Climate Change and its Impact on Flora in the South Asian Region

Organised by:

South Asia Co-operative Environment Programme (SACEP)
and
National Botanical Research Institute, Lucknow, India

9-12, March, 2008

Workshop Report
Inauguration of the SACRTF meeting by the lighting of oil-lamp

Inaugural Session L-R: Dr. Rakesh Tuli, Director NBRI, Dr. A.A. Boaz, Director General, SACPEP Prof. N.H. Ravindranath and Dr. R.D. Tripathi

Workshop Participants

Dr. A.A. Boaz, Director General-SACPEP delivering his speech of the Workshop

Dr. Rakesh Tuli, Director NBRI delivering his speech of the Workshop
Climate Change and it's Impact on Flora in the South Asian Region

Organised by:
South Asia Co-operative Environment Programme (SACEP) and National Botanical Research Institute, Lucknow, India
9-12, March, 2008

Workshop Report
I am happy to learn that the National Botanical Research Institute (NBRI) Lucknow and the South Asia Cooperative Environment Programme (SACEP) Colombo are jointly organizing an International Workshop on Climate Change and its Impact on Flora in the South Asia Region.

Climate change is a matter of concern particularly for the countries of South Asia, which are vulnerable to its potential impacts. This Workshop could be a milestone for implementation and promotion of sustainable development to address issues related to climate change. Priority should be given to sustainable development, keeping in view the fact that those with the least resources have the least capacity to adapt and are the most vulnerable.

On this occasion, I extend my greetings and felicitations to all those associated with the NBRI and wish the Workshop every success.

New Delhi
March 4, 2008

(Pratibha Devisingh Patil)
MESSAGE

The Prime Minister is pleased to know that the National Botanical Research Institute, Lucknow, and South Asia Cooperative Environment Programme, Colombo, are organizing an international workshop on Climate Change and its impact on Flora in the South Asia region from 9th to 12th March, 2008.

It is important and necessary that the countries of South Asia work together to deal with the threat of climate change. We have a shared geographical environment and have to work together to deal with shared and common challenges. India is willing to work with the global community to mitigate and address the causes and consequences of climate change within the framework of a growing economy. Developing countries have to catch up in the journey of development and require technology and financial support to deal with the problem of climate change.

The Prime Minister hopes your conference will arrive at a cooperative environment programme for the South Asian region and wishes the Workshop all success.

(Sanjaya Baru)

March 3, 2008
Dr Arvind Anil Boaz

Director General, SACEP

Message

It is in fulfillment of our Governing Council decision on including the Adaptation to Climate Change as a Priority Issue in the Work Plan of SACEP that this Workshop is being held in close collaboration with the NBRI, a Premier Institution of our South Asian Region. I have wanted to organize this workshop on climate change adaptation for quite some time. The felt need is particularly because of the growing recognition of the links between preventive measures and augmentation to increase resilience of productive natural systems; especially when susceptibility appears to be increasing along with the randomness and intensity of perturbations.

Worldwide, temperatures have risen by 0.6°C over the past 40 years and are predicted to rise by 2-6°C over the next century. Precipitation patterns have also changed – some places are receiving more rain than they did in the past, some places less. Evidence of climate change are evident through the shrinking glaciers, lengthening of mid-to-high-latitude growing seasons, pole-ward and altitudinal shifts of plants, decline of some plants populations, earlier flowering of trees etc. Natural systems are vulnerable to climate change and some will be irreversibly damaged due to the limited adaptive capacity, the examples are mangroves, boreal and tropical forest, prairie wetlands, native grasslands and biodiversity. Beside this many human systems are also sensitive like the water resources, agriculture, especially food security, forestry, coastal zones and marine systems.

Plant responses to climate change depend upon – species and cultivars, soil properties, pests and pathogens, the direct effect of pollutants - CO₂, O₃, methane etc. on plants, interactions between pollutants, air temperature, water stress, mineral nutrition, air quality and adaptive responses.

Climate change is already impacting plants and altering the structure of plant communities. Species that are particularly vulnerable to climate change include those with limited ranges and dispersal abilities. Many plant species are responding to climate change by advancing the onset of leaf burst, flowering, and fruiting, and delaying leaf drop. The growing season is lengthening. The earlier onset of bud burst, flowering, and fruiting could have major impacts on timing-sensitive relationships with pollinators, seed dispersers, and herbivores. Events that have long occurred in synchrony may become decoupled, which could especially
impact plant species with specialized pollinators and seed dispersers. Adaptation is a necessary strategy at all scales to complement climate change mitigation efforts, to reduce adverse impacts of climate change and to enhance beneficial impacts.

South Asian countries show a wide range of variation in climate, altitude and physiography. There is considerable divergence of opinion about the magnitude of climate change predicted for this region and its effect on plants. Both climate models and observational studies give conflicting and hazy pictures of the effect of climate change on vegetation. The assessment of impacts of projected climate changes on natural ecosystems is not based on accurate scientific modeling or field studies at regional level.

This workshop shall expose the participants to the latest thinking on issues of vulnerability and adaptation in the context of biodiversity, agriculture and forestry due to the changes brought by climate change. This is regardless of efforts to reduce emissions of greenhouse gases. Besides climate change, topics related to pollutions of land and water bodies and approaches based on phyto-remediation will also be discussed.

The inter-disciplinary nature of the work requires expert institutions to pool their resources, knowledge and information. It is most useful that SACEP and NBRI has been successful in bringing together through this workshop the experts from neighbourhood countries to reflect in an integrated fashion on the pertinent nodal issues and key questions, which are of direct relevance to assessing the impacts of climate change on vegetation. The issues will be towards the factors influencing vulnerability and the aspects related to planning for adaptation.

May this workshop be a milestone in the issues of Adaptation to Climate Change and its impact on Flora and the collaborative response by the countries of the region by bringing together their expertise, resources and information for the benefit of the large population that is so dependent on the natural resources of our region

I wish the workshop a very big success and some very active deliberations to develop the Strategy and the way forward for the South Asian Region.

(Dr Arvind Boaz)
Director General
5th March 2008
Message

On behalf of the National Botanical Research Institute (NBRI) and the South Asia Co-operative Environment Programme (SACEP), I extend a warm welcome to all the distinguished delegates and guests of the International Workshop on Climate Change & its Impact on Flora of South Asia Region being held at NBRI, Lucknow. We are greatly privileged to have with us several eminent experts, professionals, and administrators from India and abroad to deliberate and discuss the key issues in climate change and its impact on flora and vegetation in the South Asia region. NBRI takes pride in hosting this meeting on such an important subject that faces all of us.

National Botanical Research Institute (NBRI) is a multi-disciplinary plant research institute of international repute under the aegis of Council of Scientific and Industrial Research (CSIR), New Delhi. Established in 1953 as National Botanic Gardens, the institute was renamed as National Botanical Research Institute in 1978 to reflect its national impact and promote the R&D component. Over the years of its progressive growth, the institute has become a front-ranking national centre of excellence for basic and applied research in different areas in plant sciences. The institute has a wholesome expertise in plant biodiversity, biotechnology, bioinformatics, and environmental biology. NBRI is known for its outstanding contributions in the knowledge base on India’s plant diversity, and in developing globally competitive biotech and transgenic technologies, herbal products, and bioremediation technologies. Major solution to the problems of climate change will probably come out of plant science in the form of more efficient trees that could sequester carbon, terrestrial and marine plants that could give solution to energy, crop varieties that could utilize water more efficiently and stand the change in climate etc. Thus an institute like NBRI has a deep interest and responsibility in addressing the complex issue of climate change. I am particularly happy and thankful to Dr. Boaz, DG, SACEP for giving us this opportunity to organize this first regional workshop.

The atmospheric temperatures have risen Worldwide by 0.6°C over the past 40 years and is predicted to rise by 2-6°C over the next century. Precipitation patterns have also changed, some places are receiving more rain than they did in the past, some places less. The impact of climate change is manifested by the shrinking glaciers, lengthening of mid-to-high-latitude growing seasons, pole-ward and altitudinal shift of plants, decline of some plant populations, abrupt changes in phenology in trees, etc. The life support systems on earth, including water resources, agriculture, forestry, coastal zones, and marine systems are all susceptible to climate change. Many plant species are responding to climate change by advancing the onset of leaf burst, flowering and...
fruition, and delaying leaf drop. These events could adversely affect plant species with specialized pollinators and seed dispersers. The phenomenon is clearly visible, and all of us experience it now. Releasing the seriousness of
the issue, and the need for creative solutions, the Nobel Prize committee has aptly helped the global community by recognizing the distinguished contributions of I.P.C.C. (Chairman, Dr.R.K. Pachauri, India) and Al Gore (Albert Gore Jr., U.S.A) for the Peace Prize, 2007. The solutions to the threats posed by climate change will indeed determine long term global peace.

Climate change is a vital and widely debated issue at global conventions, world summits, international conferences and symposia. The assessment of impacts of projected climate changes on natural ecosystems require more accurate scientific modeling and field studies. It is not a local issue because the climate patterns are determined by global activities, and perhaps beyond. There are no geographical borders to climate. Thus, regional discussions of the kind planned for this workshop are important to evolve strategies to monitor the impact of climate change and devise strategies to find lasting solutions. This workshop should provide an ideal platform to initiate inter-disciplinary efforts among experts in South Asia to pool their resources, knowledge and information related to climate change and related issue, and develop appropriate strategic action plan to assess the impacts of climate change on flora and vegetation of South Asian region.

On behalf of NBRI and SACEP, I once again welcome you all to this important event. I look forward to the delegates giving their best to the proceedings and evolving recommendations for immediate and long term initiatives. I look forward to the development of a regional forum that would steer future actions in South Asia. I thank Dr Boaz, once again and look forward to his carrying this initiative forward as one of the flagship programmes of SACEP.

(Rakesh Tuli)
Patron, Organizing Committee
& Director, NBRI

Dr. Rakesh Tuli,
Director,
National Botanical Research Institute (NBRI),
Rana Pratap Marg,
Lucknow-226001.
MESSAGE

February 23, 2008

I am happy to learn that National Botanical Research Institute, Lucknow in collaboration with South Asia Cooperative Environment Programme, Colombo, Sri Lanka is organising an "International Workshop on Climate Change & its impact on Flora in the South Asia Region" during March 09 - 12, 2008.

Climate Change has become an area of great concern for all of us, as it directly affects our environment. Rising temperatures, erratic rainfall, deterioration of soil texture, swelling seas, and the threat to life forms are all linked to it. There is ample evidence to show that enhanced greenhouse gases have already modified the global climate and have consequently caused changes in the distribution of flora and fauna. Majority of the world's population depend on agriculture for their livelihoods and changing climate leading to increasing floods, droughts and rise in sea level has direct and adverse effect on agriculture productivity. Climate change thus has a direct linkage with the lively hood of the common man and the survival of life on the planet Earth. It is feared that if corrective mechanisms are not put in place quickly, it would lead to irreversible and catastrophic effects on our future generation.

The galaxy of scientists and professionals participating in this workshop will address some of the pertinent questions staring at us, with regard to the climate change and its impacts, and would come up with specific suggestions/recommendations for drawing up comprehensive strategies to minimize them.

I would like to send my best wishes to the organizers and the participants and wish the workshop a grand success.

(V. L. Chopra)
MESSAGE

I am glad that an International Workshop on Climate Change & its Impact on Flora in the South Asia Region is being held at NBRI. This is a timely initiative since climate change is likely to disturb rainfall patterns, cause a rise in temperatures and also affect sea levels. It is important to make a proactive analysis of the impact of drought, floods, cyclones and sea level rise on flora. This will help to take timely steps to prevent genetic erosion and safeguard priceless flora. I hope the workshop will provide a roadmap for achieving the security of our bioresources under conditions of climate change.

M.S. Swaminathan

M.S. SWAMINATHAN RESEARCH FOUNDATION
Chairman
Dr. R. K. Pachauri
Chairman, Intergovernmental Panel on Climate Change (IPCC)

Message

I am very happy to learn that the National Botanical Research Institute (NBRI) in partnership with South Asia Cooperative Environment Programme (SACEP) is organizing an International Workshop on Climate Change & its Impact on Flora in the South Asia region. The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) has clearly brought out the major impacts of climate change that different regions of the world are likely to face. In the Synthesis Report of the IPCC released in November 2007 some abrupt and irreversible changes were also highlighted. Among these is the possibility of a threat of extinction of 20 to 30 percent of the species assessed by the IPCC, if temperature increases exceed 1.5 to 2.5 °C. There is already growing evidence around the world of the adverse impacts of climate change on flora.

The South Asian region being rich in diversity and a region where society depends to a great extent on the healthy production and conservation of flora is particularly sensitive to the impacts of climate change. It is, therefore, particularly important that all the countries of the South Asian region work together in understanding and investigating this area of climate change impacts and in devising solutions that would allow society to adapt to these impacts.

I am sure the proposed workshop would produce a great deal of valuable knowledge that would help the countries of the South Asian region to manage the growing challenge of climate change and its impacts on flora in this region.

I convey my best wishes to the organizers of the workshop.

R. K. Pachauri
Director General, The Energy and Resources Institute (TERI) & Chairman, Intergovernmental Panel on Climate Change (IPCC)
International Workshop on 'Climate Change & its Impact on Flora in the South Asia Region' is being organized by NBRI in association with SACEP on 09-12 March 2008. In fact, I would like to congratulate you for choosing this important area as a consequence of climate change for eliciting international thinking. I would have very much liked to come over but due to prior commitments on account of Budget Session of Parliament, I shall not be able to leave headquarters. Accordingly, I regret my inability to join. However, I take this opportunity to wish all success for the deliberations of the Workshop.

With warm regards,

February 21, 2008

(P.S. Goel)
Prof. Samir K. Brahmachari
Director General, CSIR
&Secretary, Government of India
Department of Scientific & Industrial Research

Message

I am pleased to note that the National Botanical Research Institute, Lucknow, and the South Asia Cooperative Environment Programme, Colombo, are jointly organizing an International Workshop on Climate Change & its Impact on Flora in the South Asia Region, during 9-12 March 2008, at Lucknow.

The Earth’s climate is changing and its impact on biodiversity and wildlife habitats across the planet is already visible. South Asia has an exceptionally rich biological diversity and the history of fauna and flora of this region is tied closely to any climatic change. Due to the global climate change, nearly half of the South Asia’s biodiversity is at risk and any further unchecked climate change could lead to an environmental and economic catastrophe. Therefore, there is an urgent need for assessment of impact of climate change on natural eco-systems by way of accurate scientific modelling. And this needs be done at the regional level, as the South Asian countries, including India, show a wide range of variation in climate and related parameters.

In this scenario, this international workshop is very timely and relevant. I am sure, this workshop would provide an ideal platform to help evolve a suitable strategy for the expert institutions in South Asia to pool their resources, knowledge and information related to climate change in order to assess the impact of climate change on regional flora and vegetation.

I wish the event all success.

(Samir K. Brahmachari)

New Delhi
March 4, 2008
MESSAGE

March 3, 2008

I am extremely happy to learn that National Botanical Research Institute (NBRI) and South Asia Cooperative Environment Programme (SACEP) are organizing an International Workshop on Climate Change & its Impact on Flora in the South Asia region from March 9-12, 2008 at NBRI, Lucknow.

Climate change is occurring continuously over the time, but it has become an international issue when scientists agreed on 'global warming' and started drawing future scenario impacts with their research experiences. Now, the atmospheric concentration of greenhouse gases (GHGs), especially carbon dioxide, has exceeded its previous rate in last 650,000 years and caused the rise of global temperature by 0.74°C over the past 100 years and if it so continued, it is obvious that present climate is bound to change and impact all spheres of life directly or indirectly.

The whole world is in our hands—the outcome and existence of life will be determined by our actions. This is our opportunity to make the Earth a better place.

In this context, the present workshop assumes a great significance. I am sure the outcome of the workshop will go a long way in drawing some tangible action plan. I wish all success to the workshop and congratulate the organizers for selecting such an important topic of current interest.

P.K. SETH
FOREWORD

It is with a great sense of achievement that I present this report on the “Workshop on Climate Change and its impact on Flora in the South Asian Region.” It was for the first time that such a regional workshop was held in South Asia. I am extremely thankful to the Government of India and the National Botanical Research Institute for hosting the workshop and conducting it in such a successful manner. It was indeed a privilege to host the experts from all the eight member countries to deliberate on such an important and timely issue.

Climate change is a phenomenon that has had a great impact on the very existence of life on earth. It is a vital and hotly debated topic all over the world. It is already impacting plants and altering the structure of plant communities. Species that are particularly vulnerable to climate change include those with limited ranges and dispersal abilities. The IPCC special report on “Climate Change and Biodiversity” clearly indicates the adverse impacts of Climate change on natural ecosystems particularly the mangroves, coral reefs and wetlands. Climate change will also cause irreversible damage to the unique forest ecosystems of this region impacting several taxa and rendering several species extinct. Climate change is also affecting the onset of leaf burst, flowering, and fruiting, and delaying leaf drop. In several cases the growing season is lengthening. The earlier onset of bud burst, flowering, and fruiting could have major impacts on timing-sensitive relationships with pollinators, seed dispersers, and herbivores. This will have a major impact on food security of nearly 25% of the population of the world that inhabit this region.

South Asian countries show a wide range of variation in climate, altitude and physiography. There is considerable divergence of opinion about the magnitude of climate change predicted for this region and its effect on plants. Both climate models and observational studies give conflicting and hazy pictures of the effect of climate change on vegetation. The assessment of impacts of projected climate changes on natural ecosystems is not based on accurate scientific modeling or field studies at regional level. I am happy to report that this workshop was able to bring together scientists, policy makers and experts to discuss the latest thinking on issues of vulnerability and adaptation in the context of biodiversity, agriculture and forestry due to the changes brought by climate change. It is heartening to note that premier institutions like the Forest Research Institutes of India and Pakistan, various other Plant Research laboratories and Universities from the South Asian countries were able to reflect in an integrated fashion on the pertinent nodal issues and key questions, which are of direct relevance to assessing the impacts of climate change on vegetation. The major issues addressed were factors influencing vulnerability and the aspects related to planning for adaptation. Besides climate change, topics related to pollutions of land and water bodies and approaches based on phyto-remediation were also be discussed.

This workshop has proved to be a milestone in the issues of Adaptation to Climate Change and its impact on Flora and I am confident that it will serve as a starting point for the collaborative response by the countries of the region in bringing together their expertise, resources and information for the benefit of the large population that is so dependent on the natural resources of our region.

