with focus on value addition and partnership. He gave examples of various interventions that are being implemented by ADB in different countries in the region.

Mr. Luis Waldmueller of GIZ observed that the priority areas should include sustaining biodiversity; genetic improvement; agricultural diversification including fruits, vegetables, livestock; poverty alleviation and resource management; and policy/institutional improvements. In addition, adaptation of Asian agriculture to climate change should also be a priority area. The GIZ is supporting all the CG centers and CRPs and various regional projects in India, China, Philippines, etc. He also observed that adaptation and mitigation should be considered together and the rural areas should be the key targets.

Dr. A. Rajivan of United Nations Development Program (UNDP) informed that the 'Asia-Pacific Human Development Report on One Planet to Share: Sustaining Human Progress in a Changing Climate' will be available soon. It includes three big perspectives and goes beyond adaptation and mitigation. Noting that the 'discipline' of adaptation is going to grow larger and larger, dramatic action is needed now and there is a need for strong cooperation - breaking out of rich country-poor country dichotomy and working in interlinked manner. She observed that the developing countries of Asia-Pacific region must address poverty and growing inequities while managing the effects of climate change. Despite difficult trade-offs, meeting the challenges of climate change as part of a development agenda is the only way to ensure and sustain human development gains. Equitable access to resources now and for generations to follow, for both women and men, is imperative. We need to build on emerging public and private sector commitment; making action worthwhile for decision makers. Policies of inclusion, poverty reduction, including through greener agriculture, are at the core of adapting to climate change. She stressed that reducing emission of methane in rice production (alternative wetting and drying method), farming with zero tillage, biochar for sequestering carbon, reforestation and afforestation, use of indigenous crops, organic and urban agriculture, and greening of cities should be the priority areas for dealing with the adverse effects of climate change.

Mr. T. Kawashima from the Japan International Research Center for Agricultural Sciences (JIRCAS) outlined various programs on environment and natural resource management, stable

food production and rural livelihoods being implemented in different countries. JIRCAS is working with International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), International Rice Research Institure (IRRI), International Center for Tropical Agriculture (CIAT) and many local institutes on impact evaluation, adaptation, mitigation and technological development in the areas vulnerable to climate change.

Ms. T. Leonardo of United States Agency for International Development (USAID) highlighted two major initiatives undertaken by USAID. The first one is 'Feed the Future' which is U.S. Govt's flagship food security program. The USAID recognizes climate change as a cross-cutting theme and with increasing growth of agriculture sector, improving nutritional status of vulnerable groups is a key priority. The second one is 'Global Climate Change Initiative' with the objectives of accelerating the transition to low emission development, adaptation and increasing resilience and integrating climate change across USAID's entire development portfolio including agriculture and food security. The overall strategy is to provide improved seeds, breeds and varieties (drought, salt tolerance); innovations for water and soil management and implementation of principles of conservation agriculture. These measures are climate smart and contribute towards increasing productivity, minimizing emissions, sequestering carbon and increasing incomes.

Mr. J Lengoasa of WMO mentioned about global initiatives on climate services. He felt that there is a need for an organized platform and framework through which all the climate services can be implemented. The WMO is working at a global level, but there is need for concerted efforts at the regional and national level. It is clear that there is a need for a different paradigm (future earth), co-create research questions for the future and there are lot of initiatives funded by different parties with the same intent.

Dr. M. Sivakumar of WMO summed up the next steps and observed that out of the 10 top priorities, 9 relate to practice. He observed that climate resilient innovation including building resilience through adoption of appropriate practices and increasing incomes, harmonization of various practices and coordination and knowledge sharing are the key for climate resilience in Asia. He strongly felt that there is wealth of knowledge for meeting the challenges of climate change. He suggested that we should reflect on the priorities and recommendations developed in the workshop, develop a specific regional project with desired outputs/deliverables, outcomes and timelines.

Dr. Bruce Campbell of CCFAS liked the discussion about win-win situation and observed that it was unacceptable to talk about trade-offs earlier and often people of meteorological-services and agriculture did not come together and thus this workshop was extremely important in further establishing strong partnership and suggested that CCAFS will use what we have learned in this forum to change our ways and really make it win-win-win. The task now is that the 10 priorities for research and development are needed to be translated into action plans and implemented within the next 2-4 years. He assured that CCAFS will report back on progress towards concrete actions on these priorities.

