Imperatives of Global Climate Change for Agricultural Research in Asia-Pacific

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The major challenges in the twenty-first century are the rapid increase in the world population, the degradation of agricultural land and other natural resources and above all the emission of greenhouse gases in the atmosphere that contribute to climate change. Hence, the growing threat of food insecurity (Brown, 2008; FAO, 2006, 2007), and rapidly engulfing poor and under-privileged population leading to increased poverty across the globe (FAO, 2007; Anon., 2008) will be exacerbated by the projected threats to agriculture due to climate change (Cline, 2007).

Emissions of green house gases (GHGs), like carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O), resulting from human activities, are substantially increasing the average temperature of the earth's surface. Fifty percent of the increase in global warming, since the industrial revolution, is considered to be the consequence of an increased level of carbon dioxide and other gases in the atmosphere (Lal, 1999). The concentration of carbon dioxide (CO_2) in the atmosphere increased from 285 ppm at the end of the 19th century, before the industrial revolution, to about 366 ppm in 1998 (equivalent to a 28 % increase) as a consequence of anthropogenic emissions of about 405 (± 60) giga tonnes of carbon (C) into the atmosphere (IPCC, 2001). Of this increase, industrialization (fossil-fuel combustion and cement production) contributed 67 % and the remaining 33 % by the land-use change. The increase in GHGs in the atmosphere is now recognized to contribute to climate change (IPCC, 2001).

Asia is the home for more than one half of the world population living on 1/3rd of global land. The rapid and continuing increase in population and economy implies increased demand for food in the region. It is estimated that by 2020, food grain

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requirement in Asia would be 30-50% more than the current demand which will have to be produced from same or even less land that too with inferior quality of other natural resources. Hence, 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, feed, fibre, fuel etc.

Alleviating poverty and attaining food security under adverse environmental scenario due to global climate change and spiraling cost of inputs, as experienced in the recent past, would be a major challenge in the 21st century to most of the countries in the Asia-Pacific region. Agriculture, consisting of cropland, pasture, and livestock production, presently contribute 13% of total anthropogenic greenhouse gas emissions. This does not include indirect sources relating to agricultural inputs such as fertilizer, food processing industries and other energy requiring operations.

Also the direction that Asian countries would embark to meet their energy needs during the coming 30 years will have profound impacts on global climate change and energy security for the region and the world. Asia currently accounts for about 26% of global carbon dioxide (CO_2) emissions, and its share of emissions is projected to increase to nearly 50% by 2030 (USAID, 2007). By 2009, China is expected to surpass the United States as the world's largest emitter of greenhouse gases (GHGs)- a decade earlier than anticipated (IEA, 2006). In addition, the burning of coal to meet Asia's energy needs is projected to increase five-fold by 2030, accelerating GHG emissions and further contributing to global climate change (IEA, 2006). Increasingly, Asian countries are importing fossil fuels to sustain their rapid economic growth, and this is raising concerns for further energy security. By 2030, it is expected that 80% of Asia's oil will be imported from the Middle East (Saha, 2006). Reserves of natural gas in Asia (a cleaner burning fossil fuel) are limited, and 40-75% of natural gas will have to be imported by 2030 to satisfy demand (APERC, 2006). This future dependence on imported fossil fuels raises legitimate concerns for Asian countries about price volatility and shocks, and supply disruptions. Also the majority of the world's most polluted cities are in Asia and the impact of urban air pollution on health and mortality in Asia is severe. Urban air pollution in Asia is linked to 500,000 premature deaths every year, accounting for 65% of premature deaths from air pollution worldwide (UNEP, 2006).

Above facts draw global concerns and urgency to address the options by which threats to Asian agriculture due to climate change can be met successfully in the near future. On positive side, the agriculture sector also provides significant potential for the greenhouse gas mitigation and adaptation to climate change effects. This, however, would demand reorientation of agricultural research that would comprehensively address all urgent concerns of climatic change through well defined adaptation and mitigation strategy which could help maximize food production, minimize environmental degradation and attain socio-economic development.

Impact of climate change on agriculture:

The climate change is projected to impinge on sustainable development of most developing countries of Asia as it compounds the pressures on natural resources and the environment associated with rapid urbanisation, industrialisation, and economic development. The impact of climate change on agriculture is now real and without adequate adaptation and mitigation strategies to climate change, food insecurity and loss of livelihood are likely to be exacerbated in Asia. In this regard, the fourth assessment report of the Inter-Governmental Panel on Climate Change (IPCC), released in 2007, has clearly revealed that increases in the emission of green house gases (GHGs) have resulted in warming of the climate system by 0.74°C 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°C. 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. The freshwater availability in Central, South, East and Southeast Asia particularly in large river basins is projected to decrease due to climate change which, along with population growth and increasing demand arising from higher standards of living, could adversely affect more than a billion people by the 2050s.

Such 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 also on livestock productivity due to increased heat stress, lower pasture productivity, and increased risks due to animal diseases. Increase in sea surface temperature and acidification will also lead to changes in marine species distribution as well as 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 with expectation of around 17 % land getting inundated in Bangladesh alone. On the contrary, the increased intensity of rainfall and contraction of monsoon period would increase flood risks in temperate and tropical Asia.