(Dr Arvind Boaz)
Director General
ACKNOWLEDGEMENT

South Asia Cooperative Environment Programme and NBRI acknowledges the generous support offered by Go India towards the implementation of the workshop "Climate Change & its Impact on Flora in the South Asia Region". The Govt of India through CSIR, Department of Science and Technology, Department of Biotechnology, and Ministry of Environment and Forest were co-sponsored the workshop. I gratefully acknowledge the contributions of Prof. J.S. Singh for his valuable suggestions while initiate this venture.

A special thanks to Dr. Rakesh Tuli, Director, National Botanical Research Institute, Dr. R.D. Tripathi, Dr. Nandini Singh and all the Staff Members of NBRI for valuable cooperation in organizing and in the successful conduct of the workshop. I would like to thank all of the workshop participants and delegates from the region, as the workshop report is an output of their active and involved brainstorming sessions, inputs and discussions. Also, thank SACEP Staff to coordinate this event at the Regional level.

Dr. Arvind Boaz
Director General, SACEP.
SECTION 01

INTRODUCTION

Worldwide, temperatures have risen by 0.6°C over the past 40 years and are predicted to rise by 2–6°C over the next century. Precipitation patterns have also changed – some places are receiving more rain than they did in the past, some places less. Evidence of climate change are evident through the shrinking glaciers, lengthening of mid-to-high-latitude growing seasons, poleward and altitudinal shifts of plants, decline of some plants populations, earlier flowering of trees etc. Natural systems are vulnerable to climate change and some will be irreversibly damaged due to the limited adaptive capacity, the examples are mangroves, boreal and tropical forest, prairie wetlands, native grasslands and biodiversity. Beside this many human systems are also sensitive like the water resources, agriculture (esp. food security), forestry, coastal zones and marine systems.

Plant responses to climate change depend upon – species and cultivars, soil properties, pests and pathogens, the direct effect of pollutants - CO₂, O₃, methane etc. on plants, interactions between pollutants, air temperature, water stress, mineral nutrition, air quality and adaptive responses.

Climate change is already impacting plants and altering the structure of plant communities. Species that are particularly vulnerable to climate change include those with limited ranges and dispersal abilities. Although the IUCN Red List of Threatened Species lists climate change as a threat to only seven species (including plants and animals), evidence suggests that this estimate under-represents the true threat to rare species. Many plant species are responding to climate change by advancing the onset of leaf burst, flowering, and fruiting, and delaying leaf drop. The growing season is lengthening. The earlier onset of bud burst, flowering, and fruiting could have major impacts on timing-sensitive relationships with pollinators, seed dispersers, and herbivores. Events that have long occurred in synchrony may become decoupled, which could especially impact plant species with specialized pollinators and seed dispersers. Adaptation is a necessary strategy at all scales to complement climate change mitigation efforts, to reduce adverse impacts of climate change and to enhance beneficial impacts.

The subject of climate change is an important topic at global conventions, world summits, international conferences and symposia. Global Climate Change is a reality, a continuous process that needs to be taken up seriously at regional level. There are large uncertainties in its spacial and temporal impact and need to be examined regionally.

South Asian countries including India show a wide range of variation in climate, altitude and physiography. There is considerable divergence of opinion about the magnitude of climate change predicted for this region and its effect on plants. Both climate models and observational studies give conflicting and hazy pictures of the effect of climate change on vegetation. The assessment of impacts of projected climate changes on natural ecosystems is not based on accurate scientific modeling or field studies at regional level.

The Workshop

A four day International Workshop on "Climate Change and its Impact on Flora in the South Asian Region" was organized jointly by National Botanical Research Institute (NBRI), Lucknow and South Asia Cooperative Environment Programe (SACEP), at NBRI, Lucknow on March 9-12, 2008. About 139 Scientists, experts and researchers from various parts of India and South-Asian countries viz., Bangladesh, Bhutan, Maldives, Pakistan, Sri Lanka, Nepal and Afghanistan participated in the workshop.

The workshop exposed the participants to the latest thinking on issues of vulnerability and adaptation in the context of biodiversity, agriculture and forestry due to the changes brought by climate change. This is regardless of efforts to reduce emissions of greenhouse gases.

The inter-disciplinarity of the work requires expert institutions to pool their resources, knowledge and information. SACEP brought together the experts from neighborhood countries to reflect in an integrated
fashion on the pertinent nodal issues and key questions, which are of direct relevance to assessing the impacts of climate change on vegetation. The issues focused towards the factors influencing vulnerability and the aspects related to planning for adaptation.

This workshop was conducted to carry forward the Priority Area of Adaptation to Climate change that was identified as one of the main priority areas at the 9th Governing Council of SACEP collaborating with the National Botanical Research Institute (NBRI). The National Botanical Research Institute (NBRI) is the premier national plant research center for India under the umbrella of Council of Scientific and Industrial Research (CSIR) an internationally well-known research organisation of the foot of India and it focuses on both basic and applied aspects of plant sciences. It caters to the need of almost every aspect of plant research in South Asian region in general and India in particular.

Scope

The scope of the workshop was to develop key role in the area of climate change and its effect on biodiversity of various locations/ ecosystems and areas like; agriculture, forestry of South Asian countries were discussed in common. Besides, specific impacts to the flora, like carbon sequestration in changing climatic condition and plant nutrient / metal interaction etc. also discussed. Finally, a region specific recommendation for enhancing environmental sustainability was prepared. Various deliberations and discussions pertaining to various subsets of climate change interactions with flora were formulated in a project mode document.

Developed and discussed the projections of climate change and it's impact on the flora in the 08 countries in South Asia.

Outputs:

- Initiate a collaborative network to study regional impact of climate change in South Asia.
- Published research papers summarizing the expected impacts of climate change on flora in South Asian countries.
- Proposal on "Impact of Climate Change on Flora: A South Asian Initiative" was developed.
- Adopted Lucknow Declaration on "Climate Change and it's Impact on Flora in the South Asian Region" also attached.

Workshop Recommendations

- Development of collaborative network to study regional impact of climate change in South Asia.
- Development of a strategy for region specific studies on climate change, pollutants and response of regional flora.
- Identification of crop varieties for higher adaptability to different parameters of climate change factors.
- Predictive modeling under laboratory and field conditions with appropriate format and tools.
- Establishment of regional facilities for data development on climate change and effects on local flora in different countries in South Asia.
- Development of South Asian information network to enhance awareness about climate change and other environmental pollutants.
Inauguration Ceremony 09.03.08 (Day 1)

The workshop was aimed to provide an international forum for serious scientific discussion and deliberations to develop projections on climate change and its impact on the flora in various countries of South Asia.

In the inaugural function held on 9th March, 2009, Dr. Rakesh Tuli, Director NBRI, welcomed the participants from different countries and introduced the theme of the workshop. He emphasized that the workshop was to provide an ideal platform to initiate interdisciplinary work among experts in South Asia to pool their resources, knowledge and information related to climate change, and develop appropriate strategic action to assess the impact of climate change on flora and vegetation of South Asian region.

Dr. Arvind Anil Boaz, Director General, SACEP in his inaugural address enlightened on the issues of vulnerability and adaptation in the context of bio-diversity, agriculture and forestry due to the changes brought by climate change. He said that the workshop would develop strategies for regional research and development of South Asian information network for enhancing the preparedness for global climate change and enhance the mutual cooperation in the South Asian countries.

The Chief Guest, Prof. N.H. Ravindranath, of Indian Institute of Science, Bangalore said "The South Asia region inhabited by about five million people will be most affected by adverse climate change". Elaborating further Prof. Ravindranath emphasized that there had been a consistent rise in the greenhouse gas emission especially between 1970 to 2006. As a result of this, North West India, Pakistan, Nepal would see more warming conditions which would be detrimental for the vegetation of the region. In his keynote address he said that the climate change would also adversely affect the bio-diversity. Prof. N.H.Ravindranath, further mentioned that Indian Institute of Science, Bangalore has capacity to hosting of Training Programme on this issue.

The workshop was divided in seven sessions starting from the climate change scenario in different countries where all participating countries expert gave their country presentation emphasizing the extent of greenhouse gas emission and the effect on agriculture, forest and marine flora in their countries.

Session 1 Climate Change – Scenario in different countries

- **Chairperson**: Prof. N.H Ravindranath, IISc, Bangalore
- **Rapporteur**: Prof. A.S. Raghuvanshi, BHU, Varanasi

**Lead Lectures**

- "Climate Change and Environmental Impact : An Indian Perspective" J.S Pandey, NEERI, Nagpur
- "Climate Change Impact on Plants" Prof. C.K Varshney, New Delhi (20 Min.)

Dr. J.S. Pandey, Deputy Director & Science Secretary, National Environmental Engineering Research Institute (NEERI), NAGPUR, India, discussed the Development of a Dynamic and Predictive Model for Ecological Footprinting (EF) and explained the earlier models were static (no time-variation) and this model is dynamic (can be used for future predictions) and condition for ecological sustainability has been derived and tested.

Dr. Pandey further explained a Scavenging Dependent Air Basin Ecological Risk Assessment (SABERA)-Model Applied to Acid Rain Impact Around Delhi City. India. Many of even the most recently applied ecological risk assessment models have dealt with ecological risks only on the basis of single-species toxicity tests. Moreover, they have seldom treated the integrated and the complete ecological unit for the risk assessment. In other words, parameters which regulate many of those very important ecological interactions at land-water, air-land, and air-water interfaces. Therefore, a realistic ecological risk
assessment model has been developed and applied for the air basin surrounding Delhi City in India. Variations in four important parameters – leaf area index, precipitation intensity, plant-leaf stomatal density, and mixing height have been studied.

Session 2  Climate Change and Biodiversity

The second session concentrated on the effect of climate change on the biodiversity. The deliberations focused on the impacts from climate change and disruption of ecosystems such as Himalayan region, marine biota, desert conifer family and evergreen forest of Western Ghats leading to tremendous loss of biodiversity.

- **Chairperson**: Mr. Sandeep Tripathi, ICFRE, Dehradun
- **Rapporteur**: Dr. V. Nath, NBRI, Lucknow

Country Presentations I

Country delegates of Afghanistan, Bangladesh, Bhutan and Maldives presented on the efforts of the country governments on the above issue with a brief on how they could contribute to the objectives of the workshop.

Mr. Saeed Ibrahim Sherzai, Energy Efficiency Officer FFEM Project and Multilateral Environment Agreement Officer (Climate Change) of Afghanistan, mentioned that as the Afghanistan is formulating the work plan on Climate Change Issues, they need the help of member countries to institutionalize these issues in Afghanistan.

Mr. Md. Billal Hossain, Deputy Director, Department of Environment and Mr. Haradhan Banik, Assistant Chief Conservator of Forest, Department of Forest, Bangladesh presented detailed activities under the Climate Change issues on Flora.

Mr. Lobzang Dorji, Chief Forestry Officer, Department of Forests, Ministry of Agriculture, Royal Government of Bhutan, explained the Glacier outburst is the most vulnerable to Bhutan due to climate change effect.

Mr. Ibrahim Naeem, Director Ministry of Environment, Energy and Water, Republic of Maldives mentioned that although they are one of the least contributors to the GHG emission, Maldives is the highly susceptible for the Climate Change effects. Storm surges are also now common in Maldives which severely affects the coastal flora.

Lead Lectures

- "Impact of increased anthropogenic activities on marine biota" Dr. Baban Ingole, NIO, Goa
- "Climate Change and It’s Impact on Biodiversity: An Indian Perspective" Dr. J.P.N. Rai, G.B.P.U.A.T., Pantnagar
- "Carbon Sequestration potential Studies in Forest and Agro-ecosystem in Central Himalayan Region of India. Prof. Uma Melkania, Pantnagar University, Pantnagar

Country Presentations II

Country delegates of Nepal, Sri Lanka, Pakistan, presented their presentations

Prof. Sant Bahadur Gurung, Department of Agricultural Botany, Institute of Agriculture and Animal Science, Nepal, highlighted the important of the Curricula and Educational Programme under Climate Change issues on Flora.

Mr. Raja Khalid Hussain, Director General, Pakistan Forest Institute (PFI), also discussed how the climate change effects for flora giving specific examples.

Mr. M.A.A.M. Jayarathe, Additional Conservator of Forest, Forest Department, Sri Lanka explained how different ecosystems of Sri Lanka affects the Climate Change effects.
Welcome address by Dr. Rakesh Tuli, Director, NBRI

Dear Delegates,

On behalf of the National Botanical Research Institute (NBRI) and the South Asia Co-operative Environment Programme (SACEP), I extend a warm welcome to all the distinguished delegates and guests of the International Workshop on Climate Change & its Impact on Flora of South Asia Region being held at NBRI, Lucknow. We are greatly privileged to have with us several eminent experts, professionals and administrators from India and abroad to deliberate and discuss the key issues in climate change and its impact on flora and vegetation in the South Asia region. NBRI takes pride in hosting this meeting on such an important subject that faces all of us.

National Botanical Research Institute (NBRI) is a multi-disciplinary plant research institute of international repute under the aegis of Council of Scientific and Industrial Research (CSIR), New Delhi. Established in 1953 as National Botanic Gardens, the institute was renamed as National Botanical Research Institute in 1978 to reflect its national impact and promote the R&D component. Over the years of its progressive growth, the institute has become front ranking national centre of excellence for basic and applied research in different areas in plant sciences. The institute has a wholesome expertise in plant biodiversity, biotechnology, biinformatics, and environmental biology. NBRI is known for its outstanding contributions in the knowledge base on India’s plant diversity, and in developing globally competitive biotech and transgenic technologies, herbal products and bioremediation technologies. Major solution to the problems of climate change will probably come out of plant science in form of more efficient trees that could sequester carbon, terrestrial and marine plants that could give solution to energy, crop varieties that could utilize water more efficiently and stand the change in climate etc. Thus an institute like NBRI has a deep interest and responsibility in addressing the complex issue of climate change. I am particularly happy and thankful to Dr. Boaz, DG, SACEP for giving us this opportunity to organize this first regional workshop.

The atmospheric temperatures has risen Worldwide by 0.6°C over the past 40 years and is predicted to rise by 2–6°C over the next century. Precipitation patterns have also changed, some places are receiving more rain than they did in the past, some places less. The impact of climate change is manifested by the shrinking glaciers, lengthening of mid-to-high-latitude growing seasons, pole-ward and altitudinal shift of plants, decline of some plant populations, abrupt changes in phenology in trees, etc. The life support systems on earth, including water resources, agriculture, forestry, coastal zones and marine systems are all susceptible to climate change. Many plant species are responding to climate change by advancing the onset of leaf burst, flowering and fruiting, and delaying leaf drop. These events could adversely affect plant species with specialized pollinators and seed dispersers. The phenomenon is clearly visible, and all of us experience it now. Releasing the seriousness of the issue, and the need for creative solutions, the Nobel Prize committee has aptly helped the global community by recognizing the distinguished contributions of I.P.C.C. (Chairman, Dr. R.K. Pachauri, India) and Al Gore (Albert Gore Jr., U.S.A) for the Peace Prize, 2007.

The solutions to the threats passed by climate change will indeed determine long term global peace.

Climate change is a vital and widely debated issue at global conventions, world summits, international conferences and symposia. The assessment of impacts of projected climate changes on natural ecosystems require more accurate scientific modeling and field studies. It is not a local issue because the climate patterns are determined by global activities, and perhaps beyond. There are no geographical borders to climate. Thus, regional discussions of the kind planned for this workshop are important to evolve strategies to monitor the impact of climate change and devise strategies to find lasting solutions. This workshop should provide an ideal platform to initiate inter-disciplinary efforts among experts institutions in South Asia to pool their resources, knowledge and information related to climate change and related issue, and develop appropriate strategic action plan to assess the impacts of climate change on flora and vegetation of South Asian region.

On behalf of NBRI and SACEP, I once again welcome you all to this important event. I look forward to the delegates giving their best to the proceedings and evolving recommendations for immediate and long term initiatives. I look forward to the development of a regional forum that would steer future actions in South Asia. I thank Dr Boaz, once again and look forward to his carrying this initiative forward as one of the flagship programmes of SACEP.
Address of Dr Arvind Anil Boaz, Director General, SACEP

Dr. Rakesh Tuli, Director, NBRI, Dr. C.K. Varshney JNU, New Delhi Dr. Subodh Sharma, Advisor MoEF, New Delhi, Prof. N.H. Ravindranath, IISc, Bangalore and colleagues from the Ministries of Environment,

Welcome to the workshop on Climate Change & its Impact on Flora in the South Asian Region. We appreciate your efforts to travel large distances after re-scheduling your activities. Thanks indeed for accepting our invitation. Your interest reflects the importance of the present initiative. I am aware of your contributions to the growing body of knowledge and hand-holding initiatives in the field of climate change impact and mitigation. Your inputs will be valuable to consolidate and strengthen the way forward to address challenges in adaptation at the regional level in South Asia.

The Global statistics on Climate Change are alarming. The earth is getting hotter, temperatures are rising as a result of increased concentrations of greenhouse gases in the atmosphere. The recently released 4th Assessment report of the IPCC makes this very clear. Most alarmingly, the people of the planet are advised to expect significant physical, biological economic and sociological consequences of this viral change. Equally clear from the report is that any attempts to moderate these impacts will require immediate action across all levels – global, regional, national and local.

South Asian countries show a wide range of variation in climate, altitude and physiography. There is considerable divergence of opinion about the magnitude of climate change predicted for this region and its effect on plants. Both climate models and observational studies give conflicting and hazy pictures of the effect of climate change on vegetation. The assessment of impacts of projected climate changes on natural ecosystems is not based on accurate scientific modeling or field studies at regional level.

I have wanted to organize this workshop on climate change & its Impact on Flora in the South Asian Region for quite some time. My interest was generated from the felt need from the Scoping Exercise on Climate Change that we held at SACEP in January 2007 in which discussions were led by the Hon’ Mr Mohan Munasinghe, the Vice Chair of the IPCC, who had been kind enough to send a senior member of his Institute, to this workshop as he was unable to attend because of his preoccupations. This interest was further articulated in the 10th Governing Council meeting of SACEP last year. The felt need has been reinforced because of the growing recognition of the links between preventive measures and augmentation to increase resilience of systems; especially when susceptibility appears to be increasing along with the randomness and intensity of perturbations.

This also leads us to the next aspect of the relatively lesser importance given to adaptation efforts vis-à-vis mitigation; thus calling for concerted efforts to focus on adaptation opportunities. Is it because of the relatively more complex nature if adaptation frameworks involving several cross-cutting themes impinging on developmental imperatives or the lack of precise quantification tools and techniques unlike targeted mitigation goals and approaches. I invite you to deliberate on these aspects.