Dr. Raj Paroda observed that WMO, CCAFS, AAPARI and other organizations have taken initiatives in the last few years and had dialogues on climate change related issues. He was happy to see that the things have moved forward on various climate change issues and priority

is given to climate resilient agriculture. There are several regional initiatives underway and CCAFS could facilitate a regional information hub with a consortium approach. He observed that the policy issue should be one of the high priority areas at national and regional levels. Collective visions and actions should be developed and the development agencies need to come forward to implement climate related services. Advanced research centers also need to focus on climate related services and make them more efficient and easy to implement. We need to move forward towards systems approach including livestock, fish, agroforestry and the other sectors. He cautioned that the researchers generally give high priority to adaptation, but mitigation cannot be ignored and research investments in this area need to be doubled or tripled. Capacity building should be given a high priority and many technologies need to be scaled out and linked to impacts on the poor, who are most vulnerable to climate change.

Key Research and Development Priorities

1. Development of adaptation strategies to current weather variability and long-term climate change with co-benefits in mitigation including information and communication technologies, climate models and decision support systems for seasonal forecasts, refining existing technologies for insect-pest and disease management, and breeding multi-stress tolerant varieties of crops, livestock and fish
2. Renewed focus on conservation and management of resources including water, soil, nutrient, energy and germplasm (including microbial diversity)
3. Promotion of regional cooperation including regional learning platforms for transfer of technologies and knowledge of climate-resilient agriculture
4. Identification of best practices for mitigation of greenhouse gases from agriculture at local, national, regional scales including alternative wetting and drying in rice; diversification; alternate feeding strategies for livestock; grazing land management; water, land use and crop residue management
5. Improvement in credibility, accuracy timeliness, spatial resolution and relevance of weather forecast systems at short and medium-term time scales, accompanied with improved coordination and knowledge sharing among climate services and agro-meteorological advisory providers including data sharing, and documenting and evaluating case studies of good practices
6. Investment in capacity building of agriculture sector to respond to advanced information about weather events and seasonal climate fluctuations through advisory systems, delivery mechanisms, training, and favourable policies
7. Strengthening extension services including addressing gender issues and opportunities, and building capacity of tomorrow's farmers through climate-smart field schools, participatory videos, social media and community radio featuring local content and demonstrations, roving seminars, training of trainers, field demonstrations, and private sector participation
8. Documenting innovative institutional arrangements that promote climate-smart agriculture such as pricing for environmental services, carbon payments, index-based insurance, and community management of resources and risks

9. Assessment and documentation of existing knowledge of climate-smart agriculture including constraints to adoption, indigenous knowledge, impacts, benefits, costs and productivity gains, and lessons from collaborations (public-public and public-private)

10. Assessment of policies in support of climate-smart agriculture including water pricing, fertilizer pricing and subsidies, irrigation, seed, risk transfer (insurance) and disaster relief.

Major Recommendations

Asia-Pacific region currently has half of the world's poor and malnourished – around 500 million! At the same time, climate change is expected to reduce agriculture productivity by 10- 50% in the next 3 decades. Moreover, the region has witnessed considerable increase in the number of floods, droughts, devastating cyclones and degradation of water, soil and land resources. Hence, attainment of Millennium Development Goals (MDGs), particularly alleviating poverty, assuring food security and environmental sustainability, against the background of declining natural resources, together with changing climate, presents a major challenge today to most of the countries in the Asia-Pacific region. As such, APAARI in 2006 had identified 'Climate Change' as an emerging concern needing immediate attention on policy, research and development fronts by the developing countries of the region. During the "International Symposium on Imperatives for Agricultural Research due to Global Climate Change" organized at Tsukuba, Japan in 2008, NARS of the region came out with 'Tsukuba Declaration' on adapting agriculture to climate change. As a follow up, APAARI organized a workshop on Climate-Smart Agriculture in Asia: Research and Development priorities" in collaboration with CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS), the World Meteorological Organization (WMO) and United Nations Development Program (UNDP) and came out with the following key recommendations.

I. *Research*

- There is an urgent need to evaluate, map and document evidence associated with variability and expected future climatic changes at the local, national and regional levels to assess the magnitude of loss and the need to develop adaptation and mitigation strategies for ensuring more resilient agriculture.

