PREFACE

It is indeed a great pleasure to write a preface to the proceedings of the International Conference on Climate Change Impacts and Adaptations for Food and Environment Security, organized by the Coconut Research Institute in partnership with the Ministry of Environment and Renewable Energy and the Regional Office of the World Agroforestry Centre, New Delhi, India.

Climate Change which is the ultimate outcome of the global warming is now being universally recognized as the fundamental human development challenge of this century. Global warming is attributed to increased concentration of atmospheric greenhouse gases (GHG). The post-industrial era has recorded a marked increase of GHGs in the atmosphere. The climate change impacts at various levels are observed all over the world. In Sri Lanka also climate change impacts are being witnessed. Temperature increases have been recorded in all parts of the country. The rainfall patterns have changed and it has become difficult to predict seasonal rains as in the past. Also extreme events of droughts and floods are of common occurrence. As climate change has adverse effects on agriculture populations these effects have to be minimized to reduce food insecurity and environment damage. As funding is available through international development agencies, many local institutions including universities have become involved in climate change research studies. However, these studies are isolated, scattered among institutions on various topics, hence unlikely to provide information on the best options to overcome the effects of climate change. Therefore, the objective of this conference was to provide a common forum for discussion on the current status and future directions of climate change research, methodologies, significant findings and their impacts.

Receiving statements from donor agencies at the conference inauguration was commendable to set the stage for an effective discussion because they have already committed for assisting future local programs. Thereafter, during the three technical sessions, specialists in climate change research from foreign countries, national and international research institutions, departments, universities and ministries contributed to this conference by presenting papers on climate change impacts, adaptations, mitigations and current issues on climate change related policies. Based on these papers, some recommendations were made. It is expected that the outcomes of this conference will help Sri Lanka to develop sustainable, climate –friendly agriculture and assist populations and sectors that are most vulnerable to climate change to achieve food and environment security.

Hon. Jagath Pushpakumara, Minister of Coconut Development and Janatha Estate Development was the chief guest and Hon. Susil Premajayantha, Minister of Environment and Renewable Energy was the guest of honour of the conference. Dr. B. M. S. Batagoda, Deputy Secretary to the Treasury, Ministry of Finance and Planning delivered the key note address. Dignitaries from World Agroforestry Centre (ICRAF), ministries, national and international organizations in Sri Lanka, chairmen, directorate and research staff from research institutes, university academics from Sri Lanka and UK and many coconut growers participated in the conference.

The Coconut Research Institute, Ministry of Environment and Renewable Energy, Sri Lanka and Regional Office of the World Agroforestry Centre, New Delhi, India acknowledge the contributions and support received from all the participants to make this event very productive.

Prof. H. P. M. Gunasena
Dr. H. A. J. Gunathilake
Dr. J. M. D. T. Everard
Dr. C. S. Ranasinghe
Dr. A. D. Nainanayake

Editors

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To Dr. B. M. S. Batagoda, Deputy Secretary to the Treasury, Ministry of Finance and Planning for delivering the key note address; Dr. W. L. Sumathipala, Chairman, National Science Foundation, Dr. G. Jayawardena, Chairman, Tea Research Board and Dr. V. P. Singh, Regional Coordinator, South Asia, World Agroforestry Centre for chairing three technical sessions.

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RECOMMENDATIONS

- Several organizations *viz.* Department of Meteorology, Department of Agriculture, Universities, Research Institutes and Agencies etc. are engaged in climate related research, but with little coordination. These studies need to be conducted as multidisciplinary research programs linked to implementing authority of the national climate change adaptation strategy, Ministry of Environment and Renewable Energy so that the information generated from research studies could be disseminated effectively to end users. Research programs should also be interrelated to National Planning Department, Ministry of Finance *via* Ministry of Environment and Renewable Energy. The need for establishing coordinated research programs is also highlighted in the National Climate Change Adaptation Strategy for Sri Lanka.

- The need for accurate prediction of extreme climate change events was emphasized. This is an essential requisite for national planning for managing disasters without affecting the activities of the national development plan. Researchers should be encouraged and supported to conduct multifaceted modelling studies collaboratively with international organizations predicting global climate change events.