I wish to highlight the fact that the Governing Council of SACEP has mandated work on adaptation through this scoping initiative. We need to provide the Council with a clear understanding of the regional consensus on prioritizing climate change related impact on flora and set the agenda in conjunction with the developmental and environmental protection imperatives at the local, regional and global levels. The questions we wish to therefore find answers for are,

01. What are the principal impact and mitigation related issues in the region on Flora?

02. Do we think it will be useful for SACEP and NBRI to initiate intensive assessments through reality checks on
   a. Adequacy of information on Floral eco-system vis-à-vis susceptibility to Climate Change
   b. Existing institutional and technical strengths to assess and guide implementation of solutions within location-specific frameworks
   c. Indigenous solutions which need to be significantly up-scaled and in this process avoid duplication of efforts. You may agree that the scope for technical and technological cooperation
at the regional level is quite significant in this context. This could signify a true South – South cooperation model of enabling Impact – focused development.

d. Is it possible to also establish a few pilots which demonstrate the feasibility of evolving appropriate systems integrating institutional, technical and technological collaborations on the regional level.

I am raising these questions to draw your attention to the framework of discussions so that a roadmap for our work may be charted. I invite you all to provide leadership in this joint initiative which we have had the privilege of kick-starting. I am sure you have the necessary insights to provide clear answers to the questions I have raised for your consideration.

I am glad that our thinking is inline with the NBRI and reflects the questions raised earlier by me. I am sure Dr. Rakesh Tuli, Director, NBRI, will be able to help design and evaluate appropriate tools which may be used by relevant stakeholders in this process. NBRI as the premier national plant research center for India under the umbrella of Council of Scientific and Industrial Research (CSIR) an internationally well-known research organisation of India and it focuses on both basic and applied aspects of plant sciences. I am sure this initiative would cater to the need of almost every aspect of plant research in South Asian

SACEP and NBRI are planning to wish re-visit you after the Governing Council deliberations this month to seek your guidance and involvement based on mutually acceptable terms to fulfill the regional agenda of improving preparedness to adapt through the following objectives;

- Development of collaborative network to study regional impact of climate change in South Asia.
- Development of a strategy for region specific studies on climate change, pollutants and response of regional flora.
- Identification of crop varieties for higher adaptability to different parameters of climate change factors.
- Establishment of regional facilities for data development on climate change and effects on local flora in different countries in South Asia.
- Development of South Asian information network to enhance awareness about climate change and other environmental pollutants.

I am confident that the result of our deliberations here will help us to take immediate steps to create a South Asian forum for enhancing the preparedness to face the challenges posed by the global climate change to regional flora and ecosystems.

I once again welcome Prof. N.H. Ravindranath, IISc, Bangalore who is one of the lead authorities on the subject, his inputs here will set the stage for the deliberations appropriately. Dr. Rakesh Tuli, Director, NBRI with all his experience on bio-diversity and his research considerations related to Climate Change; Dr. C.K. Varshney, JNU coming as he does from one of the foremost schools of ecological research, contributing to the body of knowledge through the IPCC will undoubtedly add to the value of the deliberations.

It is unfortunate that Our Hon’ Prof Mohan Munasinghe from Sri Lanka and Dr. Atiq Rahman from BCAS Bangladesh could not join us. However we will communicate with them regarding the outcome of this meeting and seek their views on the issues. I am also indebted to all my country governments for consenting to my request to send delegates to this important meet and to all delegates to have spared their valuable time and for their immense effort to come to this workshop. Thank you for being with us now and I hope that the discussion will yield a concrete suggestion to the Ministerial meeting at the end of this April 2008.
Impact of Climate Change on Biodiversity in Forest and Natural Ecosystems in India

Climate is probably the most important determinant of vegetation patterns globally and has significant influence on the distribution, structure and ecology of forests and other natural ecosystems. Several climate-vegetation studies have shown that certain climatic regimes are associated with particular plant communities or functional types. It is therefore logical to assume that changes in climate would alter the configuration of forest and other ecosystems.

The Third Assessment Report of IPCC concluded that recent modelling studies indicate that forest ecosystems could be seriously impacted by future climate change. Even with global warming of 1–2°C, much less than the most recent projections of warming during this century, most ecosystems and landscapes will be impacted through changes in species composition, productivity and biodiversity. These have implications for the livelihoods of people who depend on forest resources for their livelihoods.

The Fourth Assessment Report of IPCC made the following conclusions on impacts of climate change on ecosystems (IPCC, 2007).

- The resilience of many ecosystems is likely to be exceeded this century by an unprecedented combination of climate change, associated disturbances (e.g. flooding, drought, wildfire, insects, ocean acidification), and other global change drivers (e.g. land-use change, pollution, fragmentation of natural systems, over-exploitation of resources).
- Over the course of this century, net carbon uptake by terrestrial ecosystems is likely to peak before mid-century and then weaken or even reverse, thus amplifying climate change.
- Approximately 20-30% of plant and animal species assessed so far are likely to be at increased risk of extinction if increases in global average temperature exceed 1.5-2.5°C (minimum confidence).
- For increases in global average temperature exceeding 1.5-2.5°C and in concomitant atmospheric CO2 concentrations, there are projected to be major changes in ecosystem structure and function, species ecological interactions, and shifts in species' geographical ranges, with predominantly negative consequences for biodiversity and ecosystem goods and services, e.g. water and food supply.

India is a mega-biodiversity country where forests account for about 20% (64 million ha) of the geographical area. With nearly 200,000 villages classified as forest villages, there is obviously large dependence of communities on forest resources. Thus it is important to assess the likely impacts of projected climate change on forests and develop and implement adaptation strategies for both biodiversity conservation and the livelihoods of forest-dependent people.

Preliminary qualitative assessments of potential climate change impacts on forests in India were based on earlier GCM (General Circulation Model) outputs of climate change that have undergone considerable refinement. Following this there were two regional studies, the first pertaining to potential climate change impacts on forests in the northern state of Himachal Pradesh, and the second in the Western Ghats. These studies indicated moderate to large-scale shifts in vegetation types, with implications for forest dieback and biodiversity. The studies conducted in India so far have had several limitations, e.g. coarse resolution of the input data and model outputs due to the use of GCM scale grids, the use of earlier versions of the BIOME model that had limited capability in categorizing plant functional types, and the absence of any national level model-based assessment of climate impacts. A recent study using the BIOME3 model and climate change scenarios of HadCM2 projected large-scale shifts in areas under different vegetation types and an increase in NPP. As part of our ongoing efforts in refining our predictive capabilities, the present study assesses the potential impacts of future climate change on forest ecosystems at the national level based on RCM (Regional Climate Model) projections and a more advanced version of the BIOME model.
Current and future climate patterns

The mean annual precipitation over India as computed from the CRU data was seen to be about 1094 mm and the mean annual temperature was about 22.7°C. The projected climate (average for 2071–2100) for the more moderate B2 scenario is both wetter (an average increase of about 220 mm) and warmer (an average increase of about 2.9°C) compared to the HadRM3 baseline. The corresponding values for the more extreme A2 scenario are about 300 mm and 4.2°C respectively. The mean annual precipitation for the projected values for B2 scenario turns out to be 1314 mm and the projected mean temperature is about 25.6°C. There is considerable geographical variation in the magnitude of changes for both temperature as well as rainfall.

North-western India is likely to become drier, while north-eastern India is likely to become much wetter. The temperature increase in north-western India is also much more than that in the northeast. Southern and south-eastern parts of India are likely to experience only a moderate increase in temperature.

Changes in climate over forested areas

The high-resolution data from FSI (Forest Survey of India) can be used to map the location of various types of forests across India. The major forest types in India (those occupying 0.5% or more of the forested area) and their areas are given in Table 1. Forests in India are extremely diverse and heterogeneous in nature, and it is difficult to classify them into a small number of categories. As a result, the pan-Indian 'Miscellaneous forest' category (with no dominant species) shows the highest (63%) proportion. The miscellaneous forest area occurs under all the forest types. The other two most dominant forest types are Shorea robusta or sal (12%) in the eastern part of Central India and Tectona grandis or teak (9.5%), spread across Central India and the Western Ghats in Southern India. The climate impact analysis is carried out for the FSI forest categories as well as the BIOME model vegetation types.

Changes in climate in the forest areas are presented in Table 1 using the B2 scenario projections and FSI categories of forests. The temperature and rainfall means are obtained by considering all the grids of each forest type, occurring in different parts of India. In general, under the B2 scenario projections, the mean rainfall (and mean temperature) in areas under forest cover is somewhat higher than that in the non-forested areas. The increase expected in rainfall under the changed climate is also relatively larger for the forested areas, about 376 mm compared to the overall average of about 235 mm. The mean change in temperature, however, is not different from that in the non-forested regions. As expected, the changes in climate are not uni-form across the different forest types – ranging from a large increase of more than 550 mm/year for hardwood and bamboo forests to a modest 220 mm for the colder fir/blue-pine forests (Table 1).

<table>
<thead>
<tr>
<th>Forest type</th>
<th>Number of grids</th>
<th>% area</th>
<th>Mean annual rainfall (mm)</th>
<th>Change in rainfall (mm)</th>
<th>Mean temperature (°C)</th>
<th>Change in temperature (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blue pine (Kathi)</td>
<td>311</td>
<td>0.82</td>
<td>761.0</td>
<td>253.5</td>
<td>10.6</td>
<td>3.6</td>
</tr>
<tr>
<td>Chlor-pine</td>
<td>561</td>
<td>2.25</td>
<td>1373.4</td>
<td>437.4</td>
<td>15.4</td>
<td>2.8</td>
</tr>
<tr>
<td>Mixed conifer</td>
<td>1071</td>
<td>3.04</td>
<td>810.1</td>
<td>375.9</td>
<td>9.3</td>
<td>3.0</td>
</tr>
<tr>
<td>Hypa elastica communis mix</td>
<td>296</td>
<td>0.84</td>
<td>1360.7</td>
<td>537.6</td>
<td>13.1</td>
<td>3.8</td>
</tr>
<tr>
<td>Upland hardwoods</td>
<td>881</td>
<td>2.55</td>
<td>1523.8</td>
<td>476.9</td>
<td>16.4</td>
<td>3.7</td>
</tr>
<tr>
<td>Teak</td>
<td>3564</td>
<td>8.56</td>
<td>1514.6</td>
<td>353.0</td>
<td>26.1</td>
<td>2.9</td>
</tr>
<tr>
<td>Sal</td>
<td>4231</td>
<td>12.08</td>
<td>1435.2</td>
<td>348.3</td>
<td>24.6</td>
<td>2.7</td>
</tr>
<tr>
<td>Bamboo forest</td>
<td>567</td>
<td>1.61</td>
<td>2268.3</td>
<td>561.9</td>
<td>23.8</td>
<td>2.7</td>
</tr>
<tr>
<td>Mangrove</td>
<td>261</td>
<td>0.57</td>
<td>1734.3</td>
<td>231.8</td>
<td>26.6</td>
<td>2.5</td>
</tr>
<tr>
<td>Miscellaneous forest</td>
<td>22339</td>
<td>61.42</td>
<td>1679.8</td>
<td>374.5</td>
<td>23.0</td>
<td>2.7</td>
</tr>
<tr>
<td>Western Ghats evergreen forest</td>
<td>163</td>
<td>0.46</td>
<td>3411.3</td>
<td>908.7</td>
<td>25.4</td>
<td>2.4</td>
</tr>
</tbody>
</table>

Source: Forest types and area11.

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The changes in temperature also show a striking pattern, with colder forests being subjected to a larger increase of about 3°C, compared to the Western Ghat evergreen forests, which on an average become warmer by only about 2.4°C, compared to the national average of 2.9°C under the B2 scenario. The changes under the more extreme A2 scenario are qualitatively similar to those described above, except that the magnitude of change is larger. Most of the forests show an increase of about 4°C with the northern temperate forests being subjected to about 4.6°C increase, while the Western Ghat evergreen forests show the least change of about 3.3°C.

Impact of climate change on forest types and distribution

A comparison of the extent of area that is likely to occur in each of the forest types under the present climate regime, and that under the two future climate scenarios reveals the magnitude of changes that are expected to take place in each of the forest types (Fig 1). The BIOME4 model was run for a total of 10,864 grid points (10 min · 10 min) located in the Indian region, using the CRU 10-min climatology. Due to gaps in data related to soil parameter values, the model could assign vegetation types to only 10,429 of these grid points. As mentioned earlier, a comparison with the FSI database (available at a much finer resolution of 2.5 min · 2.5 min) allowed us to use the information from 35,190 FSI grids. There was a reasonable match between the forest types predicted by BIOME4 with the forest types assigned by FSI. Thus, tropical evergreen forests were seen in the southern Western Ghats and in the northeastern region, while the temperate forests were seen to occur in regions corresponding to fir/spruce/deodar forests.

Forest Biodiversity

A review of studies by IPCC and Gitay et al. has shown that forest biodiversity or the species assemblage is projected to undergo changes due to the projected climate change. Biodiversity is likely to be impacted under the projected climate scenarios due to changes or shifts in forest or vegetation types (in 57 to 60% of forested grids), forest dieback during the transient phase, and different species responding differently to climate changes even when there is no change in forest type. Climate change will be an additional pressure and will exacerbate the declines in biodiversity resulting from socio-economic pressures.

The climate impact assessment made for Indian forest sector using regional climate model (HadRM3) outputs and BIOME4 vegetation model has shown that nearly 68 to 77% of the forested grids are likely to
experience change, which includes loss of area under a given forest type and replacement by another type from the prevailing forest type by 2055. In other words, over half of the vegetation is likely to find itself less optimally adapted to its existing location, making it vulnerable to adverse climatic conditions and to biotic stresses. Further, the actual negative impact may be more than what is initially expected from the above description. This is because different species respond differently to the changes in climate. Thus, one expects that a few species may show a steep decline in populations and perhaps even local extinctions. This, in turn, will affect the other taxa dependent on the different species (i.e., a ‘domino’ effect) because of the interdependent nature of the many plant-animal-microbe communities that are known to exist in forest ecosystems. This could eventually lead to major changes in the biodiversity. The positive impact of projected climate change, under the A2 and B2 scenario, is the projected increase in NPP. Thus, the projected climate impacts are likely to have significant implications for forest management in India.

Thus, climate change could cause irreversible damage to unique forest ecosystems and biodiversity, rendering several species extinct, locally and globally. Forest ecosystems require the longest response time to adapt, say through migration and regrowth. Further, a long gestation period is involved in developing and implementing adaptation strategies in the forest sector. Thus there is a need to develop and implement adaptation strategies. Adaptation is adjustment in natural or human systems in response to actual or expected climatic stimuli and their impacts on natural and socio-economic systems.

Impact of climate change on biodiversity of natural ecosystems

The IPCC special report on “Climate change and Biodiversity” reports of adverse impacts of climate change on natural ecosystems, particularly the coral reefs, mangroves and wetlands.

Coral reef and Mangroves: Coral reefs will be negatively affected by beaching and reduced calcification, which can lead to the loss of many reef-associated communities and species. Consequently there will be a loss of revenue from tourism and fisheries sectors. Mangroves, seagrass beds and other coastal ecosystems will be adversely impacted by increased temperatures and accelerated sea level rise. Salt water intrusions into fresh water habitats will affect biodiversity. Coastal wetlands play an important role in the economy of the country, especially in fisheries. The mangroves and the coral reefs in particular are important nurseries for several fishes, prawns and crabs. Of the annual fish catch of about 5.6 Mt, about half is from marine fisheries; the coral reefs and associated shelves and lagoons alone have the potential for about 10 per cent of the total marine fish yields. Climate change impacts on the coastal wetlands would thus have serious consequences for the livelihoods of people, as well as the integrity of the coastal environment.

Impacts on Mangroves: Impacts of climate change on mangrove ecosystems is governed by factors such as sea-level changes, storm surges, fresh-water flows in rivers both from precipitation in their catchments as well as from snow melt in the mountains, local precipitation, and temperature changes that would influence evapo-transpiration. Sea-level rise would increase the salinity of wetlands and submerge the mangroves as well. As a result, mangroves with higher salinity tolerance would be favoured. At the same time, increased snow melt in the western Himalayas could bring larger quantities of fresh water into the Gangetic delta with significant consequences for the composition of the Sunderbans mangroves. Changes in local temperature and precipitation would also influence the salinity of the mangrove wetlands and have a bearing on plant composition. Any increase in freshwater flows would favour mangrove species that have least tolerance to salinity.

Impacts on Wetlands: Climate change impacts on inland wetlands is a complex issue, dependent on several variables such as increased temperature, rate of evaporation, changes in precipitation of the catchment, changes in nutrient cycling and responses of a variety of aquatic species. Although tropical lakes are less likely to be impacted by climate change as compared to temperate lakes, an increase in temperature would alter the thermal cycles of lakes, oxygen solubility and other compounds, and affect the ecosystem. In high-altitude lakes an increased temperature would result in the loss of winter ice cover, causing a major change in the seasonal cycle and species composition of the lake. Reduced oxygen concentration could alter community structure, characterized by fewer species, especially if exacerbated by eutrophication from surrounding land use. Lake-level changes from increased temperature and changes in precipitation would also alter community structure.
Impacts on Grasslands: There are five major grassland types recognized in India, on the basis of species associations, geographical location and climatic factors. The same anthropogenic factors such as livestock grazing and fire that were responsible for creating many of the grassland types in the country are also involved in their degradation. While moderate levels of grazing could be sustainable and even promote plant species diversity, heavy grazing reduces the plant cover and eliminates palatable grasses and herbs while promoting the growth of unpalatable plants. When considering the likely impact of future climate change on natural grasslands, we need to consider several factors including the direct response of grasses to enhanced atmospheric CO$_{2}$, as well as changes in temperature, precipitation and soil moisture.

It is well known that C3 and C4 plants respond differently to atmospheric CO$_{2}$ levels and also to temperature and soil moisture levels. The C4 plants constitute much of the biomass of tropical grasslands and include the arid, semi-arid and moist grasslands in India. These plants thrive well under conditions of lower atmospheric CO$_{2}$ levels, higher temperatures and lower soil moisture, while C3 plants exhibit opposing traits. GCM model projections of HadCM2 for India indicate an increase in precipitation by up to 30 per cent for the north-eastern region in addition to a relatively moderate increase in temperature of about 2°C by the period 2041-2060. This could increase the incidence of flooding in the Brahmaputra basin and thus favour maintenance of moist grasslands in the regions. The HadCM2 projections for the rest of the country (southern, central and north-western India) are a steep increase in temperature of 3°C in the south (except along the coast) to over 4°C in the northwest, and a decrease in precipitation of over 30% in the northwest with little change in parts of the south. Such a temperature increase and rainfall decrease would cause major changes in the composition of current day vegetation in these regions, with an overall shift to a more arid type. Increased atmospheric CO$_{2}$ levels and temperatures, resulting in lowered incidence of frost, would favour C3, plants including exotic weeds such as wattle that could invade the montane grasslands of the Western Ghats. Rising temperatures would also impact cool, temperate grasslands of the Himalayas, promoting upward migration of woody plants from lower elevations.