Asia-Pacific Association of Agricultural Research Institutions (APAARI) which has been instrumental in promoting regional cooperation for agricultural research in the Asia-Pacific region has been organizing series of expert consultations for debating on emerging issues vis-à-vis agricultural research and development (ARD) concerns in the Asia-Pacific region. In this endeavor, 'biofuel' and 'climate change' were identified as major themes during the expert consultation on "Research Need Assessment" organized by APAARI during 2006. Accordingly, the issue of climate change and its imperatives for agricultural research in the Asia-Pacific region was deliberated in an International Symposium organized jointly by APAARI and JIRCAS. Participants representing NARS, CGIAR, IARCs, GFAR, ACIAR, JIRCAS, ARIs, universities and regional fora from 30 countries came out with agricultural research priorities for adapting agriculture to climate change in the form of "Tsukuba declaration on adapting agriculture to climate change" (APAARI, 2009) described below:

Tsukuba Declaration on Adapting Agriculture to Climate Change

- 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. 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.
- It was fully recognized 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.

- It was also recognized 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.
- It was recognized 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.

The deliberations also led to identification of research priorities and both adaptation and mitigation strategy to deal with the challenge of climate change. These were:

Research strategies for coping with global climate change:

Coping with global climate change is a must and for that there are two strategies (i) Adaptation through learning to live with the new environment (e.g., time of planting, changing varieties, new cropping systems, etc.) and (ii) Mitigation through offsetting the causative factors such as reducing the net emission of greenhouse gases.

Adaptation strategies: The potential strategies and actions for adaptation to climate change effects could be as follow-

1. New genotypes

- Intensify search for genes for stress tolerance across plant and animal kingdom
- Intensify research efforts on marker aided selection and transgenic development
- Develop genotypes for biotic (diseases, insects etc) and abiotic (drought, flood, heat, cold, salinity) stress management either by traditional plant breeding, or genetic modification

- Attempt transforming C3 plants to C4 plants

2. New land use systems

- Shift of cropping zones
- Critical appraisal of agronomic strategies and evolving new agronomy for climate change scenarios
- Exploring opportunities for maintenance /restoration/ enhancement of soil properties
- Use of multi-purpose adapted livestock species and breeds

3. Value-added weather management services

- Developing spatially differentiated operational contingency plans for temperature and rainfall related risks, including supply management through market and non-market interventions in the event of adverse supply changes
- Enhancing research on applications of short, medium and long range weather forecasts for reducing production risks.
- Developing knowledge based decision support system for translating weather information into operational management practices
- Developing pests and disease forecasting system covering range of parameters for contingency planning and effective disease management.

4. Integrated study of 'climate change triangle' and 'disease triangle', especially in relation to viruses and their vectors

5. Documentation of indigenous traditional knowledge (ITK) and exploring opportunities for its utilization

6. Reforming global food system

Mitigation strategies: The basic strategies for mitigating climate change effects are reducing and sequestering emissions. However, before jumping to band-wagon of mitigation strategies, the following points should be considered for effective implementation of mitigation strategies.

- Improve inventories of emission of greenhouse gases using state of art emission equipments coupled with simulation models, and GIS for up-scaling

- Evaluate carbon sequestration potential of different land use systems including opportunities offered by conservation agriculture and agro-forestry
- Critically evaluate the mitigation potential of biofuels; enhance this by their genetic improvement and use of engineered microbes
- Identify cost-effective opportunities for reducing methane generation and emission in ruminants by modification of diet, and in rice paddies by water and nutrient management. Renew focus on nitrogen fertilizer use efficiency with added dimension of nitrous oxides mitigation
- Assess biophysical and socio-economic implications of mitigation of proposed GHG mitigating interventions before developing policy for their implementation

1. Reducing Emissions: The strategies for reducing emissions includes-

- Avoiding deforestation
- Minimizing soil erosion risks
- Eliminating biomass burning and incidence of wild fires
- Improving input use efficiency (e.g., fertilizers, energy, water, pesticides)
- Conservation Agriculture

2. Sequestering Emissions: The stored soil carbon is vulnerable to loss through both land management change and climate change. There are numerous agricultural sources of GHG emissions (Duxbury, 1994) with hidden C costs of tillage, fertilizer, pesticide use and irrigation. In general, net C sequestration must take into account these costs. The important strategies of soil C sequestration include restoration of degraded soils, and adoption of improved management practices (IMPs) of agricultural and forestry soils. For example in India, the potential of soil C sequestration is estimated at 39 to 49 (44 ± 5) Tg C/y of which 7 to 10 Tg C/y for restoration of degraded soils and ecosystems, 5 to 7 Tg C/y for erosion control, 6 to 7 Tg C/y for adoption of IMPs on agricultural soils, and 22 to 26 Tg C/y for secondary carbonates (Lal, 2004). Therefore, agricultural practices collectively can make a significant contribution at low cost to increasing soil carbon sinks and reducing GHG emissions. A large proportion of the mitigation potential of agriculture (excluding bio-energy) arises from soil carbon sequestration, which has strong synergies with sustainable agriculture and generally reduces vulnerability to climate change. A considerable mitigation potential through sequestration is available from reductions in methane and nitrous oxide emissions in some agricultural systems. However, there is no universally applicable list of mitigation practices and the mitigation through sequestration practices need to be evaluated for individual agricultural systems and settings (e.g. conservation tillage). The biomass from agricultural residues and dedicated energy crops can be an important bio-energy feedstock, but its contribution to climate mitigation to 2030 depends on demand for bio-energy from transport and energy supply, on water availability, and on requirements of land for food and fibre production. Hence, widespread use of agricultural land for biomass production for energy may compete with other land uses and can have positive and negative environmental impacts and implications for food security.

Epilogue:

Impact of climate change on agricultural production in Asia Pacific is real. Hence, immediate action at national level to understand and address the issues of climate change becomes a priority. Strategy around both adaptation and mitigation is called for, which would require research reorientation and major policy interventions. Regional and global collaboration would help in addressing these concerns and for building both institutional and human resource capabilities being the two cradles for sustainable agriculture.

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