- Comprehensive assessment of farmers' beliefs on predicting the climate change is useful for disseminating among scientists for further researching on such and farmers for adapting to climate change

- Plant breeding programs should be planned with the focus on producing cultivars capable of withstanding climate change effects while enhancing the yielding capacity, high input use efficiency and resistance to biotic stresses.

- Biofuel sector can have positive effects on food security by providing new sources of income, employment, and alternative sources of energy for rural communities. Many developing countries have now developed policies that specifically target biofuels from non-food / multiple-use crops and the potential use of marginal land for such.

- Sri Lankan home gardens dominated with tree crops show resilience to the climate change impacts. The components of this sub sector have to be studied thoroughly to identify the ways of strengthening the tree based agroforestry systems.

- It is predicted that North-East monsoon rainfall (December to January) will decrease by 26-34% and the annual average runoff by 8-10%. These will have serious consequences on water storage and surface tanks, risking the availability of water resources for agriculture. Conversely, in the wet zone run off will increase by 40-100%. It is important to take steps to retain the excess water during the five-month duration of South-West monsoon. Proper adaptation measures should be taken to drain and store the excess rainfall in the wet zone areas where demand for water is low and divert the water to the dry zone areas where demand for water is high to ensure water security. Proper drainage and erosion control structures should be designed to minimize landslides and flash floods during the South-West monsoon. Other possible adaptations to overcome rainfall related problems are opting to short duration paddy varieties during low rainfall in January and February, innovating new methods to use less water for paddy cultivation, introducing other field crops, which need less water, using water saving methods such as drip irrigation in the dry zone, harvesting rainwater and making people aware on proper methods of collecting, storing, maintaining and using water. There is a need to repair turbines and action to prevent silting of tanks.

- Achieve self-sufficiency in rice, other field crops, vegetables and fruits, breeding high yield potential varieties with high input use

efficiencies and resistance to biotic stresses (as earlier mentioned), develop mix cropping systems, promoting tree crops in home gardens are areas that should receive attention to ensure food security. This is the best alternative for island countries like Sri Lanka as the land is limited. The main adaptation options for plantation crops are: screening varieties with reproductive survivability, breeding varieties for heat stress tolerance, screening clones for tolerance to quality parameters, persuade growers to adopt good agronomic practices and change micro-climate by developing agroforestry based cropping systems.

- The vulnerability of biodiversity and ecosystems should be assessed accurately by careful estimation of changes taken place in *fauna* and *flora* and the ecosystems over the years due to climate change.

- Partnerships should be established with international research centers and universities engaged in climate related research for exchange of technical information and expertise.

- Importance of capacity building at all levels; policy makers and implementing agencies, researchers, farming community and the general public for adapting and mitigating drastic climate change effects.

MESSAGES FROM DIGNITARIES

Hon. Jagath Pushpakumara
Minister of Coconut Development and Janatha Estate Development,
Sri Lanka

It gives me great pleasure to write this message in connection with the International Conference on Climate Change Impacts and Adaptations for Food and Environment Security jointly organized by the Coconut Research Institute, Ministry of Environment and Renewable Energy and the International Centre for Research in Agroforestry (ICRAF, World Agroforestry Centre), Regional Office New Delhi, India.

Climate change has become a major concern to human society because of its potentially deleterious impacts worldwide. In scientific terms, climate change is defined as a long-term change in the statistical distribution of weather patterns over periods of time that range from decades to millions of years. Climate change may be a change in the average weather conditions or a change in the distribution of weather events. The mandated organization formed in this regard, the Inter-governmental Panel on Climate Change (IPCC) has comprehensively recognized that the recent climate change was induced by global warming which was a direct result of excessive emissions of greenhouse gasses, particularly the carbon dioxide emitted from uncontrolled combustion of fossil fuels.