- Concerted efforts need to be made to improve the credibility, accuracy, timeliness, spatial resolution and relevance of weather forecast systems at short, medium, and seasonal time scales. This should be accompanied with advanced agro-meteorological research so as to get required information about weather events and seasonal climate fluctuations. A recent initiative of WMO to have a "Global Framework on Climate Services (GFCS)" is a welcome initiative in this regard and sincere efforts need to be made at the national level to implement the Framework.

- New genotypes and breeds tolerant to multiple stresses: drought, floods, heat, salinity, pests and diseases, will help further increase food production. This would require substantial efforts through breeding and biotechnology (including genetically modified organisms) based on collection, characterization, conservation and utilization of new genetic resources that have not been studied and used. CGIAR Centers, Advanced

Research Institutes (ARIs) and the National Agricultural Research Systems (NARS) of the region have a major role to play in this context. CG Centers could play major role through pre-breeding and supply of useful germplasm to NARS. This will require substantial support in terms of institutional infrastructure, human resource capacity and the required political will to take up associated agricultural reforms. Therefore, the national policy makers, overseas development agencies (ODA), other donor communities as well as the private sector should increase their funding support for agricultural research for development in the Asia-Pacific region.

- There is a strong need to identify and promote best practices/success stories for mitigation of greenhouse gases from agriculture, especially from rice paddies, bovine livestock activities and land use management; quantify their climate adaptation co-benefits, and identify integrated adaptation and mitigation options suitable for local circumstances. The potential, constraints and cost of these technologies at various scales must be estimated and their long-term consequences assessed.

- Farmers in Asia, often poor and marginal, have been experimenting with adaption to the climatic variability for centuries. There is a wealth of indigenous knowledge concerning the range of measures that can help in developing technologies to overcome climate vulnerabilities. Such knowledge should be assessed and documented for its relevance in today's agricultural context, and further validated and upscaled to enhance resilience in agriculture.

- There is an urgency to undertake studies on the pest risk analysis with respect to climate variability and to develop low cost surveillance systems for their effective monitoring and advance forecasting as well as preparedness.

- There is a need to strengthen policy research on climate smart agriculture practices such as pricing subsidies on fertilizer, irrigation and energy, cost effective information and communication tools, insurance, market intelligence, impact assessment, risk analysis as well as assessment of future food demands in a changing climate scenario.

- The women farmers are likely to be affected the most by the adverse impacts of climate change. Research on developing climate change adaptation and mitigation technologies, therefore, should take into account the gender-specificity and policies that are women-farmers friendly.

- It is extremely important to synergize modern agricultural research with indigenous wisdom of farmers to enhance the resilience of agriculture to climate change. Hence, the traditional knowledge bases need to be documented and validated on priority.

- There is an urgent need to address the key research areas for mitigation such as improved water management to reduce methane emission from rice fields, improved nutrient management for reducing nitrous oxide emission, enhancing carbon sequestration in the soil, developing feed and feeding practices that reduce greenhouse gas emission from bovine animals.

II. *Development*

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

- For required insulation to weather vagaries and better livelihood, concerted efforts are now needed to promote integrated farming systems in a watershed approach with greater emphasis on conservation agriculture, organic farming, agroforestry, dairy/ animal production, fishery, horticulture etc. All these initiatives will help in improving the livelihood of smallholder farmers.

- Concerted efforts need to be made to strengthen existing extension services, including those related to gender issues. There is also a need to build the capacity of tomorrow's farmers through regional knowledge platforms on climate-smart agriculture, ICT based dissemination of knowledge, participatory videos, dedicated television channels on agriculture, social media and community radio featuring local content and demonstrations. Emphasis on vocational trainings to build a new cadre of 'Technology Agents' to provide knowledge without dissemination loss and services on custom hire basis will be critical for desired success.

- There is a need to make higher investments in enhancing water storage capacity to check infrequent runoff associated with climate change. For this, greater emphasis needs to be laid on bunding, laser leveling and on-farm water harvesting which should be addressed on priority.

- There is a strong need to increase investment in capacity building of agriculture sector to respond to information about weather events and seasonal climate fluctuations through advisory systems, delivery mechanisms, training, favourable policies including neglected groups like pastoralists, fishers, farm women etc.

- Climate-smart field schools, roving seminars, training of trainers' demonstrations and encouraging private sector participation should be made integral part of state-run extension services to encourage tomorrow's farmers for adopting climate-smart agriculture.