The global circulation models are robust in projecting mean temperature at global level compared to their ability for making projections at regional level. The uncertainty involved in projections of precipitation changes is higher at global and particularly at regional level. The climate projections, particularly the rainfall projections, have high uncertainty and vary from model to model. The BIOME is an equilibrium model and does not project the transient phase vegetation responses. The use of equilibrium and particularly the dynamic models is characterized by data limitations related to climate parameters, soil characteristics and plant physiological functions. Thus, the projections of impacts using the outputs of the current climate models and vegetation response models are characterized by high uncertainty. There is therefore a need to improve the reliability of climate projections at regional level and use of dynamic vegetation models. Data limitations need to be overcome by initiating studies to develop database on forest vegetation characteristics and plant functional types, plant physiological parameters, soil and water data and socio-economic dependence and pressures on forest ecosystems. Research on impact of climate change on natural ecosystems such as coral reef, mangroves, wetland and grasslands is very limited. Thus there is a need to intensify modelling and research efforts on impact of climate change on flora and fauna of Asia.

Note based on:

2. Ravindranath N.H., Joshi, N.V., Sukumar, R., Indu, K Murthy and Suresh H.S, Chapter 7: Vulnerability and Adaptation to Climate Change in the Forest Sector "Climate Change and India; IN Shukla et al., Vulnerability Assessment and Adaptation, University Press, 2003.
Country Presentations
Country Presentation Afghanistan

General information about climate change
And its impact on living organism
in Afghanistan

Prepared by: Tazib Adilali Rahmati
National Environmental Protection Agency (NEPA)
Afghanistan: Kabul

<table>
<thead>
<tr>
<th>Afghanistan’s biography</th>
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<tbody>
<tr>
<td>- Afghanistan is an arid country that covers 652,090 km²</td>
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<tr>
<td>- Approximately 27% of Afghanistan lies above 2,500m elevation.</td>
</tr>
<tr>
<td>- The population of Afghanistan in 2005 was around 28 million and the country is divided into 34 provinces with Kabul as the largest city and the administrative capital.</td>
</tr>
<tr>
<td>- Afghanistan's area is approximately the size of Texas is bordered on the north by Turkmenistan, Uzbekistan and Tajikistan on the extreme northeast by China on the east and south by Pakistan and by Iran on the west.</td>
</tr>
</tbody>
</table>

CONTENTS

- Afghanistan’s biography
- Afghanistan’s climate
- Ratification of Climate Change Convention in Afghanistan
- Key Climate Hazards

CONTINUE....

- Afghanistan experienced severe drought during the 1995-2005 period. The associated decrease in precipitation generated several adverse ecological, economic, social and even cultural consequences. |
- The rural and urban environments have also experienced degradation in the quality of environmental services. |
- The quality of drinking water and sanitation has become a matter for concern as regards public health in the urban areas. |
- The quality of the air in the main urban centers has degraded by increasing quantities of vehicles exhaust fumes.

<table>
<thead>
<tr>
<th>Afghanistan’s climate</th>
</tr>
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<tbody>
<tr>
<td>- Afghanistan has arid and semi-arid continental climate with cool winters and hot summers.</td>
</tr>
<tr>
<td>- The climate varies substantially from one region to another due to dramatic changes in topography.</td>
</tr>
<tr>
<td>- The last season generally runs from winter through early spring till the country in the summer is dry. Failing with in the desert or arid desert climate classification.</td>
</tr>
<tr>
<td>- The snow season averages in October, April in the mountains and varies considerably with elevation with very little snow falling in the low and desert of the southwest.</td>
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</tbody>
</table>
Key Climate Hazards:
1) Periodic drought
2) Flood due to untimely and heavy rainfall
3) Flooding due to thawing of snow and ice
4) Rise in temperature
5) Frost and cold spells
6) Hail, thunder and lightning
7) Monsoon and 120-day winds

Ratification of Climate Change (UNFCCC) Convention in Afghanistan.
- Afghanistan signed on UNFCCC Convention on 12th June 1992
- But ratified on 19th September 2002
- The transitional authority Entered into force on 18th December 2002
- Afghanistan is not signed Kyoto protocol yet

1) Periodic drought
Decrease in productivity of crops, forced migration, livelihood export and financial losses

2) Flood due to untimely and heavy rainfall
Collapse and sedimentation of irrigation canals, destruction of agricultural lands loss of crops and live stock collapse of dwellings spread of epidemic diseases destruction of infrastructure such as bridge and roads and damage to the national economy

5) Frost and cold spells
Degradation of fruits, crops vegetable and health disease, poor economy and increasing of poverty

6) Hail, thunder and lightning
Destruction of crops (particularly horticultural crops), human and livestock losses and outflow/gush and floods
Country Presentation Bangladesh

CLIMATE CHANGE AND BANGLADESH
MD. BILLAL HOSSAIN
HARADHAN BANIK

Bangladesh: at a glance
- Capital: Dhaka
- Area: 1,43,998 square km.
- Population density: 953 per square km.
- Population: 140.6 million
- Per capita income: US dollar 482
- Literacy rate: 43%
- Life expectancy: 64.4 years (male) 65.7 years (female)
- Climate: Sub tropical monsoon

Vulnerability Context
- Geographical location
- Flat deltaic topography
- Low elevation from the sea
- Extreme climate variability
- High population density and poverty
- Mostly climate sensitive sectors

Environmental impacts of climate change
- Temperature regime
- Change in rainfall patterns
- Increased frequency and severity of floods, droughts, storms, heat waves
- Changes in growing seasons and regions
- Changes in water quality and quantity
- Sea level rise
- Salinity intrusion

Socio-economic Resources and Sectors affected
- Agriculture and Forestry
- Water Resources
- Food security
- Human health
- Infrastructure (e.g. transport)
- Settlements
- Coastal management
- Industry and energy
- Disaster response and recovery plan
Climate Change Major Challenges
- Livelihoods
- Development
- Human health
- Risks past gain
- Threatens future development

Climate change impact on Floral diversity
- Aquatic flora
- Mangrove species
- Agricultural diversity
- Estuarine species

Climate change response
- Establishing CCC (Climate Change Cell)
- Capacity building
- Climate impact prediction modeling
- Knowledge management
  - Library
  - Database
  - Website
  - Reports and publication

Climate change response...cont
Adaptation Research:
- Climate change and health impacts in Bangladesh
- Climate change and its impact on transmission dynamics of cholera
- Adaptive crop agriculture including innovative farming practices in the Haor basin
- Adaptive crop agriculture including innovative farming practices in the coastal zone
- Climate change, gender and vulnerable groups in Bangladesh
- Crop insurance as a risk management strategy in Bangladesh

Climate change response, Institution
- Different ministries and agencies
- Climate Change Cell, Department of Environment
- Department of Forest
- Large number of NGO's
- Different universities and research institutes
Flood: capital city Dhaka

River Bank Erosion

Bangladesh innocent victim

Thanks.
Country Presentation Bangladesh

Climate Change and its Impact on Flora in Bangladesh

FOREST DEPARTMENT and DEPARTMENT OF ENVIRONMENT BANGLADESH
Harish H. Banik
Md. Billal Hossain

BANGLADESH: Forestry
- Forest Act 1977
- National Forest Policy 1994
- Social Forestry Action Plan 2004
- Forest Management Plans
- Major Forestry sector development programmes
  - Social Forestry
  - Co-management of the Protected Areas
  - Coastal Afforestation
  - Industrial plantation
  - Eco-tourism development

Forest Land of Bangladesh

<table>
<thead>
<tr>
<th>Forest Types</th>
<th>Area (ha)</th>
<th>% with respect to country's area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fo Managed Forest</td>
<td>1,025</td>
<td>10.00%</td>
</tr>
<tr>
<td>Unclassified State Forest</td>
<td>0.75</td>
<td>0.75%</td>
</tr>
<tr>
<td>Plantation Forest</td>
<td>1.25</td>
<td>1.25%</td>
</tr>
<tr>
<td>Total</td>
<td>2,846</td>
<td>17.00%</td>
</tr>
</tbody>
</table>

Forest Department Managed Forest Land

<table>
<thead>
<tr>
<th>Forest Types</th>
<th>Area (ha)</th>
<th>% with respect to country's area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hill Forest</td>
<td>0.67</td>
<td>0.67%</td>
</tr>
<tr>
<td>Natural Mangrove Forest</td>
<td>0.60</td>
<td>0.60%</td>
</tr>
<tr>
<td>Mangrove Plantation</td>
<td>0.15</td>
<td>0.15%</td>
</tr>
<tr>
<td>TE Forest</td>
<td>0.29</td>
<td>0.29%</td>
</tr>
<tr>
<td>Total</td>
<td>1.67</td>
<td>10.00%</td>
</tr>
</tbody>
</table>
Natural Mangroves: Sundarban

Sundarban is the unique largest tract of mangrove forest.

Total area of Sundarban is 4,91,700 hectares; 4.14% of the country.

Flora -334 species and Fauna -769 species and abode of the world famous Royal Bengal Tiger.

The Sundarban World Heritage site is composed of three wildlife sanctuaries comprising 1,39,700 hectares. Sundar (Mangrove forest), the most common species occupies 72% of Sundarban.

Mangrove Plantations

Since 1990-91, Bangladesh Forest Department has developed 0.153 million ha. mangrove plantation. Using 550 km coastal barrier through indigenous technology.

Sal Forests

Sal (Shorea robusta) Forests spread over central & northern part of Bangladesh. These forests are scattered in nature and intricately mixed with habitats. It is classified as Tropical Moist Deciduous Forest.

Sal Forest area is 1,20,000 hectares, which is 0.81% of the country's area and 7.9% of forest land managed by the Forest Department.

According to an inventory estimate Sal Forests have a growing stock of 3.38 million cubic meters of wood.

A massive plantation programme under Social Forestry programme is in progress on the basis of benefit sharing.

Village Forests

The tree cover in village forest is 2,70,000 hectares. A reasonable portion of the total demand of forest produce is being met from homestead forest.

According to the 1995 inventory report the village woodlots have a growing stock of 84.7 million cubic meters. Gross volume has increased from 6.5 cuma in 1957 to 10.4 cuma in 2007.

Social Forestry & Co-management

In line with the MDG, PRSP and guidance of the Forest Policy 1994, Forest Department has undertaken nationwide Social Forestry programme in degraded reserved forests & marginal lands with benefit sharing arrangement with local peasants.

Similar arrangements are made in collaborative management of the Protected Areas of the country.

Protected Areas of Bangladesh

The Forest Department has the mandate for management of protected areas. The Bangladesh Wildlife (Preservation) (Amendment) Act, 1974, recognizes three categories of PAs viz. National Parks, Wildlife Sanctuaries and Game Reserves. For the conservation and development of biodiversity and natural environment as well as for eco-tourism, education and research, 20 protected areas have been established so far, covering an area of 344,175 hectares.
List of protected areas

<table>
<thead>
<tr>
<th>No.</th>
<th>Name</th>
<th>Year of Establishment</th>
<th>Area (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Rajshahi Wildlife Park</td>
<td>1973</td>
<td>1200</td>
</tr>
<tr>
<td>2</td>
<td>Sylhet Wildlife Park</td>
<td>1973</td>
<td>1500</td>
</tr>
<tr>
<td>3</td>
<td>Chittagong Wildlife Park</td>
<td>1973</td>
<td>1000</td>
</tr>
<tr>
<td>4</td>
<td>Barisal Wildlife Park</td>
<td>1973</td>
<td>800</td>
</tr>
<tr>
<td>5</td>
<td>Khulna Wildlife Park</td>
<td>1973</td>
<td>900</td>
</tr>
<tr>
<td>6</td>
<td>Mymensingh Wildlife Park</td>
<td>1973</td>
<td>700</td>
</tr>
<tr>
<td>7</td>
<td>Khagrachari Wildlife Park</td>
<td>1973</td>
<td>500</td>
</tr>
</tbody>
</table>

Eco-park, Safari Park and Botanical Gardens in Bangladesh

<table>
<thead>
<tr>
<th>No.</th>
<th>Name</th>
<th>Year of Establishment</th>
<th>Area (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Bangladesh Eco-Park</td>
<td>1990</td>
<td>1000</td>
</tr>
<tr>
<td>2</td>
<td>Sylhet Eco-Park</td>
<td>2000</td>
<td>800</td>
</tr>
<tr>
<td>3</td>
<td>Barisal Eco-Park</td>
<td>2000</td>
<td>600</td>
</tr>
<tr>
<td>4</td>
<td>Khulna Eco-Park</td>
<td>2000</td>
<td>500</td>
</tr>
<tr>
<td>5</td>
<td>Mymensingh Eco-Park</td>
<td>2000</td>
<td>400</td>
</tr>
<tr>
<td>6</td>
<td>Khagrachari Eco-Park</td>
<td>2000</td>
<td>300</td>
</tr>
</tbody>
</table>

Ecologically critical areas of Bangladesh

<table>
<thead>
<tr>
<th>No.</th>
<th>Name</th>
<th>Area (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ganges - Brahmaputra Delta</td>
<td>300,000</td>
</tr>
<tr>
<td>2</td>
<td>Sundarbans &amp; Barind Forest Reserve</td>
<td>150,000</td>
</tr>
<tr>
<td>3</td>
<td>West Bengal Hills &amp; Terai</td>
<td>100,000</td>
</tr>
<tr>
<td>4</td>
<td>Indo-Burmese Border</td>
<td>50,000</td>
</tr>
<tr>
<td>5</td>
<td>Karimganj - Hazaribagh</td>
<td>30,000</td>
</tr>
<tr>
<td>6</td>
<td>Sundarbans</td>
<td>20,000</td>
</tr>
</tbody>
</table>

Environment Management Programme

- Protection of country's environment.
- Development of a pragmatic forest management process compatible with the country's social, economic and environmental criteria.
- Incorporation of social and environmental aspects in forest resource management systems.
- Preparation of management plans for natural protected areas.
- Creation of an effective environment management process within the Forest Department.

In the present world environment management is given the topmost priority. Bangladesh has already experienced the harmful effects of continuous environmental degradation. Keeping in view the aspects of creating pollution free environment and conservation of biodiversity, Bangladesh Forest Department is implementing environment management programmes. The prime objectives of Environment Management are:

Plant Species diversity in Bangladesh

Despite its small area, Bangladesh is endowed with a myriad biological diversity in terms of floral species richness. The table summarises the number of species recorded under different major taxonomic plant groups from Bangladesh. Nonetheless, Bangladesh still awaits a complete inventory of its total biological diversity. This can be indicated by the estimated number of floral species.

<table>
<thead>
<tr>
<th>Groupname</th>
<th>Estimated (species, no.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Algae</td>
<td>2,500</td>
</tr>
<tr>
<td>Bryophytes</td>
<td>200</td>
</tr>
<tr>
<td>Pteridophytes</td>
<td>300</td>
</tr>
<tr>
<td>Gymnospermae</td>
<td>2</td>
</tr>
<tr>
<td>Angiospermae</td>
<td>3,000</td>
</tr>
</tbody>
</table>
**Threatened Species**

Bangladesh National Herbarium published the first volume of a Red Data Book of vascular plants in 2003. Out of the 106 species listed in this book, one is Critically Endangered, one Endangered, two Vulnerable, three Lower Risk, 29 Data Deficient and 74 are not evaluated.

**Genetic Diversity**

Broad genetic variation occurs among both wild and domesticated plant and animal. With its diverse agro-ecosystems, Bangladesh is also rich in such genetic resources. The greatest genetic diversity in Bangladesh has been seen in rice (Oryza sativa). Six thousand varieties of rice are known to have existed in the country. Other domesticated plants in Bangladesh range from rice and millets to tubers (e.g. sweet potato, turnip, yam), legumes, oil seeds, vegetables, fruits, spices and fiber (cotton and jute).

**Ecosystem Diversity**

A wide range of ecosystems is found in Bangladesh. These include tropical rain forest, mangrove forest, floodplains and other lands, freshwater and coastal wetlands, littoral, sub-littoral and benthic zones of the Bay of Bengal. Nonetheless, the ecosystems of Bangladesh can be divided into four broad categories, namely:

- Coastal and marine ecosystem,
- Freshwater ecosystem,
- Forest ecosystem and
- Marine ecosystem (Dashti, 2003).

Nishat et al. (2007), from the perspective of synergizing biodiversity and ecology, divided Bangladesh into 12 broad bio-ecological zones, with several sub-zones.

**FRA, Bangladesh 2005-07**

In Bangladesh, the total number of tree species measured was 278 with 588 species in villages, 127 species in forests, 127 species in cultivated land and 28 species are found in urban areas.

**Biodiversity**

- **Forest**
  - 278 species
- **Villages**
  - 127 species
- **Urban areas**
  - 28 species
- **Total**
  - 433 species

**Biomass and Carbon**

- **Forest**
  - 130,923 tons
- **Villages**
  - 86,810 tons
- **Urban areas**
  - 2,836 tons
- **Total**
  - 220,569 tons

**Effect of Climate Change : SDR**

In Bangladesh, the pressures on biological resources are intense and growing due to high population growth, unplanned and overexploitation of natural resources and agricultural expansion onto marginal and forest lands. Over exploitation of natural resources is intensifying the climate change.

- The super cyclone Sidr of 15th November 2007 with wind speeds of up to 240 kilometers per hour hit Bangladesh and caused significant damage to life, livelihood, productive infrastructure and biodiversity.
- 19 Coastal districts have been severely affected with slightly affected 11 other districts.
- About 153,800 ha. forests of the Sundarbans are affected by the Sidr including the Sundarbans East Wildlife Sanctuary. The cyclone caused leaves of plants to fall in the form of bushes, twisted and uprooted. Forests in the eastern 20% have been extensively altered, as evident in recent MODIS and ASTER satellite imagery, immediately before and after the Sidr.