Compared to other sectors, agriculture is highly dependent on specific climate conditions. Hence, the food supply sector is highly vulnerable to climatic changes but, the understanding of the overall effect of climate change on our food supply is somewhat difficult due to the multifaceted nature of the climate change. Although it is argued that the increase in temperature and carbon dioxide (CO_2) can be beneficial for some crops in some places, it adversely affects for most crops in tropical regions. Not only the temperature but also the increased frequency and severity of droughts and floods could pose serious challenges for farmers. Hence, climate change could make it more difficult to grow crops and raise animals in same ways and in same places as we have done in the past. The effects of climate change also need to be considered along with other evolving factors that affect agricultural production, such as changes in farming practices, relevant crop and technologies. However, despite all those improvements that made to increase yields of many crops, extreme weather events are now causing significant yield reductions all over the world. Under this context ensuring food security is of paramount importance and a major challenge faced by agricultural scientists all over the world. However, the food crop sector of Sri Lanka has gained significant growth in the recent past mainly due to the pro agricultural policies, availability of better varieties and associated technologies, fertilizer subsidy and other promotional schemes and the increase of the area under cultivation by many major food crops. As a result, Sri Lanka has attained self-sufficiency or near self-sufficiency in many food crops especially rice, vegetables and few upland crops such as maize, green gram, big onion, ground nut, soybean, cowpea and red onion while plantation crop sector is also showing significant improvements. Similarly, among plantation crops, coconut production has increased substantially, but often subjected to vagaries of weather. However, with the dramatic changes in the climate and increased frequency of extreme events in the recent past pose a real threat to the food security of the country. Therefore, it is high time to look in to the latest changes in the climate with emphasis on food security.

Under the present context, Sri Lanka has developed a National Climate Change Policy containing a set of guiding principles under specific themes of Vulnerability, Adaptation, Mitigation, Sustainable Consumption and Production and Knowledge Management. In the

implementation of this policy into meaningful set of actions to meet the challenges of climate change, a collaborative action at all levels is necessary. It is extremely important to identify gaps of research in climate change related issues for effective implementation of the national climate change policy. At this juncture, the 'International Conference on Climate Change Impacts and Adaptations for Food and Environment Security' jointly organized by the Coconut Research Institute, World Agroforestry Centre and the Ministry of Environment and Renewable Energy, Sri Lanka is most timely and extremely important. Therefore, I wish to complement the Coconut Research Institute for its leadership role in organizing conference with other relevant local and international organizations. I wish success for the conference and expect all scientists and relevant parties to reach more meaningful and fruitful achievements and a way forward in improving the food security sector even under the present climatic changes occurring and yet to occur in the future.

Hon. Susil Premajayantha

Minister of Environment & Renewable Energy,
Sri Lanka

Sri Lanka being an island nation subjected to tropical climatic influences is highly vulnerable to climate change impacts. We are already experiencing significant climatic imbalances manifested through increasing average temperatures, drastic variations in rainfall patterns and extreme climatic events such as heavy rainstorms, flash floods, and extended droughts and weather related natural disasters in various forms and severity. These extreme and sometimes unseasonal events affect not only the human lives and properties but also have long term impacts on the ecosystems as well.

The issue of climate change and climate variability is among the priorities of governments today because of the growing recognition of its potential and real threat to human systems as well as to ecosystems including food production, biodiversity, health, and other sectors. "Mahinda Chinthana – Vision for the Future", the Government of Sri Lanka's Ten Year Development Policy Framework assigns a very high priority to the management of the environment and the natural resources sector including addressing climate change impacts. In keeping with the Government's overall vision the "National Climate Change Policy (NCCP) of Sri Lanka" identifies the paramount need of undertaking appropriate actions for climate change adaptation in order to build resilience of the country to face the adverse impacts of climate change.

However, most researches on climate change are conducted in fragmentary fashion by different countries, disciplines and sectors. Hence, there is much opportunity for developing multisectoral/ multidisciplinary approaches. This International Conference on Climate Change Impacts and adaptations for Food and Environment Security aims to provide a venue for promoting integrative partnerships that can eventually result in a convergence of ideas for holistic solutions to reduce the adverse impacts of climate change on agriculture and environment.

My appreciation is extended to the climate change researchers, scientists, experts and policy makers and all other stakeholders who are actively participating to this international conference and giving their invaluable contribution towards the sustainable development of the country.

Mr. Nihal Somaweera
Secretary, Ministry of Coconut Development and Janatha Estate Development,
Sri Lanka

I am pleased to forward this message in connection with the International Conference on Climate Change Impacts and Adaptations for Food and Environment Security jointly organized by the Coconut Research Institute, Ministry of Environment and Renewable Energy and the International Centre for Research in Agroforestry (ICRAF, World Agroforestry Centre), Regional Office, New Delhi, India.