III. *Policy*

- It is necessary to assess the current policies in support of climate-smart agriculture including food price policies, water pricing, fertilizer pricing and subsidies, irrigation, seed, payments/rewards for environmental services, risk transfer (insurance) and disaster relief. Efforts should be made to refine these policies to make them more effective and responsive to deal with urgent and immediate needs of climatic risks. Also, there is a need to review the existing national policies related to agricultural sector development, food security and climate change including bioenergy and

reducing emissions from deforestation and forest degradation (REDD), with analysis of the extent to which current policies are aligned or are in conflict with each other. The policy instruments and frameworks must be consistent across the policy areas in order to integrate them to enhance effectiveness.

- It is extremely essential to make provision of establishing a regional/national fund to provide incentives/support to promote climate smart interventions at local, national and regional scale and for setting-up emergency food reserves, seed banks etc.

- An enabling environment needs to be created to attract public and private partnership for increased investments in climate smart agriculture and encourage the role of the non-governmental organizations, public and philanthropic organizations for enhancing climate-change preparedness among the local communities.

- Provision has to be made for additional budgetary support to the National Meteorological Services for enhancing their capacity in climate data collection and management, seasonal forecasting of weather, and developing climate driven simulation models. Greater thrust also needs to be given on implementation of global framework on climate services (GFCS) at the national and regional level.

- There is an urgent need to strengthen regional cooperation for addressing trans-boundary issues of water sharing, pest surveillance and control, and facilitating the exchange of technologies and knowledge relating to climate-resilient agriculture.

- The soil carbon sequestration has an added potential advantage of enhancing food security at the national/regional level. The global community must 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.

- 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 and activities. Active participation of young professionals is also called for.

- 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.

Annexure I

Technical Program

11 April, 2012

Time		Topic	Resource persons
From	**To**		
8:00	9:00	Registration	Mr. N. Sigtia, Ms. U. Rujirek
Inaugural Session			
9:00	9:10	Welcome and initial remarks	Dr. Raj Paroda, APAARI
9:10	9:20	Welcome and initial remarks	Dr. B. Campbell, CCAFS
9:20	9:35	Summary of past regional conferences	Dr. P.K. Aggarwal, CCAFS
9:35	9:50	Inaugural address by Chief Guest	Mr. J. Lengoasa, WMO
9:50	10:00	Chairman's remarks	Mr. Man Ho So, FAO
10:00	10:30	*Tea/Coffee Break & Group Photograph*	
Technical Session 1 : Climate Services to Agriculture, Adaptation to Progressive Climate Change and Mitigation in Agriculture			
		Chair : P. Faylon	
		Rapporteur : J.C. Dagar	
10:30	11:00	Climate services in agriculture	Dr. M. Sivakumar, WMO
11:00	11:30	Adaptation to progressive climate change	Dr. T. Horie, NARO, Japan
11:30	12:00	Mitigation in agriculture	Dr. P. Grace, QUT, Australia
Technical Session 2 : Agriculture in the UNFCCC			
		Chair : N. Van Bo	
		Rapporteur : P. Kristjanson	
12:00	12:20	Agriculture in UNFCCC : Durban and beyond	Dr. B. Campbell, CIAT/CCAFS
12:20	12:25	Remarks	Dr. Md. Sohrab Ali, Bangladesh
12:25	12:30	Remarks	Dr. B.M.U.D. Basnayake, Sri Lanka
12:30	12:35	Remarks	Dr. K.P. Sharma, Nepal
12:35	12:40	Remarks	Dr. S.D. Attri, India
12:40	12:45	Remarks	Dr. N. Sharma, Nepal
12:45	12:50	Remarks	Dr. A. dePinto, IFPRI
12:50	13:15	General Discussion	
13:15	14:15	*Lunch*	