**Damage of South Eastern part of Sundarbans by the Cyclone Sidr 2007**

- **Highly affected**
  - 130,923 tons
- **Extremely affected**
  - 86,810 tons
- **Moderately affected**
  - 2,836 tons
- **Total**
  - 220,569 tons

**Effect of Sidr on Vegetation**

- The natural vegetation of the Sundarbans is sensitive to mangrove ecosystems.
- There are 334 plant species reported to exist in the Sundarbans.
- Sidr has severely disrupted this ecosystem and also damaged the natural regeneration in the affected area.

**Effect of Climate Change on Tree Regeneration**

- NFA study identified regeneration of 111 species in forest. The study revealed that 8 species in the forests do not have regeneration which is probably due to effect of climate change.

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Climate Change resilient activities in Bangladesh

<table>
<thead>
<tr>
<th>Sl. no.</th>
<th>Name of the project</th>
<th>Period</th>
<th>Cost (TK in MRR)</th>
<th>Completion</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>REDD Plus Project</td>
<td>2009-2013</td>
<td>600.00</td>
<td>On-going</td>
</tr>
<tr>
<td>2.</td>
<td>Climate Change</td>
<td>2009-2010</td>
<td>600.00</td>
<td>On-going</td>
</tr>
<tr>
<td>3.</td>
<td>Resilience</td>
<td>2009-2012</td>
<td>600.00</td>
<td>Reaching Donor</td>
</tr>
<tr>
<td>4.</td>
<td>Coastal Greenfood</td>
<td>1995-2003</td>
<td>1000.00</td>
<td>Ongoing</td>
</tr>
<tr>
<td>5.</td>
<td>Forest Biodiversity</td>
<td>1997-2003</td>
<td>4500.00</td>
<td>Completed</td>
</tr>
<tr>
<td>6.</td>
<td>Parkcity Coastal</td>
<td>2008-2009</td>
<td>34606.13</td>
<td>Submitted to Forest Carbon Partnership Pacific (FCPP) for financing</td>
</tr>
<tr>
<td>7.</td>
<td>Recovery of Biodiversity in the Chittagong SFRA</td>
<td>April 2008 to June 2010</td>
<td>7607.37</td>
<td>Submitted to USAID under the Global Environment Facility (GEF) for financing</td>
</tr>
</tbody>
</table>
Looking Forward: Bangladesh Climate Change and Forestry

- The climate change adaptation funds promised by the developed countries be adequate and distributed according to the real vulnerability of recipient nations.
- An international research centre for the study of climate change and its impacts on nature and life can be setup. Bangladesh would like to host this institution.
- Strengthening Social Forestry and Co-management in Forest reserves and PAs.
- Undertaking long-term forestry development programme for Climate Change Resilient.
- Reinforce professional expertise of FD personnel
- Developing Forestry Information Network with national government agencies, NGOs, research/education institutions and international partners.

Climate Change Resilient Activities in Bangladesh

<table>
<thead>
<tr>
<th>s.n.</th>
<th>Name of the project</th>
<th>Period</th>
<th>Cost (Tk. in Mln)</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Eco Development and Settlement Project (COPPh)</td>
<td>2009-2010</td>
<td>1800.00</td>
<td>On-going</td>
</tr>
<tr>
<td>2.</td>
<td>Climate Change Resilient Afforestation in Bangladesh</td>
<td>2009-2012</td>
<td>6000.00</td>
<td>Escalating Gender</td>
</tr>
<tr>
<td>3.</td>
<td>Coastal Greenbelt Project</td>
<td>1995-2003</td>
<td>13000.00</td>
<td>Completed</td>
</tr>
<tr>
<td>4.</td>
<td>Forest Social Project</td>
<td>2007-2008</td>
<td>4500.00</td>
<td>Completed</td>
</tr>
<tr>
<td>5.</td>
<td>Park Ecology Coastal Afforestation Project</td>
<td>2009-2010</td>
<td>34600.13</td>
<td>Submitted to Forest Resources Agency (FORA) for Financing</td>
</tr>
<tr>
<td>6.</td>
<td>Recovery of Eucalyptus in the Devastating Eucalyptus Affected Eucalyptus</td>
<td>April 2009 to June 2010</td>
<td>1527.07</td>
<td>Submitted to USDA under Tropical Forest Conservation Act 416(d) OECG for Financing</td>
</tr>
</tbody>
</table>

www.bforest.gov.bd
Country Presentation Bhutan

Kingdom of Bhutan

Bhutan: Environment
High biodiversity concentration
- Junction of paleartic and Indo-Malayan biogeographic realm
- Mountainous altitudes and microclimatic variations
- 72.5% forest cover

Agricultural Land

Impacts of Climate Change

1994 Glacier Lake Outburst Flood

Rangnagren Tso
Lagre Tso

Glacier Retreat
- Total of 2,794 global lakes
- 8% potentially hazardous
- Phubrimo Lake basin
- Moncho Lake basin
- Chokloka Lake basin
- Khardung Lake basin
- Mongri Lake basin
1994 Glacier Lake Outburst Flood

GLOF events in Phochhu Basin

- Damage due to 1994 Floods:
  - 1500 acres of agriculture and pasture land
  - 300 families affected
  - 10 years worth crops
  - 90% of local future destroyed
  - 22 houses Total
  - Many houses and livestock damaged

Forest Fires

Issues - Climate Change Impacts on Flora

- Forest fires
- Cordyceps sinensis - main economy to highlanders
- Mesutake mushroom - declining
- Highland pasture land

Publication and work

- Bhutan National Adaptation Programme of Action (NAPA)
- Disaster management strategy
- Artificial lowering of Trongsa Glaciers lake
- Weather forecasting system to serve farmers and agriculture
- Flood protection of downstream in & agri area
- GLOF hazard zoning
- Installation of early warning system
- Promotion of community based forest fire mgt and prevention

Questions

- No facilities established with regard to research
- No data generated
- RNR RC do research on specific topic but not directly relating to climate change
Country Presentation Maldives

**CLIMATE CHANGE AND ITS IMPACTS ON FLORA**

*Maldives*

**Geography**
- A chain of coral atolls
  - 260 km long, 80-120 km wide
  - 16 geographical atolls
  - 1,192 islands
  - 195 inhabited islands, 87 resorts, 5 airports (2 international airports)

**Geography - islands**
- Average height above mean sea level in 2.5 m
- Over 80% of land area less than 1 m above mean sea level
- Size: from 0.5 to 20 km
- 3 islands greater than 5 sq km
- Total land area less than 1% of the EEZ

**Population**
- Population 300,000 with annual growth rate of 1.5% (2006 Census)
- About 25% of the population live in the capital Male
- Nearly half the islands have densities over 1,000 persons/km²

**Economy**
- Tourism leading sector contributing to 33.4% of GDP
- Tourism arrivals increased from 1,507 in 1971 to 563,563 in 2003
- 25% of population engaged in fishing industry
- Decline in fisheries sector contribution to GDP from 2.2% in 1973 to 7.1% in 2002

**Climate**
- Warm, humid tropical climate
- Dry North East Monsoon from January to March, and wet South West Monsoon from May to November
- Mean annual temperature 28°C
- Average annual rainfall for Male = 2,030.2 mm
Terrestrial biodiversity

- Limited terrestrial biodiversity
- 263 species of plants, 305 numbered, 386 native or
  naturalized, 300 species medicinal
- 2 species of geckos
- 2 species of garden lizards
- 1 species of snake
- 2 species of fruit bats
- 1 species of frog
- 1 species of road

The fragile marine and terrestrial environment including the reefs and biodiversity would be greatly affected unless careful management of the environment is done.

Our beauty and natural resources are strongly linked with economic development of the country.

Agriculture

- Limited arable land, poor soil and freshwater supplies makes it a small sector in the economy
- Share in the GDP declined from 5.3% in 1986 to 2.7% in 2002

Climate change & Sea Level Rise

1. Threatens the very existence of Maldives.
2. Other impacts include beach erosion.
3. 97% of all inhabited islands reported erosion and 64% of them undergo severe erosion.
4. A large number of resort islands have also experienced severe erosion.

Being low lying makes islands vulnerable to climate change impacts

- Contributes to ONLY 0.001% of global GHG emissions
- Natural disasters

Sea water intrusion during a storm surge
INSTITUTIONAL SETUP

- Ministry of Environment, Energy and Water
- Environment Section created in 1986
- Environment Research Centre, 1990
- Environment Protection and Preservation Act (Law no. 4/93)
- National Commission for the Protection of the Environment Created in 1986

Adaptation Policies to Climate Risks
National Adaptation Programme of Action - NAPA

- Foster the development of plans, strategies and approaches to:
  - Avoid or adapt to climate change
  - Mitigate the impacts of economic activities, human health, human settlements and critical infrastructure
  - Foster development and application of legal and institutional systems, mechanisms for planning and responding to climate change
  - Foster development of economic incentives to encourage public & private sector adaptation measures

On Going Measures

- Male seawall
- Holluhivile
- Population and Development Consolidation Strategy
- Safer Islands Development
- Coral mining - banned

A safer island - concept

Diagram Section of an Island with Enhanced Mitigation Features

The Maldives' approach to environmental issues as with many other small states stays in harmony with the concept "Think globally and act locally"

Research has been done evaluating on climate change impacts on flora in Maldives
Country Presentation Nepal

Climate Change and its Impact on Flora

Prof. Sant Bahadur Gurung
Assistant Dean (Administration)
Institute of Agriculture and Animal Science
Tribhuvan University
Rampur, Chitwan, Nepal

Fighting Climate Change:

- Human Solidarity in the Divided World

NATIONAL CAPACITY NEEDS SELF-ASSESSMENT, NEPAL

STOCKTAKEING REPORT ON CLIMATE CHANGE

Universities in Nepal

- Tribhuvan University
- Kathmandu University
- Mahendra Sanskrit Vishwavidyalaya
- Patan Deenanath Campus
- Patan Bhanubhakal University
- Pachchhimanchal University

Tribhuvan University (TU)

- Institute of Agriculture & Animal Science (IAAS)
- Institute of Forestry
- Institute of Engineering
- Institute of Medicine
- Institute of Science & Technology

IAAS/TU

Rampur Campus (Banke Town)
Pakhnait Campus (Terai)
Lalitpur Campus (Hill)

Educational Programmes

- B. Sc Program: Agriculture and B. V. Sc.
- M. Sc Program: Agriculture, Agriculture Animal Science, Veterinary Medicine
- Ph.D. Program: Agriculture, Animal Science, Agronomy, Horticulture, Botany

Page | 50
Rampur Campus
- Departments (.... Environmental Science)
- Farms
- Library
- SEMLC
- Central laboratory
- Local Knowledge & Innovation Resource Centre

Environmental Education at IAAS
- Department of Environmental Science
- Faculties and Staff
- Facilities
- Subject Matter Committee
- Curriculum Development

Subject Matter Committee of Environmental Science
- Chairperson: DES
- Member-secretary: DES
- Members from the DES: 4
- Members from branch campuses: 2
- Members from IAAS other than DES: 3
- Members from outside IAAS: 3

Academic Programs
Undergraduate program
Core courses
- Biochemistry
- Agricultural microbiology
- Environmental Science and Agroecology
- Medicinal and Aromatic Plants
Elective courses
- Environmental Ecology
- Biodiversity Conservation
- Fundamentals of Ethnobiology
- Ecological Research Methods

Climate change in UG
Environmental Science and Agroecology (2+1)
- Unit 6. Urbanization, global warming and climate change: Factors causing, global warming and its adverse effect on agricultural production and climate change.
- Practical
  - Record and analyze the climatic data
No separate course in Climate Change

Recent Advances
Course: Environmental Science and Agroecology
6. Climatic change
   - 6.1. Concepts of climate change; man factors causing climate change and its impact on agriculture (2 lectures)
   - 6.2. Innovations related to climate change (1 lecture)
   - 6.3. Organizations and their contribution in the study and research in climate change (2 lectures)

Draft Course for M. Sc. in Agrobiodiversity Management
Clime Change (2+0)
- Introduction to topography, climate, social and economic conditions, forests and land use, biodiversity, water resources, and mineral resources as sources of climate change. National Greenhouse Gas (GHG) inventory: carbon dioxide, methane, and nitrous oxide, and their emission and removal from different sources including agriculture, GHG projections and management, options for energy, non-energy agriculture and livestock, and solid waste sector. Vulnerability and adaptation. Climate change scenarios and their impacts on agriculture and livestock, water resources, biodiversity, and human health. National policies on sustainable development, environmental management, policies and measures related to climate change, status of international and regional cooperation and technology transfer in climate change. Public participation in education and research issues on climate change.

Recent Advances
One faculty (Agronomist) trained on climate change in Bangladesh
IAAS Partner Organization in a Network (ICIMOD)

Published Paper

Thesis Research on Climate change
- Kabita Kharel (M. Sc. Ag. Conservation Ecology) (recently initiated)

Participatory Conservation
Education, Research & Development
- Training on Climate Change
- Training on Ecological Agriculture/organic agriculture
- Training on local innovation
- Training on plant/animal identification
Future Directions

1. Involvement of faculty and students in action research conducted by GOs, NGOs and CBSs.
2. Identification of potential partners involving in climate change, networking and partnership development for promoting education and research.
3. Capacity building of institutions, faculty, students and staff with the help of organizations such as Practical Action, Ministry of Environment, Science and Technology.

Educational resources, trainings, thesis, participation in action researches.

Future Directions

- Participation by faculties, students and staff in the seminars, workshops, conferences, trainings.
- Organizing guest lectures of experts at IAAS and other academic institutions to aware or educate about the climate change.
- Revise or develop course curriculum to incorporate adequate information of climate change.
- Field visits to observe impact of climate changes.

Thought Of The Day

We invent by intuition, though we prove by logic.

Radhakrishnan

Now, What is the missing DIMENSION?

Let's join hands for educating people about climate change.
Country Presentation Pakistan

Impacts of Climate Change on the Floral Diversity of Pakistan

by
Raja KHALID Hussain
Director General
Pakistan Forest Research & Education Institute
PESHAWAR

Pakistan – General

- Population: 160 million
- Languages:
  - Urdu (National Language)
  - English (Official)
  - Regional (Pashto, Punjabi, Baluchi, Sindhi)
- Literacy: 83%
- GDP per capita: US$900
- Forests in Pakistan cover 4.224 million ha (4.8% of land area)
- Percentage of forests in different provinces is different:
  - The NWFP and Northern Areas have forests cover 16.5% and 7.5% of the land area respectively
  - In Punjab and Sindh, about 2.8%
  - It is just 0.7% in Balochistan

Major Vegetative Zones

- Permanent snow fields & glaciers
- Dry Alpine & cold deserts
- Alpine Scrub & Moist Alpine Himalayan Forests
- Dry Temperate Forests
- Himalayan Moist Temperate Forests
- Sub-tropical Pine Forest
- Sub-tropical Drier mixed Deciduous Scrub Forests
- Juniper Forests
- Tropical Thorn Forests
- Mangroves
- Sand-dune vegetation

The Rising Temperatures ???

- Global and regional temperatures are rising
- 1998 was the hottest year of the millennium
- 1990s the warmest decade
- Climate models suggest a future warming of 0.2 – 0.5°C per decade
- Sea levels are expected to rise @ 4 to 10cm per decade
- All this must have global implications; including adverse impacts on our floral diversity
- Add fuel to the fire: the deforestation in our region

Deforestation

- Our regional countries have one of the highest rates of deforestation
- The threat of extinction now faced by much of the unique and rich fauna and flora are now real
- The known impacts on our biodiversity are likely to be just the tip of the iceberg; owing to lack of research data
- This looming disaster demands immediate and definitive actions
- Such measures continue to be constrained by socioeconomic factors, including poverty and lack of infrastructure
- Any realistic solution will need to involve political, socioeconomic and scientific input, in which all major stakeholders must participate
Other Threats to Ecosystems
- Rapid population growth
- Ever-increasing demand for agricultural land
- Poverty
- Poor institutional capacity
- Lack of effective community participation in forest-based activities

Effects of Climate Change
- Climate change is expected to affect the boundaries of forest types and areas, especially:
  - Productivity
  - Species populations and migration
  - Occurrence of pests and diseases
  - Forest regeneration

The GreenHouse Gases: Contributors to Climate Change
- GHGs affect species composition and the structure of ecosystems
- These changes, in turn, affect ecosystem function
- The End Result:
  - Climate change will have a profound effect on the future distribution, productivity, and health of forests throughout Asia

Most Recent Catastrophes
- Floods:
  - The year 2005 brought a lot of snow to the upper reaches of Pakistan
  - The same year brought an early summer as well
  - The result:
    - Early, quicker and heterogeneous melting of snow
    - Floods devastating vast stretches of agricultural lands in the Indus delta

contd...
- Freezing Cold:
  - This past winter brought down the mercury below freezing point, even in deserts
  - As if it was not enough, moisture laden winds unleashed heavy snow in the form of snow and winds
  - Results:
    - Mango trees, acacia, baobab, and cassia trees died in thousands
    - Almost all the shrubbery vegetation got dried
    - Wheat crop was affected so bad that even the livestock wouldn’t browse it
Parksonia ... autumn revisited?

Hedges ... gone dead

... as if burdened with dead leaves

Phoronia obtusa (Gulchen) ... as if mourning

Cassia fistula (Amaltas) ... do we need any further evidence?

Effects of global warming on environment

* It is difficult to attribute specific natural phenomena to long-term causes of warming.
* Some effects of climate change may already be occurring:
  - Rising sea levels, glacier retreat, Arctic shrinkage, altered patterns of agriculture, etc. are cited as its direct consequences.
* Predictions for secondary and regional effects include:
  - Extreme weather events
  - Expansion of tropical diseases
  - Changes in the timing of seasonal patterns in ecosystems
  - Drastic economic impact.
* Concerns have led to political activism advocating proposals to mitigate, eliminate, or at least, adapt to it.
Steps Taken

• Pakistan is a country that contributes very little to GHG emissions.
• Nonetheless, it views climate change as an issue not only requiring international cooperation but also a pro-active policy at the national level.
• Pakistan has embarked upon dealing with an issue that threatens the predominantly agriculture base of the economy and has implications for livelihood and survival of a population of over 160 million people.
• Pakistan’s vulnerability to the impacts of climate change guides its overall national response in dealing with the issue.
• In view of limited resources, the level of studies and work undertaken has largely been in the area of mitigation, although a few important studies have also been commissioned on impacts and adaptation.
• Most of this work has been largely financed by GEF.

Existing Policy, Institutional & Legislative Structure

• Pakistan’s environmental policy & management framework is based on Environment Protection Act (1972).
• The Act has two important responsibilities:
  - creation of institutions; and
  - regulation of activities causing the environment
• The National Environmental Quality Standards (1993) provide standards for industrial and municipal effluents and air emission.
• Major policy initiative has been the the enactment of National Conservation Strategy (1992).