Broad scientific agreement exists all over the world that continued accumulation of heat-trapping "greenhouse" gases, mainly Carbon Dioxide (CO_2) in the atmosphere will eventually lead to changes in the global climate. The gravity of the problem led to the formation of the Intergovernmental Panel on Climate Change (IPCC), the international body of leading natural and social scientists sponsored by the United Nations Environment Programme and the World Meteorological Organization. According to their first report released in 1996, an increase in atmospheric concentrations of greenhouse gases equivalent to a doubling of carbon dioxide (CO_2) will force a rise in global average temperature by 1.0 to 3.5°C by 2100. Average precipitation also will rise as much 10 to 15 % because a warmer atmosphere holds more water.

Predicted changes in local climate will have an enormous impact on agricultural production which would lead to serious consequences for food security because food production systems interact very closely with water and land resources. Food crops in Sri Lanka, including coconut will be exposed to increased atmospheric CO_2 levels along with many abiotic stress factors such as increased air temperatures above threshold, reduction in the quality and quantity of irrigation water leading to the increased frequency of water stress periods and some biotic stresses such as shifting of insect / pathogen behavior and virulence.

Although the higher carbon dioxide levels can increase crop yields, the degree of change is highly variable with different crops and the area where the crop is grown. However, if temperature exceeds a crop's optimal level or if sufficient water and nutrients are not available, yield increases may be reduced or reversed. Moreover, extreme events of temperature and precipitation, droughts and floods which are in increased frequency may harm crops and reduce yields. Therefore, dealing with drought could become a challenge in areas where temperatures are projected to increase and precipitation is projected to decrease causing a reduction in water supply. Furthermore, many weeds, pests and fungi thrive under warmer temperatures and increased CO_2 levels. This would cause new problems for farmers' crops previously unexposed to these species. Counteracting with increased use of pesticides and fungicides may negatively affect the human health.

Although, all nations are affected by the impacts of climate change, impacts on developing countries remain poorly understood because few studies have successfully measured the effects of climate on economies of developing countries. Nonetheless, it is likely that developing countries will be more vulnerable because a greater fraction of their economies are in climate sensitive sectors like agriculture, they are mostly in hot climatic zones, and their economies mostly rely on labor-intensive technologies with fewer adaptations and opportunities to changes in climate. Sri Lanka also being a tropical country situated close to the equator is more vulnerable especially with changes in temperature. Flash floods, landslides and extended dry spells causing water shortages and crop losses are now becoming more and more frequent in Sri Lanka. These adverse changes would adversely impact on socio-economic activities in the country. Hence, Sri Lanka has to actively participate in the global efforts to minimize the greenhouse gas emissions based on the principles of the United Nations Framework Convention on Climate Change (UNFCCC) and it's Kyoto Protocol (KP) while taking other adaptation measures to cope up with the situation.

Hence, this 'International Conference on Climate Change Impacts and Adaptations for Food and Environment Security' jointly organized by the Coconut Research Institute, Ministry of Environment and Renewable Energy and World Agroforestry Centre and with the theme of 'Sustaining agriculture under changing climate' would be extremely valuable in analyzing the latest developments in the global and Sri Lankan context with respect to the climate change and food security. I extend my whole hearted wishes for the conference to achieve targeted goals paving a way to safeguard the food security within our country.

Prof. H. P. M. Gunasena
Chairman, Coconut Research Board,
Sri Lanka

It is indeed a pleasure to write this message on behalf of the organizing committee for the International Conference on Climate Change Impacts and Adaptations for Food and Environment Security, organized by the Coconut Research institute in partnership with the Ministry of Environment and Renewable Energy and the Regional Office of the World Agroforestry Centre, New Delhi, India.