Time		Topic	Resource persons
From	**To**		
Technical Session 3 : Parallel Group Discussions (Goal: To identify 5 key priorities)			
14:15	16:15	**Technical Session 3a : Adaptation to Climate Change**	*Chair* : Dr. T. Horie *Co-Chair* : Dr. C.L.L. Gowda *Panelists* : Dr. D. Beare, Dr. M. Mc Cartney, Dr. A.K. Joshi, Mr. T.S. Kang, Ms. Le Thi Thu Ha
		Technical Session 3b : Mitigation in Agriculture	*Chair* : Dr. A. dePinto *Co-Chair* : Dr. P. Grace *Panelists* : Dr. V.P. Singh, Dr. J. Sander, Dr. A. dePinto, Dr. P. Mehta
16:15	16:30	*Tea/Coffee Break*	
Technical Session 4 : Country Reports on Current State of Research and Development on Climates-Smart Agriculture *Chair* : Dr. M. Sivakumar; *Rapporteur* : Dr. P.H. Zaidi			
16:30	16:40	Bangladesh	Dr. Md. R.I. Mondal
16:40	16:50	India	Dr. J.C. Dagar
16:50	17:00	Nepal	Dr. D.B. Gurung
17:00	17:10	Pakistan	Dr. N. Ajmad
17:10	17:30	Discussion	
17:30	17:40	Vietnam	Dr. N. Van Bo
17:40	17:50	Indonesia	Dr. A. Unadi
17:50	18:00	Malaysia	Dr. D. Haron
18:00	18:10	Philippines	Dr. P. Faylon
18:10	18:20	Thailand	Dr. P. Prasertsak
18:20	18:40	Discussion	
18:40	18:50	Chairman's remarks	
19:00	21:00	*Reception Dinner*	

12 April, 2012

Time		Topic	Resource persons
From	**To**		
Technical Session 5 :		**Adapting to Current Weather Variability and Knowledge to Action and Policies for Climate-Smart Agriculture**	
		Chair : Dr. Raj Paroda	
		Rapporteur : Dr. M. McCartney	
8:30	9:00	Adapting to current weather variability	Mr. J. Hansen, IRRI/CCAFS
9:00	9:30	Knowledge to action and policies for climate-smart agriculture	Dr. P. Kristjanson, ICRAF/CCAFS
9:30	10:00	*Tea/Coffee Break*	
Technical Session 6 :		**Parallel Group Discussions** (Goal: To identify 5 key priorities)	
10:00	12:00	**Technical Session 6a : Adapting to current weather variability**	*Chair* : Dr. M. Sivakumar *Co-Chair* : Mr. J. Hansen *Panelists* : Dr. K.P. Sharma, Dr. M.R. Arif, Mr. S. Kingkeo, Mr. J.A. Weerawardena, Ms. J. Jutakorn
		Technical Session 6b : Knowledge to action and policies for climate-smart agriculture	*Chair* : Dr. P.K. Joshi *Co-Chair* : Dr. P. Kristjanson *Panelists* : Dr. P. Mehta, Dr. R. Lefroy, Dr. J.D. Samarsinghe, Dr. P.K. Joshi, Dr. K. Kamp
12:00	13:00	*Lunch*	
Plenary Session : Reports from Group Disscussions			
		Chair : Dr. B. Campbell	
		Co-Chair : Dr. D.B. Gurung	
		Facilitator : Ms. H. Leitch	
13:00	13:05	About the Session	Ms. H. Leitch
13:05	13:15	Adaptation to progressive climate change	
13:15	13:25	Mitigation in agriculture	
13:25	13:35	Adapting to current weather variability	

Time		Topic	Resource persons
From	**To**		
13:35	13:45	Knowledge to action and policies for climate smart agriculture	
13:45	14:15	Participatory prioritization exercise	Ms. H. Leitch
14:15	14:40	Discussion	
14:40	15:00	*Tea/Coffee Break*	
Concluding Session			
		Chair : Dr. Raj Paroda *Co-Chairs* : Dr. B. Campbell Dr. M. Sivakumar *Rapporteur* : Dr. B.O. Sander	
15:00	15:15	Research and development priorities for climate-smart agriculture in Asia: Summary of Plenary Session	Ms. H. Leitch
15:15	15:25	Regional programs/projects of ADB and comments on conference R&D priorities	Mr. J. Zhang, ADB
15:25	15:35	Regional programs/projects of GIZ and comments on conference R&D priorities	Mr. L. Waldmueller, GIZ
15:35	15:45	Regional programs/projects of UNDP and comments on conference R&D priorities	Dr. A. Rajivan, UNDP
15:45	15:55	Regional programs/projects of JIRCAS and comments on conference R&D priorities	Mr. T. Kawashima, JIRCAS
15:55	16:05	Regional programs/projects of USAID and comments on conference R&D priorities	Ms. T. Leonardo, USAID
16:05	16:15	Global initiatives on climate services	Mr. J. Lengoasa, WMO
17:15	17:00	General discussion, next steps, conclusions, and follow-up actions	
17:00	17:30	Chair's/Co-Chairs' remarks and closing	Dr. Raj Paroda Dr. B. Campbell Dr. M. Sivakumar

Annexure II

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