Even brushwood and twigs are consumed ...

Can this landscape sustain the pressure of grazing?

What can be possibly saved in the presence of this menace?

The heartless removal of wood - the Carbon Sink.
The Logical Impacts — for Pakistan

- Tharparkar has degraded to desert, double in magnitude, in the last 15 years
- The scrub of Salt Range — extremely important from watersheds' protection & fuelwood values — are taken over by deserts to the extent of 30% in the last 10 years
- About 40% of the natural vegetation of Suleiman mountains has degraded to deserts since 1975

What Shall Happen Because of All This?

- The concentration of carbon dioxide, methane, and other heat-trapping ("greenhouse") gases in the atmosphere shall enhance;
- The temperature shall rise; and
- An unpredictable climate prevail

The (logical) Outcomes

- Late autumns
- Brief winters
- Early springs
- Longer hotter summers

Impacts on Flora & Fauna

- Adversely affecting agrivulture, horticulture, livestock, & movements of fauna
- Movement of flora up
- Scrub in to Charpoa Zone, Chaplain in to Bluepine Zone, Bluepine in to Fy/5pinu Zone, Fy/5pinu in to Alpine Pusture, and Alpine Pusture in to Glaciers
  - Reduced glacial area
  - Glacier melting
  - Floods
  - Erosis and desertation of hills
  - Drought
  - Siltation of dams
  - Unesse supply of irrigation water from dams and barrages
  - Loss electricity generation
  - Loss production of manufactured goods
  - Higher manufacturing costs
  - Rising prices
  - Food scarcity
  - Poverty

Could this be helped?

Yes ..... But .....  

- Save energy: use it judiciously
- Avoid wasteful consumption
- Shift to solar, wind, water, & bio-energy
- Grow more trees: to get CO₂ absorbed
Country Presentation Sri Lanka

Climate Change & its Impact on Flora In Sri Lanka

By
Ministry of Environment / Dpt of Forest
M.A.A.M.Jayarathna

What is climatic change?
Climatic Change is a global environmental problem connected to the total atmospheric concentration of greenhouse gases.

Global Climatic Factors on Flora
In terms of global climate change, environmental factors that are expected to have the greatest direct effects on flora:
- Temperature change
- Sea-level rise
- Availability of water from precipitation and runoff
- Wind patterns
- Storminess.

Causes for the Climate Change
- Combustion of fossil fuels – Carbon dioxide
- Deforestation
- Live-stock raring
- Land use changes
- Power plants
- Automobiles
What is Global Warming?

- Gradual increase of global temperature
- Gases trap the sun's heat in the atmosphere
- Greenhouse gases: 
  - CO₂
  - CH₄
  - NOₓ
  - SO₂
  - H₂O
  - CFCS/Halocarbons

The green house effect

- Gases involved in the greenhouse effect

<table>
<thead>
<tr>
<th>Greenhouse Gas</th>
<th>Concentration (beginning of the century)</th>
<th>Present Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon Dioxide</td>
<td>280 ppm</td>
<td>360 ppm</td>
</tr>
<tr>
<td>Methane</td>
<td>0.70 ppm</td>
<td>1.70 ppm</td>
</tr>
<tr>
<td>Nitrous Oxide</td>
<td>280 ppb</td>
<td>310 ppb</td>
</tr>
<tr>
<td>Chlorofluorocarbons (CFCs)</td>
<td>0</td>
<td>900 ppb</td>
</tr>
<tr>
<td>Ozone</td>
<td>Unknown</td>
<td>Varies with latitude and altitude in the atmosphere</td>
</tr>
</tbody>
</table>

Green house gases

- Since the industrial revolution atmospheric concentration of,
  - Carbon-dioxide: increased 30% (3 BT)
  - Methane: more than doubled
  - Nitrous Oxide: increased 15%

Resulting more and more heat trapping

Population in Sri Lanka

<table>
<thead>
<tr>
<th>Year</th>
<th>Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>1981</td>
<td>14,846,750</td>
</tr>
<tr>
<td>2001</td>
<td>18,797,257</td>
</tr>
</tbody>
</table>

Average Annual population growth rate: 1.2%

Total Land area: 65,610 sq km

Land use:
- Agriculture: 45%
- Forest: 32%
- TOF (Trees out of Forest): 24%
- Other: 9%
Climate Change Impacts in Sri Lanka

- Impacts on the agricultural sector
- Impacts on the forestry sector
- Impacts on the water resources
- Impacts due to the changes in sea level

Rainfall

The effect of climate change on rainfall varies from region to region.

Some areas of the world will receive more rain while other areas will receive less.

Scientific community is still uncertain about the regional variations of rainfall.

Impacts due to extreme weather conditions

Rainfall

with intense rains,

"accelerated" Soil erosion

Areas with intensity > 25 mm for 24 hours can accelerate soil erosion - "accelerated"

Landslides

High probability of landslides when daily rainfall exceeds 200 mm in landslide-prone areas.

Land degradation and Floods

Impacts on ecosystems
Temperature

- Increased temperature
during the last century, global temperature has increased by 0.6 °C

In Sri Lanka, the average temperature has increased at the rate of 0.16°C per decade since 1960

Sri Lanka

- Has a long coastline of 1600 km
- Coastal zone contains 24% of land
- 32% population
- 80% tourism
- Commercial ports and fishery harbors
- Principal road and rail infrastructure
- Richest areas of bio-diversity - coral reef, lagoons, mangroves

Sea Level Rise

- During the period 1860 - 2000, the global mean sea level has risen by between 10 - 20 cm
- During the next century global mean sea level is expected to rise by between 9 - 85 cm.

Impacts due to Sea level rise

Increased coastal erosion
- Already 30 - 35% of the coastline is eroded at the rate of 0.30 - 0.35 meters per year
Impacts on the agricultural sector

An increase in the amplitude of rainfall extremes will lead to more frequent floods:

- Increased soil erosion
- Landslides
- Damage to agriculture through flooding of low-lying areas
- TPC & moisture changes will also force farmers to change the existing cropping patterns

Some effects of global warming on agriculture

- Loss of biodiversity in fragile environments
- Increased frequency of weather extremes (droughts/floods)
- Loss of fertile coastal lands caused by rising sea levels
- More unpredictable farming seasons
- Increases in incidence of pests and vectors
- Longer growing seasons in cool areas

Long-term fluctuations in weather patterns could have extreme impacts on agricultural production,导致 crop yield, and forcing farmers to adopt new agricultural practices in response to altered conditions.

Adaptive actions can be taken to lessen or overcome adverse effects of climate change on agriculture.

- Introduction of later-maturing crop varieties or species
- Switching cropping sequences
- Sowing earlier
- Adjusting timing of field operations
- Conserving soil moisture through appropriate tillage methods
- Improving irrigation efficiency
- Breeding of heat- and drought-resistant crop varieties

Types of Vegetation in Sri Lanka

- Tropical Wet Evergreen Forests
- Wet Semi Evergreen Forests
- Moist Semi Evergreen Forests
- Sub Montane Ever Green Forests
- Montane Ever Green Forests
- Dry evergreen forests
- Moist Deciduous forests
- Tropical Savannah Forests
- Tropical thorn forests
- Grasslands
Tropical Wet Evergreen Forests
- Vegetative climax of the wet zone in the south west sector of the country.
- Characterized by the 2500 mm - 5000 mm rainfall and best developed in the lowlands below 800 m.
- The canopy is dense with evergreen trees rising from 25-40 m.
- The five major plant communities are:
  - Miombo
  - Miombo woodland
  - Miombo savanna
  - Miombo bushland
  - Miombo woodland

Wet Semi Evergreen Forests
- Found in dry zone and Intermediate zone around Badulla and Bible.
- This is an open plant community of scattered trees amidst a sea of grasses.
- The common tree species are:
  - Sapium
  - Dracaena
  - Ficus
  - Dorea
  - Cinnamomum

- The two principle types of grasses:
  - Cenchrus ciliaris
  - Echinochloa crus-galli

Moist Semi Evergreen Forests
- Found in Intermediate zone (annual rainfall ranges from 1900 mm - 2500 mm) and best developed in the Moneragala District.
- The common tree species:
  - Sapium
  - Ficus
  - Dracaena
  - Cinnamomum
  - Dalbergia

Sub Montane Ever Green Forests
- Occur in the hills between 900-1500 m in the Wet Zone.
- The vegetation is essentially transitional between the Wet Evergreen and Montane Evergreen Forests.
- The characteristic trees are:
  - Eucalyptus
  - Ficus
  - Erythrina
  - Cinnamomum
  - Dalbergia

Montane Ever Green Forests
- Characteristic of the highland hills above 1500 m in the Wet Zone.
- The forest is low reaching around 1.3 m in the better sites.
- The trees are in poor form with the dense spread with flat crowns.
- Principal Species:
  - Eucalyptus
  - Myrtaceae
  - Bergenia
  - Viburnum
The Ginopy is 25 m in height...

Dry evergreen forests
- Occur mainly in the dry zone such as in Hambantota, Puttalam, Vellankulam and Nachchikadu where the mean annual rainfall varies from 1250 mm - 1900 mm
- The main vegetation in these areas comprise Paleu.

Moist Deciduous forests
- Occur in the Dry Zone
- The general canopy is 25 m in height
- Most of the emergent species are
  - Pala
  - Dendrophylax falcata
  - Dendrophylax carinatus
  - Ficus occidentalis
  - Ficus glomerata
  - Ficus elastica
  - Morus (Moringa)
- Common evergreen species are
  - Croton (Croton species)
  - Mallotus (Mallotus species)

Tropical Savannah Forests
- Found mainly in the eastern slopes of the central hills between 300 - 900 m belonging to both the intermediate and dry zones
- These conditions are maintained by repeated droughts during drought periods.
- The tree species are
  - Mahua (Madhuca longifolia)
  - Burma (Shorea robusta)
  - Sissoo (Dalbergia sissoo)
  - Tala (Terminalia alata)
  - Dalbergia (Dalbergia species)

Tropical thorn forests
- Found in the oldest areas of the North Western and South Eastern sectors of the country.
- The rainfall is under 1250 mm per annum
- It is a low open thorny scrub with isolated patches of trees.
- The common species are
  - Carinica (Carinica species)
  - Babassu (Babassu species)
  - Acacia (Acacia species)
  - Anogeissus (Anogeissus species)
Grasslands

- Grasslands comprise four main types:
  - Savannah
    - A Savannah type vegetation found in the lowland dry zone
  - Flooded
    - A grassland often associated with wetland conditions around abundant irrigation tanks, river banks, water holes, and flood plains
  - Foothills
    - Pastures have been classified as wet and Dry lands depending on locations
  - Driftland
    - It is found in the low country and near intermixed with trees which occur in clumps

Impacts on the forestry sector

- The boundaries of existing forests are predicted to change significantly by 2070 and this will have impacts on:
  - Timber Production
  - Biological diversity
  - Recreational opportunities
  - Watersheds
  - The hydrological cycles influenced by forests would also be affected
  - Forest fires may also increase
  - Rise in T°C could increase the insect population and disease incidence that damage forest
  - Loss of mangroves
Three broad areas in which Sri Lanka has reasonable potential to reduce GHG emissions

- Energy sector
- Transportation sector
- Forestry sector

Policy strategies for enhancement of sinks fall into two broad categories

- Conservation - twin benefits
  - Preserving the existing source of carbon sequestration
  - Preventing release of accumulated carbon stored in the trees after years of growth through deforestation

- Reforestation -
  - Increase the forest cover and the capacity for carbon sequestration

Forestry sector

A significant measure for mitigating GHG emission is the enhancement of GHG sinks in the form of forest and green belts in and around urban areas.

The role of forestry as a source of GHG sinks and economic growth should be fully exploited by

- Maintaining existing forest land
- Improving forest management practices
- Expanding forest lands and biomass
- Substitution of bio-energy fuels for fossil fuels
- Increasing extent and efficiency of the use of forest products

Possible Mitigation option for Sri Lanka

Forestry sector

THANK YOU
Session 3  Climate Change and Forestry Sector

A session focused on Forestry sector with special reference to carbon sequestration. Prof. S.P Singh, Vice Chancellor, H.N.B. University, Uttarakhand enlightened about the vulnerability of high Himalayas and the remedial steps to manage alpine forests and meadows in a sustainable way to reduce the effect of global warming. He pointed out methods to give economic incentives to community’s efforts to ecosystem health.

- Chairperson: Dr. P.S. Ahuja, IHBT, Palampur
- Rapporteur: Dr. Baban Ingole, NIO, Goa

Lead Lecture

- "Rewarding Forest Conservation in Forest and Climate Change Regime: Indian Perspective" Mr. Sandeep Tripathi, ICFRE, Dehradun (20 Min.)
- "Afforestation and Reforestation Projects for Climate Change Mitigation: Current Status and need for Policy Reforms." Mr. V.R.S. Rawat, ICFRE, Dehradun (20 Min.)
- "Climate Change and Himalayas with special reference to carbon sequestration." Prof. S.P. Singh, Garhwal University, Srinagar, Uttarakhand.

Mr. Sandeep Tripathi, Secretary of the Indian Council of Forestry Research and Education (Dehradun) expressed his views on devising appropriate mitigation and adaptation strategies under Land Use, Land Use Change and Forestry (LULUCF) sector. He expressed his concern of the COM (Clean Development Mechanism) Projects in forestry sector which can provide relatively low cost opportunities to combat climate change.

Group Discussion (30 Min.)

Session 4  Climate Change & Agriculture

- Chairperson: Dr. S.P. Sharma, MoEF, New Delhi
- Rapporteur: Dr. Bajrang Singh, NBRI, Lucknow

Lead Lectures

There were five key lectures were given under the following themes by the experts representing five key institutes in India.

- "Rise in atmospheric CO2 and its impact on crop productivity: Research and Technology: South Asian studies." Dr. D.C. Uprety, IARI, New Delhi
- "Adaptation to climate change in semi-arid regions" Dr. A.A. Nambi, MSSRF, Chennai
- "Influence of Agriculture resource conservation technologies on environment." Dr. A.R. Khan, ICAR, Patna
- "Climate Change and Extreme Weather Events: Impact on Agriculture" Dr. Akhilesh Gupta, Advisor, Ministry of Science and Technology & Earth Sciences
- "Simulation of Rice yield and methods of adaptation under climate change scenarios" Dr. P. Krishnan, CRRI, Cuttack

In the session on climate change and agricultural sector renowned speakers delivered lectures in topics like "Rise in atmospheric CO2 and its impact on crop productivity", "Influence of agriculture resources conservation technologies on environment" and "Climate change and extreme weather conditions-its impact on agriculture”. Advisor in the Ministry of Science Technology and Earth Science, Dr. Akhilesh Gupta, through his lecture, informed about the prevailing weather condition especially high temperature on the decline in agriculture yield. An example of this can be seen in the fact that preliminary evidences indicate that decrease in rice yields, in Indo-Gangentic plains is associated with a slight rise in minimum temperature.
Session 5  Environmental Issues Related to Climate Change
• Chairperson: Dr. Akhilesh Gupta, Advisor, Ministry of Science and Technology & Earth Sciences
• Rapporteur: Dr. A.P Dixit, Chairman, Sustainable Development Foundation, New Delhi

Lead Lectures
• "Climate Change and CDM Regime: Sundarbans Mangroves". Dr Joyshree Roy, Jadavpur University, Kolkata
• "Observed sea level rise along the coasts of the North Indian ocean". Dr. Unnikrishnan, NIO, Goa
• "Climate change impact on trace metals in soil and plants" Prof. M.N.V. Prashad, Hyderabad University, Hyderabad

• Chairperson: Prof. R.S Tripathi, INSA, Lucknow
• Rapporteur: Dr A.A. Nambi, MSSRF, Chennai

Prof. M.N.V. Prashad, Hyderabad University, Hyderabad explained the impacts of sodicity and salinity on biogeochemistry of trace metals – bioproductivity implications. Salinity and sodicity is a global serious problem for commercial agriculture, particularly in arid and semi-arid regions. Mediterranean and tropical regions have a high degree of soil variability that affect the crop yield. The increasing world population and urbanization have forced farmers to utilize marginal lands with ground water irrigation leading to salinization of crops lands. Salinity is known to reduce the plant growth of. Salinity stress also decreases photosynthesis, alters the mineral composition in plants and causes essential ionic imbalance or toxicity.

Invited Lectures
• "Climate Change, GHG emissions & Agriculture, Indian & South-Asian efforts for quality data to meet future Challenges" Dr. A.K. Attri, JNU, New Delhi
• "Modeling Plant response to climate change: Opportunities and research needs" Prof. A.S. Raghubanshi, BHU, Varanasi

Prof. A.S. Raghubanshi, Banaras Hindu University discussed the Future Directions on "Modeling Plant response to climate change" which is Ecophysiological characterization of important plant functional traits and interface with IPCC scenarios to develop predictive capabilities in face of climate change for Long Term Ecosystem Research Site approach
- Micrometeorological approach
- Open top chamber/FACE experiments
SECTION 04
11.03.08 (Day 3)

Session 6 Environmental Issues Carbon Sequestration & Clean Development Mechanism

- Chairperson: Prof. S.P. Singh, VC, Gharwal University
- Rapporteur: Dr. P. Krishnan, CRRI, Cuttack

Invited Lectures
- "Carbon Sequestration by higher plants and Algae to combat global warming" Prof. B.C. Tripathy, JNU, New Delhi: Use of higher plants and algae for carbon sequestration (20 min.)
- Mr. S. Pal, Genesis Technologies, Thane: FACE Technology (20 min.)
- "Human dimension of Climate Change: Geo-Spatial perspective" Dr. P.S. Roy, NRSA, Hyderabad
- "Global and Regional Climate Change" Dr. S.D. Attri, IMD, New Delhi
- "Carbon Sequestration and Carbon trading opportunities" Dr. Vivek Kumar, TERI, New Delhi
- Mr. B.K. Patnaik, PCCF, U.P., Lucknow
- "Free air CO2 Enrichment Technology" Mr. S. Pal, Genesis Technologies, Thane

Dr. S.D. Attri, Director, India Meteorological Department, New Delhi, made detailed explain on the Indian Scenario under the "Global and Regional Climate Change ."
- The rate of sea level rise has been observed to be between 1.06-1.75 mm/year with regional average of 1.29 mm/year which is comparable with 1-2 mm reported by IPCC.
- Temperature rise over India is expected to be uniform over most of the country while slightly more warming over NW region is expected. The expected warming by 2070 is likely to be 1.5 to 2.0°C over most parts of the country.
- Extreme rainfall events are likely to increase along the west coast, west central India and NE region.
- Model simulations suggest, projected rise in sea level in north Indian Ocean is around 30 cm in next 100 years.