The climate change impacts at various levels are observed all over the world. In Sri Lanka also climate change impacts are being witnessed. Temperature increases have been recorded in all parts of the country. The rainfall patterns have changed and it has become difficult to predict seasonal rains as in the past. Also extreme events of droughts and floods are of common occurrence. In 2012, the drought that prevailed in some of the coconut growing districts devastated coconut plantations. In the paddy growing areas floods have caused damage to the rice crop seriously affecting the income and sustenance of farmers. As climate change has adverse effects on agriculture populations these effects have to be minimized to reduce food insecurity and environment damage. These changes have been attributed to increases in greenhouse gas emissions, however mitigation is an arduous task and other alternatives solutions have to be found.

This conference is the outcome of several years of discussion with climate change specialists, academics, policy makers and researchers on achieving food and environment security in the face of impending climate change. More and more discussions with experts revealed the complexity of the climate change on environment and food production systems and few opportunities available for the sustainable development of these sectors.

Taking the leadership in organizing this conference, the Coconut Research Institute searched for local and global organizations which are either mandated or working on climate change issues. Obviously as climate change is of considerable importance in achieving food and environment security it was a main agenda item of several international development agencies. As funding is available through these agencies many local institutions including universities have become involved in climate change studies. However, a closer scrutiny of literature and on-going research showed the lack of focused research and development initiatives to find practical solutions to meet challenges of climate change .These studies are isolated, scattered among institutions on various topics, hence unlikely to provide information on the best options to overcome the effects of climate change.

Therefore, the objective of this conference is to provide a common forum for discussion on the current status and future directions of climate change research, methodologies, significant findings and their impacts. In order to set the stage for an effective discussion, the international development agencies have been requested to provide the background on the global scene. In addition, specialists in climate change research from foreign countries will address on current research issues. Thereafter, the researchers in state institutions and universities involved in climate change will add to the knowledge from their research. The information generated in this conference will provide the basis for developing a national framework and implementing strategies to respond to wider and larger scale implications of climate change on natural resources. It is expected that the outcomes of this conference will help Sri Lanka to make sustainable, climate –friendly agriculture and assist populations and sectors that are most vulnerable to climate change to achieve food and environment security.

Dr. H. A. J. Gunathilaka
Director, Coconut Research Institute,
Sri Lanka

I am pleased to send this message for the International Conference on Climate Change Impacts and Adaptations on Food and Environment Security organized by the Coconut Research Institute together with the Ministry of Environment and Renewable Energy and the World Agroforestry Center Regional Office, New Delhi, India.

Climate change is a very important phenomenon taking place in the world due to changes in weather patterns continuing for millions of years. In Sri Lanka increases in temperature mainly in the dry zone has been already being witnessed and this has significantly affected coconut and other agricultural production. The current events that are taking place in Sri Lanka in unusual weather patterns, mainly occurrence of high rainfall, prolonged droughts and floods, thunder activity, coastal erosion, landslides and Tsunamis are evidence of impending climate change. It has been mentioned that Sri Lanka being an island nation will face serious impacts of climate change. The changes in climate could cause threats to natural resources, biodiversity, loss of infrastructure, human dwellings and to the people with serious consequences on all sectors of the country's economy. The most vulnerable is the agricultural sector as agricultural production depends on climate and any extreme climate events could have adverse effects on food production. Also, as most of the poorer segments of society are dependent on agriculture, they are likely to be the most affected. As identified in the theme of this conference, it will have serious consequences on both environment and food security and the people of this country.

The global climate change or global warming is irreversible and efforts are being made to mitigate such effects that occur due to emissions of greenhouse gases. However, greenhouse gas emissions are not easily controllable due to the development activities that are taking place both in developed and developing countries. Therefore, it is important to build up the adaptive capacity and reduce the vulnerability of the natural resources and the communities. Also, the adaptive initiatives of any form will require enabling policies, collective action and coordination at inter-ministry and local levels.

This international conference organized by the Coconut Research Institute, Ministry of Environment and Renewable Energy and the World Agroforestry Centre attempts to bring together the experts on climate change, policy makers, researchers and practitioners to one platform to discuss the current status of climate change research and development initiatives for strengthening food and environment security. The outcomes of this conference will be of considerable importance to Sri Lanka and other Asian nations to implement strategies that may respond to implications of climate change on natural resources.

While I complement the organizers for initiating this important event, I also request them to come up with tangible recommendations for meeting this challenge of climate change to secure Sri Lanka's natural resources for achieving food and environment security.