Session 7 Strategic Paper and Project Formulation

Chairperson: Dr. A.A. Boaz, DG, SACEP

Steering Committee
- Prof. S.P. Singh, VC, Gharwal University (20 min.)
- Dr. P.S. Ahuja, Director IHBT, Palampur
- Dr. D.C Upreti, Emeritus Scientist, IARI, New Delhi (20 min.)
- Dr. R. Tuli, Director, NBRI, Lucknow (20 min.)

Strategy and Action Plan on "Climate Change & its Impact on Flora in the South Asian Region"

Salient Features "Lucknow statement 2008"

The participants of the workshop also prepared and adopted a "Lucknow statement on Climate and its impact on flora." Following are the key features of the Statement.

- Establish of a South Asia Forum for Climate Change Challenges to Flora in South Asia (FC3F-SA) to support and guide the development of regional and local strategic plans by working closely with global, regional and local governmental and non-governmental partners.
• Setting up a FC3F-SA web portal of member countries for communication, creation of database on regional floral diversity, ecosystems, climate change indicators and projects in progress.

• Generate multidisciplinary climate change information to supplement existing educational materials, textbooks and publications in member countries.

• Coordinate with Donor agencies to generate Fund for regional projects to evolve standard operative procedures to collect data, monitor, quantify and analyse climate change impact on agriculture, forestry and wild flora.

• Enhance focus on strategies for responding to climate change vulnerability of flora through adaptation and mitigation research on trees, higher and lower plants.

• Evolve strategies to minimize climate change impacts on agriculture and minimize agricultural impacts on climate change. Promote the development of stress tolerant varieties and management practices to cope with climate stress on agriculture and forestry systems.

• Integrate biofuel policy in a comprehensive energy, agriculture, climate, population, social and ecosystem sustainability model.
The Lucknow Statement 2008

The consensus document was prepared under the auspices of the National Botanical Research Institute, Lucknow and South Asia Co-operative Environment Programme (SACEP) International Workshop on Climate Change and its Impact on Flora in the South Asian Region held in the background of increasing global concerns related to climate change at National Botanical Research Institute, Lucknow from March 9 to 12, 2008.

Aware that the countries in the South Asia region are very rich in terrestrial and marine Flora which are storehouse of global Carbon as well as source the rapidly growing regional demand of food.

Acknowledging that climate change poses a major threat to the conservation and long term survival of biodiversity in South Asia. Recalling that all the countries in the region are presently engaged in research and studies on the impact of climate change on flora particularly food and forestry crops in the region.

Recognizing that cultivation and the legal harvesting and trade in wild species is an important and sustainable source of livelihood and income to many rural communities and that adequate protection, sustainable harvest and wise use of wild plants can play vital role in conservation of species and their habitats as well as in lifting people out of poverty and securing their future and that it is clear now as per the recent IPCC report that Climate Change is having an adverse effect on the productivity of plants.

Recognizing that all the countries in the region have committed themselves to the UNFCC Convention and are actively associated in various activities related to both mitigation and adaptation to climate change.

Recalling the decision taken in the Tenth Governing Council meeting of SACEP on 25th January 2007 make to Climate Change a priority issue in the work programme (2007-2008). Stressing the importance of mutual networking and technical support as well as financial and technical support from the international community for building expertise, resources, and capacity to address the needs of studying the impact of Climate Change in the SA Region.

Realising the need for collaborative research on the effect of global climate change on South Asian flora and the need for urgent action for enhancing regional preparedness for sustainability.

Acknowledging that the Lucknow meet recommended and to take immediate steps to create a South Asian forum for enhancing the preparedness to face the challenges posed by the global climate change to regional flora and ecosystems.

Believing that regional cooperation can provide the best solution for regional problems, we the delegates at the NBRI - SACEP International Workshop on Climate Change and its Impact on Flora in the South Asian Region, hereby support the Lucknow Statement on the effect of global climate change on South Asian flora and regional action plan, and urge to:

I. Establish of a South Asia Forum for Climate Change Challenges to Flora in South Asia (FC3F-SA) to support and guide the development of regional and local strategic plans by working closely with global, regional and local governmental and non-governmental partners. This Strategic Plan will be developed for promoting education, research and extension, for knowledge-based assessment, monitoring, preparedness and mitigation of climate change effects on flora in South Asian countries.

II. Setting up a FC3F-SA web portal of member countries for communication, creation of database on regional flora diversity, ecosystems, climate change indicators and projects in progress.

III. Generate multidisciplinary climate change information to supplement existing educational materials, textbooks and publications in member countries.

IV. Coordinate with Donor agencies to generate Fund for regional projects to evolve standard operative procedures to collect data, monitor, quantify and analyse climate change impact on agriculture, forestry and wild flora.

V. Enhance focus on strategies for responding to climate change vulnerability of flora through adaptation and mitigation research on trees, higher and lower plants.

VI. Evolve strategies to minimize climate change impacts on agriculture and minimize agricultural impacts on climate change. Promote the development of stress tolerant varieties and management practices to cope with climate stress on agriculture and forestry systems.

VII. Integrate biofuel policy in a comprehensive energy, agriculture, climate, population, social and ecosystem sustainability model.

Research on models for scale up of carbon balance from experiments to ecosystems, life cycle green house gas analysis of biofuel and crop production systems, climate stress response of plant growth and development, ecosystem dynamics and climate impact modeling in hot spots to prioritize adaptation opportunities to meet the challenges of climate change.
GLOBAL AND REGIONAL CLIMATE CHANGE

Dr. S.D. Attri, India Meteorological Institute

Extensive recent coverage in national / international dailies, weeklies and monthlies

The World is Burning Up

Global Warming

Fortune

Global Climate Change: The Frightening New Realities

U.S. Navy: Kicking the Oil Habit

Climate change will affect the ability of ecological systems

Energy

Food

Sustainability

Water

Biodiversity

SIGNALS OF CLIMATE CHANGE?

- 40% of world population now faces chronic shortage of fresh water for daily needs.
- Half of the world's wetlands have been lost.
- One-fifth of the 10,000 fresh water species have become extinct.
- Contaminated water kills around 2.2 million people every year.
- Air pollution has now become major killer accounting for death of 3 million people every year.

Cont'd.

- Since 1990, 24% of the world's forests have been destroyed. The rate of loss is 30,000 sq. km every year.
- Half the world's grasslands are overgrazed.
- 800 wildlife species have become extinct and 11,000 more are threatened.
- Almost 75% of the world's marine captures is over fished or fully utilized. In North America, 10 fish species went extinct in the 1990s.
- Two-thirds of the world's farm lands suffer from soil degradation.
- Of the 9,964 known bird species, 70 per cent have declined in numbers.
**What is 'climate change'?**

Climate change is a shift in climate relative to a reference period. It is caused by:

- **Natural factors**
  - Solar variability
  - Volcanic activity
  - Internal variability
  - Geological change

- **Human factors**
  - Greenhouse gases
  - Aerosols
  - Ozone depletion
  - Land use change

---

**Composition of the atmosphere**

**Major Permanent gases (99%)**

<table>
<thead>
<tr>
<th>Gas</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen</td>
<td>78.0%</td>
</tr>
<tr>
<td>Oxygen</td>
<td>20.9%</td>
</tr>
</tbody>
</table>

**Other permanent gases**

<table>
<thead>
<tr>
<th>Gas</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Argon</td>
<td>0.9%</td>
</tr>
<tr>
<td>Neon</td>
<td>0.002%</td>
</tr>
<tr>
<td>Helium</td>
<td>0.0005%</td>
</tr>
<tr>
<td>Krypton</td>
<td>0.0001%</td>
</tr>
<tr>
<td>Hydrogen</td>
<td>0.0005%</td>
</tr>
</tbody>
</table>

**Variable gases in the atmosphere**

- Water vapour: 0 to 4%
- Carbon Dioxide: 0.035%
- Methane: 0.0002%
- Ozone: 0.000004%

**Main Greenhouse Gases (WMO 2007)**

<table>
<thead>
<tr>
<th>Gas</th>
<th>Pre-industrial</th>
<th>Year</th>
<th>Change</th>
<th>Change</th>
<th>Change</th>
<th>Anthropogenic</th>
<th>2019</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO₂</td>
<td>285 ppm</td>
<td>2019</td>
<td>-2.5</td>
<td>0.1</td>
<td>0.2</td>
<td>170</td>
<td>0.5</td>
</tr>
<tr>
<td>CH₄</td>
<td>715 ppm</td>
<td>2019</td>
<td>-1.5</td>
<td>0.05</td>
<td>0.4</td>
<td>21</td>
<td>0.2</td>
</tr>
<tr>
<td>N₂O</td>
<td>270 ppm</td>
<td>2019</td>
<td>-0.1</td>
<td>0.3</td>
<td>0.1</td>
<td>81</td>
<td>0.7</td>
</tr>
<tr>
<td>SF₆</td>
<td>1.3 ppb</td>
<td>2019</td>
<td>-0.03</td>
<td>0.01</td>
<td>0.07</td>
<td>12</td>
<td>0.1</td>
</tr>
<tr>
<td>HFC-143a</td>
<td>4 ppb</td>
<td>2019</td>
<td>-0.05</td>
<td>0.02</td>
<td>0.06</td>
<td>12</td>
<td>0.1</td>
</tr>
<tr>
<td>CF₃Br</td>
<td>8 ppb</td>
<td>2019</td>
<td>-0.05</td>
<td>0.02</td>
<td>0.06</td>
<td>12</td>
<td>0.1</td>
</tr>
</tbody>
</table>

**Radiative Forcing Components**

- Mount Pinatubo, Philippines, 1991
  - Dust cloud caused worldwide cooling.
CONTRIBUTION OF DIFFERENT GREENHOUSE GASES TOWARDS GLOBAL WARMING

Percent Contribution of Different Regions to GHG Emissions

GHG ESTIMATION IN INDIA

NATIONAL COMMUNICATION

Temperature and CO₂ concentration in the atmosphere over the past 400,000 years (Note the Vertical, no care)

We have some Global Earth Observations

We don't have:

20th Century 21st Century

OBSERVING SYSTEM TIMELINE
The Nobel Peace Prize (2007)

Oslo, 10 December 07

The Intergovernmental Panel on Climate Change and Albert Arnold (Al) Gore Jr. were awarded the Nobel Peace Prize "for their efforts to build up and disseminate greater knowledge about man-made climate change, and to lay the foundations for the measures that are needed to counteract such change".

Observed Climate Change (IPCC 2007)

- The earth has warmed by 0.74 [0.56 to 0.92]°C during last 100-years (1880–2005)
- Eleven of the last twelve years (1995–2005) rank among the 12 warmest years in the instrumental record
- At global ocean temp. has increased to 3000 m depth and the ocean has been absorbing more than 80% of the heat added to the climate system
- More intense and longer droughts observed over wider areas since the 1970s, in the tropics and subtropics.
- The frequency of heavy precipitation events has increased over most land areas

- Significantly increased rainfall has been observed in eastern parts of North and South America, northern Europe and northern and central Asia.
- Drying has been observed in the Sahel, the Mediterranean, southern Africa and parts of southern Asia
- Average Arctic temperatures increased at almost twice the global average rate in the past 100 years
- Cold days, cold nights and frost have become less frequent, while hot days, hot nights, and heat waves have become more frequent
- Mountain glaciers and snow cover have declined on average in both hemispheres
The maximum area covered by seasonally frozen ground has decreased by about 7% in the Northern Hemisphere since 1900, with a decrease in spring of up to 15%.

Increase of intense tropical cyclone activity in the North-Atlantic since about 1970.

There are also suggestions of increased intense tropical cyclone activity in some other regions where concerns over data quality are greater. Multi-decadal variability and the quality of the tropical cyclone records prior to routine satellite observations in about 1970 complicate the detection of long-term trends in tropical cyclone activity. There is no clear trend in the annual numbers of tropical cyclones.

Human contribution to climate change

Global atmospheric concentrations of greenhouse gases increased markedly as result of human activities.

In 2005, concentration of CO₂ exceeded by far the natural range over the last 550,000 years.

Direct observations of recent climate change

Changes in temperature, sea level and forest cover.

Heavier precipitation, more intense and longer droughts.

Coastal settlements most at risk
Monsoons - a relatively regular phenomenon interspersed with large extremes.

Trend of south-west monsoon season in mm in 100 year

Percentage of total area of the country affected by drought during all India drought years (Dec 2001)
In the next two decades, a warming of about 0.2°C per decade is projected for a range of SRES.

Even if the concentrations of all greenhouse gases and aerosols had been kept constant at year 2000 levels, a further warming of about 0.1°C per decade would be expected.

Snow cover is projected to contract.

Widespread increases in thaw depth are projected over most permafrost regions.

Sea ice is projected to shrink in both the Arctic and Antarctic under all SRES scenarios.

In some projections, Arctic late-summer sea ice disappears almost entirely by the latter part of the 21st century.
Ranges for predicted surface warming

Key vulnerabilities to climate change
- Some regions will be more affected than others
  - The Arctic ice sheet loss, ecosystem changes
  - Sub-Saharan Africa (water crisis, desertification)
  - Small islands (ocean rise, population)
  - Asian mega deltas (floods from sea and rivers)
- Some ecosystems are highly vulnerable
  - Coral reefs (marine shell organisms)
  - Tropical forests (biodiversity, Mabula-Molokwane region)
  - 20-30% of plant and animal species at risk of extinction

Projected Changes in Annual Temperatures for the 2050s

Indian Scenario
- The rate of sea-level rise has been observed to be between 1.60-1.76 mm/year with a regional average of 1.29 mm/year which is comparable with 1-2 mm reported by IPCC.
- Temperature rise over India is expected to be uniform over most of the country while slightly more warming over NW region is expected. The expected warming by 2070 is likely to be 1.5 to 2.0°C over most parts of the country.
- Extreme rainfall events are likely to increase along the west coast, west central India and NE region.
- Model simulations suggest, projected rise in sea level in north Indian Ocean is around 30 cm in next 100 years

How climate change affects world regions

Climate change threatens world ecosystems
Adaptation and Mitigation

Mitigation urgently needed
- Continued GHG emissions at or above current rate would induce larger climatic changes than those observed in 20th century
- Emissions of the greenhouse gases covered by the Kyoto Protocol increased by about 7% from 1970-2004

Mitigation needs to start in short term, even if benefits may only arise in a few decades

Beyond adaptation
- Adaptation to climate change is necessary to address impacts resulting from the warming which is already unavoidable due to past emissions
- However:
  - Adaptation alone cannot cope with all the projected impacts of climate change
  - The costs of adaptation and impacts will increase as global temperatures increase

Making development more sustainable can enhance both mitigative and adaptive capacity, and reduce emissions and vulnerability to climate change

Pathways towards stabilization

<table>
<thead>
<tr>
<th>Scenario</th>
<th>2000</th>
<th>2050</th>
<th>2100</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference</td>
<td>5000</td>
<td>7000</td>
<td>9000</td>
<td>9000</td>
<td>9000</td>
</tr>
<tr>
<td>Stabilized</td>
<td>4500</td>
<td>6500</td>
<td>8500</td>
<td>8500</td>
<td>8500</td>
</tr>
<tr>
<td>Mitigation</td>
<td>4000</td>
<td>5500</td>
<td>7500</td>
<td>7500</td>
<td>7500</td>
</tr>
</tbody>
</table>

Mitigation efforts over the next two to three decades will have a large impact on opportunities to achieve lower stabilization levels
Key technologies to reduce emissions

- Energy: Provided by the following technologies:
  - Fossil fuels: improving energy demand, use and performance and improving energy recovery; heat and power, natural gas, coal, etc.
  - Advanced energy production: combining technologies and renewable sources of energy, fuel and power generation.
- Transportation: produced by an electric or hybrid vehicle. Electrification of the public transport and urban transport systems, electric vehicles, and fuel cells.
- Buildings: energy-efficient buildings, passive solar design, and green buildings.

Initiatives to slow down the human contribution to the increasing concentration of GHGs

- Increase in energy use efficiency & its conservation
- Greater use of, and research on non-CO2 fuels and CO2 producing sources of energy
- Phasing out of CFCs
- Sustainable use of forests & extensive afforestation
- Net reforestation to Net afforestation
- Low-cost transfer of 'Low GHG emission technology' to the developing countries

Climate problem is a long-term problem and will require "thinking long-term" to solve

Key policies to reduce emissions

- Appropriate incentives for all development of technologies
- Effective carbon price signals to reduce emissions and increase GHG products, technologies, and processes
- Appropriate policy to ensure new infrastructure investment, which will have long-term effects on emissions
- Changes in lifestyles and increased awareness, especially in buildings, transport, and industrial sectors

Individual efforts

- Share what we have learnt about climate change
- Buy more efficient household appliances
- Replace all incandescent bulbs by compact fluorescent bulbs that last four times longer and use just one-fourth of the electricity
- Build houses so that they let in sunlight during the daytime reducing the need for artificial lighting
- Use sodium vapour lights for street lighting: these are more efficient

Keep car engines well tuned and use more fuel-efficient vehicles

Avoid using engines for long periods, especially at crossings and during a traffic jam by switching off the engine.

Form car pools and encourage friends for the same. Cycle or walk to the neighbourhoud market.

Manage vehicle traffic better to reduce fuel consumption.

'No Car Days' and have limited city parking on alternate days for odd- and even-licensed numbers.

Turn off all lights, devices, and AC's, computers and other electrical appliances and gadgets when not in use.

Plant trees in our neighbourhood

Recycle all cans, bottles and plastic bags and buy recycled items.

Generate as little trash as possible, because trash in landfills emits large quantities of methane, and if it is burnt, CO2 is released.

...thank you
The Dead Sea, "Sea of Salt," is a salt lake between the West Bank and Israel to the west, and Jordan to the east. It is said to be the lowest point on Earth, at 420 m (1.378 feet) below sea level.[4]

Lake Chad in a 2001 satellite image, with the actual lake in blue, and vegetation on top of the old lake bed in green. Above that, the changes from 1973 to 1997 are shown.

[Images of the Dead Sea and Lake Chad]
The Greenhouse Effect

- The greenhouse effect is the rise in temperature that the Earth experiences because certain gases in the atmosphere (water vapor, carbon dioxide, nitrous oxide, and methane, for example) trap energy from the sun. Without these gases, heat would escape back into space. Because of how they warm our world, these gases are referred to as greenhouse gases.
Another Comparison

Countries of Low Human Development

Global Ecological Footprint
How much land is required for:
- Waste Management
- Energy Requirements
- Water Needs
- Transportation
- Food Requirements and
- Housing

One Acre Of Prime Land Can Produce (Pc)

Interactive Web of Sustainability Indicators

Leak and Modern Development Countries

Global Ecological Footprint

Global Ecological Footprint
The number of gallons of water needed to produce one pound of edible product:

- Apples: 49
- Carrots: 33
- Potatoes: 23
- Tomatoes: 23

Fresh:

Environment Friendliness Index
(ESI = PC/WC)

<table>
<thead>
<tr>
<th>Plant</th>
<th>PC</th>
<th>WC</th>
<th>ESI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apple</td>
<td>5</td>
<td>0</td>
<td>0.05</td>
</tr>
<tr>
<td>Carrot</td>
<td>4</td>
<td>0</td>
<td>0.04</td>
</tr>
<tr>
<td>Potato</td>
<td>6</td>
<td>0</td>
<td>0.06</td>
</tr>
<tr>
<td>Tomato</td>
<td>2</td>
<td>0</td>
<td>0.02</td>
</tr>
</tbody>
</table>

Atmospheric CH₄ Past Trends, Future Predictions

Air quality-Climate Linkage:

CH₄ contributes to background O₃ in surface air. CH₄, O₃, and important greenhouse gases.
Wetlands

Competing processes:
- Carbon sink (peat accumulation)
- Methane source

Hydrology plays key role:
- Wetland extent
- Balance between CO₂ and CH₄

Terrestrial Carbon Modeling Issues (cont.)

To adequately model water-mediated processes, carbon models need sophisticated soil hydrological components:
- Hydraulics
- Thermodynamics
- Snow formulation
- Streamflow
- Lakes/wetlands
- Permafrost

Wetland CH₄ Emissions

Issue of Greenhouse Gas Emissions

- Flannigan (2002, 2004) argues that wetlands in the tropics are producing as much greenhouse gas as a conventional power station.
- Whereas International Hydropower Association (IHL, 2003) suggests that emissions from hydroelectric power are up to 50 times lower than from thermal power plants, and can absorb and store more CO₂ than they emit.
- On the other hand, International Rivers Network (2003) points out that the flooded areas may be sources of GHGs rather than sinks (Parry, 2004; McCullough, 2004).

Aerenchyma—Lifelines for Living Underwater

Aerenchyma

Issue of Greenhouse Gas Emissions

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- Whereas International Hydropower Association (IHL, 2003) suggests that emissions from hydroelectric power are up to 50 times lower than from thermal power plants, and can absorb and store more CO₂ than they emit.
- On the other hand, International Rivers Network (2003) points out that the flooded areas may be sources of GHGs rather than sinks (Parry, 2004; McCullough, 2004).
Parameters Which Affect Methane Emissions: Wide variations in the estimate of Brazilian reservoirs

- Mainly because of the following factors:
  - Temperature
  - Measurement point depth
  - Wind speed
  - Sag level
  - Physical and chemical water parameters
  - Reservoir contamination
  - Hematological system

Orinoco River Floodplain Study

- Emission rates have generally been observed to be five times higher for flooded forest than that for open water or macrophyte mats
- Orinoco River floodplain study in Venezuela is an example case study of this kind. Out of the total methane emission, 25% of the contribution comes from flooded water.

Relative Contributions

- Macrophyte mats, open water and exposed sediments make very small contributions.
- In any of these areas, ebullition / bubbling accounts for approximately 45% of emissions and diffusion about 55%.

How to extrapolate from site-measurements to regional estimates?

- From determinations of (1) the potential methane emissions from a particular site, (2) the percentage of area that is flooded, and (3) the proportion of the flooded area covered by flooded forest, it appears possible to estimate regional emissions.
- Such an estimate should be very carefully correlated with input data.

Methane Emission Routes

- Diffusion across the air-water interface
- Ebullition, and
- Through the stems of plants

Atmospheric Brown Cloud

Atmospheric Brown Cloud (ABC) network. More of information and analyses documented and compiled by the Atmospheric Brown Cloud (ABC) network. This is a project of Hemispheric Institute of Atmospheric
Aerosol Optical Thickness

"Aerosol Optical Thickness" is the degree to which aerosols prevent the transmission of light. The aerosol optical depth or optical thickness ($\tau$) is defined as the integrated extinction coefficient over a vertical column of unit cross-section. Extinction coefficient is the fractional depletion of radiance per unit path length (also called attenuation especially in reference to radar frequencies). The optical thickness along the vertical direction is also called normal optical thickness (compared to optical thickness along slant path length).

Water Pollution: Can you see some water!?

Endangered Species

- At least 100 animals are added to the endangered species list each year.

Biodiversity: Right combination of species!
- Ecological Interactions (Birds & Trees)

Soil Erosion

Local & Indigenous Knowledge
-in the fields of:
- Education
- Science
- Culture and
- Communication.

Sustainable Development for Whom (?), Where (?), When (?) & Why (?)
In the period that Einstein was active as a professor, one of his students came to him and said: "The questions of this year's exam are the same as last year!"

"True," Einstein said, "but this year the answers are different."

Just have a look at few cities in Spain (Cadaqués city)

How to locate sustainable development?

- Where is it — between sand and trees?

Journey from natural jungles to concrete jungles

Brazil's View from Sky

Occasionally, we had some natural disasters like volcanoes. Here you can easily compare it with the copper mining (photograph on the right)
Floods in Bangladesh (Do We Remember Mumbai Floods and Rashes?)

Ship in search of Sustainable Development!!

Confusing Steps Towards Sustainable Development!!

Peaks of Development : Which one Is Sustainable ?

Just have a look at this!

- Does it charm you?
- How to plan for this journey?
- Shall we aim at an eco-system like this?

rediff.com

As 9 per cent growth feasible?

Nidh Dave

December 5, 2006 | 04:43 IST

The government has raised the 9 per cent growth target for the Eleventh Plan. The Appraisal Paper on undergroundsworth the 9 per cent level by the end of the Plan. Some of the optimism rests on a projection of the high growth of recent years. Though the Paper does describe the major policy changes required to get to this high growth pace, the most probable is whether these estimated changes can be affected.
ESSENCE
Structural Modelling Approach

- Problem Definition
- Model Purpose Definition
- Verbal Model
- Identification of System Elements
- Structure: Interconnections of State Variables, Intermediate Variables, Parameters, Exogenous and Event Functions, etc.
- Cause-Effect Diagram (Cause-Effect Relationships)
- Functional Relations and Quantification
- Computer Programming and Simulation
- Testing and Validation (Structural, Behavioural, Empirical and Application Validity Tests)

Models

- Verbal or Graphic Models
- Mathematical Models
- Linear & Non-Linear Models
- Ecological compartment Models
- Statistical & Structural Models
- Computer Models

Forcing Functions

- State variables
- Inter-compartment Flows
- Interactions amongst various compartments

Ecosystem Function
Thank You

Depletion in Forest Areas

Carrying Capacity Studies
NCR & Doon Valley

Thank You

(Articles are invited for our Hindi Magazine PATRAKAR PATRAKAR)
Climate change impact on trace metals in soil and plants
Prof. M.N.V. Prasad, Dept. of Plant Sciences

- Plant uptake/exclusion and translocation of trace metals (as contaminants and nutrients)
- Exploit 'genomics, proteomics and metabolomics' approaches in phytotechnologies (phytoremediation)
- Improving nutritional quality and safety of food crops
- Integration and application of remediation technologies across the fields of environment and health.
Plants that hyperaccumulate metals (more than 1% of metal in the dry matter)

Metal hyperaccumulating Brassicaceae

Metal ion transport plays a very crucial role in maintenance of the ion homeostasis in plant cells. There are specific metal ion uptake systems in cells that are tightly controlled at both transcriptional and post-transcriptional levels with specific regulatory mechanisms identified.

Although research into the molecular physiology of plant transport systems for elemental nutrients and pollutants is still in its infancy, a large number of genes have been identified that function in metal ion transport and have illuminated the existence of importance of gene families that play related roles in these processes in animals.
Salinity refers to the amount of sodium in soils. It develops through a process whereby sodium ions build up in preference to other cations (specifically calcium) on the exchange complex of the soil. Increases in soil pH and decreases in calcium and magnesium, usually accompany this process. Soils with these features are known as sodic soils. A measure of soil salinity is known as the Exchangeable Sodium Percentage or ESP.

Salinity is more widely known and refers to the amount of soluble salt in a soil. Unlike salinity, movement of water influences salinity. Hence, salinity has been related to clearing and irrigation developments and results from changes of land use and water movements in landscapes. Soil salinity is measured by the electrical conductivity (EC) and/or chloride content.

Salinity regimes in aquatic systems can vary significantly over time, either as a result of evaporative effects or the influx of saline groundwater. Metal uptake, transport and release by salt marsh plants play an important role in the dynamics of essential trace elements and hydrology and has implications for enhanced biodiversity of agro-forestry systems as well as brackish/wetland ecosystems.

**Figure:**

- **Salinity/Sodium stress:**
  - Ionic
  - Osmotic

- **Measures:**
  - Crop adaptations
  - Genetic

1. Damage must be prevented or alleviated.
2. Homologous conditions must be established in the problem environment.
3. Saline conditions must be established for optimum growth or crop yield.
1. Tolerance index: Root growth in metal solution
2. Whole plant analysis - ability to accumulate Tm

Trace Metal Tolerance in Plants
Ernst et al 1992 Acct Bot Neerl 41: 229-248
Modeling Plant Response to Climate Change Opportunities & Research Needs

A.S. Raghubanshi, Professor of Botany, Banaras Hindu University

Models

- A simplified representation of real system
  - Pictorial
  - Conceptual or verbal
  - Physical
  - Mathematical

Global Carbon Budget

<table>
<thead>
<tr>
<th>Reservoir (GTonnes)</th>
<th>Fluxes (GTonnes/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atmosphere</td>
<td>720</td>
</tr>
<tr>
<td>Ocean</td>
<td>39,000</td>
</tr>
<tr>
<td>Land biosphere</td>
<td>550</td>
</tr>
<tr>
<td>Soils</td>
<td>1,500</td>
</tr>
<tr>
<td>Fossil fuels</td>
<td>6</td>
</tr>
<tr>
<td>Biomass burning</td>
<td>2</td>
</tr>
</tbody>
</table>

Page 114
Modeling Ecosystem Responses to Climate Change

- Predicting future vegetation structure is necessary to quantify biotic feedbacks to climate change and rising greenhouse gas concentrations.

Approaches to Assessing Ecosystem Responses to Climate Change

- **Equilibrium Models:**
  - Simulate vegetation to carbon concentrations and transfer future vegetation to climate change

- **DGVM (Dynamic Global Vegetation Models):**
  - Simulate vegetation to carbon concentrations
  - Simulate vegetation distribution and structure
  - Simulate vegetation interactions with atmospheric factors
  - Model ecosystems at various scales
  - For by climate, CO2 output from DGVM

Missing Sink

- Models in sink is located 30-90°N
  - Retrigration?
  - Feet hog?
  - CO2 fertilization?

Modeling Ecosystem Responses to Climate Change

- Developing general predictions is challenging
  - Individual nature of species responses
  - Few long-term realistic experiments in most ecosystems
  - Different rates of past, experimental and future climate changes

Biome-BGC

- Mechanistic ecosystem model that simulates the storage and fluxes of water, C, and N within the vegetation, litter, and soil components of the terrestrial ecosystems.
- Developed from the Forest-BGC family of models
- An extended version for use with different vegetation types.
| Biome-BGC
| Problems:
- Uses daily time step, driven by daily values for maximum and minimum temperatures, precipitation, solar radiation, and air humidity.
- Model requirements: definitions
  - Vegetation
  - Climate
  - Site characteristics

| Biome-BGC
| Challenges:
- Parameter calibration necessary
- But a challenging task
  - Values are difficult to locate and standardize for several reasons:
    - In India, data absent for most of the parameters
    - Older publications (pre-1990) not catalogued in online databases
    - Data published in obscure journals or grey literature
    - Data collection methodologies and units differ substantially for some parameters making standardization difficult

| Ecophysiological Parameters
| Overview:
- Mostly temperate-measured for individual species on a variety of sites with a variety of age classes present
- Despite these difficulties, it is critical that important parameter values and all references for these parameter values be provided for any model-based study.

| Ecophysiological Parameters
| Averaging Effects:
- Observations of many communities and locations are typically averaged across broad vegetation classes (e.g. evergreen needleleaf, broadleaf deciduous) to generate default parameterization values
- Thus, the average or default values include a high degree of variability even within these broad vegetation types.

| Ecophysiological Parameters
| Database Development:
- New parameterization datasets required more specifically to account for changes in the physical environment or species.

| Key Ecophysiological Parameters
| for Models:
- Allocation Parameter
- Carbon to Nitrogen Ratios
- Decomposition Constant
- Use Efficiencies
  - Nutrient Use Efficiency
  - Production Use Efficiency
- Leaf Area Indices:
  - Leaf area index (LAI)
  - Specific leaf area (SLA)
  - Projected leaf area
  - All-sided leaf area

(Continued...)
Ecophysiological Parameters

- Canopy Light Extinction Coefficient
- Nitrogen Distribution
- Nitrogen Input
- Proportions
  - Laike, Cellulose, Lignin
- Leaf and Fine Root Turnover
- Transpiration Parameters

Allocation Parameters

- Control how carbon is allocated throughout the ecosystem or biome:
  - fine root, coarse root, stem, and leaf NPP
- Livingwood
  - actively respiring woody tissue that is the lateral sheathing meristem of all living tissue, plus any ray parenchyma extending radially into the xylem tissue
- Deadwood
  - all the other woody material, including the heartwood, the xylem, and the bark

FRC:LC

- Fraction of root carbon to leaf carbon
- Establishes a relationship between different plant pools that control how photosynthetically produced carbon is allocated throughout the ecosystem

Root Allocation

- The transfer of photosynthate below ground by roots may be a major input to the soil C pool
- Quantitatively, the least understood, due to the technical difficulties associated with its measurement and labelling
- Most estimates of below-ground production in perennial vegetation are based only on the increased in below-ground biomass, i.e., losses through root death are not considered
- In situ tracing of root-derived C, using 13C, pulse labelling in the field

Belowground Allocation

- Ability of models to predict C balance could be improved with better estimates of annual residue inputs, particularly the below-ground part

Accumulation of maize-derived organic carbon in soil (0-35 cm), as estimated from 13C natural abundances

A clear predominance of root-derived C in the stored soil C of croplands and grasslands
Belowground Allocation

- Approximately 70% of the total root biomass in the 0-15 cm layer
- Highly variable R:S ratio

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<tbody>
<tr>
<td>Wheat</td>
<td>0.13-0.20</td>
</tr>
<tr>
<td>Oat</td>
<td>0.37-0.42</td>
</tr>
<tr>
<td>Barley</td>
<td>0.41-0.59</td>
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</tbody>
</table>

Root biomass allocation in the world's upland forests

Carbon to Nitrogen Ratios

- In different plant components
  - leaves
  - litter
  - roots
  - live or dead wood

C:Nlv

- Carbon to nitrogen mass ratio in the leaves
- Determines three important factors:
  - the nitrogen required to construct leaves,
  - the amount of nitrogen available for investment in photosynthetic machinery, and
  - leaf respiration rates

Leaf C:N Ratio

Litter C:N Ratio

![Graphs showing Leaf and Litter C:N Ratios](image)
Decomposition Constant

- Exponential pattern of loss and is calculated accordingly to Olson (1963) based on litter bag loss:

\[ \ln \left( \frac{M}{M_0} \right) = \frac{t}{k} \]

where:
- \( M \) is mass remaining after time \( t \)
- \( M_0 \) is mass at the start of the experiment
- \( k \) is the decomposition constant

Use Efficiencies

- Nutrient use efficiency
  - ratio of organic matter produced to nutrient taken up. For herbaceous plants, it is also a measure of how long a nutrient is retained in the plant to be used for carbon fixation.
- Product use efficiency
  - ratio of ANPP to standing biomass.

Leaf Area Indices

Morphological Parameters

- Leaf area index (LAI)
  - the total leaf area on one surface over a unit ground area
- Specific leaf area (SLA)
  - leaf area per unit leaf carbon mass
- Projected leaf area
  - leaf area projected horizontally on the ground surface
- All-sided leaf area
  - total surface area of leaves

LAI measurement

- Wide range of field techniques
  - radiation transmittance (Chen et al. 1997),
  - leafwood allometrics (Berdowski and Smyth 1993),
  - foliage biomass
  - Remote sensing

SLA

- Defines leaf area per unit mass
- Thin, light leaves, such as grass blades, have a higher SLA than dense conifer needles
- Model needs
  - Shaded SLA sans leaf

Leaf Traits
Future Directions

- Ecophysiological characterization of important plant functional traits
- Model optimization for Indian Ecosystems
- Interface with IPCC scenarios to develop predictive capabilities in face of climate change
- Long Term Ecosystem Research Site approach
  - Micrometeorological approach
  - Open top chamber/PACE experiments

Thank You
Project formulation

Several key points emerged from this discussion other than the distributed position paper.

The other highlights of the Workshop were deliberations by experts on environmental issues related to climate change like effect on Sundarbans mangroves, coasts of north Indian Ocean, carbon sequestration and carbon trading opportunities and Free Air CO$_2$ Enrichment Technology (FACE) to assess the effect of CO$_2$ and temperature rise on crop plants.

The outcome of the Workshop was a “Lucknow Statement on the effect of global climate changes on South Asian Flora and Regional action plan”. The statement highlights the development of strategic plan for promoting education, research and extension, for knowledge based assessment, monitoring, preparedness and mitigation of climate change effects on flora in South Asian Countries.

A project proposal “Impact of Climate Change on Flora: A South Asian Initiative” for a coordinated action programme was developed, with the following three objectives to enhance capacity building, floral vulnerability assessment and adaptation/mitigation strategies. The project has been forwarded to SACEP Governing Council for the approval and then for seeking funds from International Organizations. The workshop concluded with thanks to the participants and especially experts from India and South Asian Countries by the organizing secretaries – Drs. R.D. Tripathi and Nandita Singh.

Objective 1: Enhancing Capacity Building

Activities:
1. To organize workshops and training program (short and long term) for researchers, administrators, policy / decision makers, industry and other stakeholders.
2. To sponsor candidates from SA countries for graduate diploma / degree courses on climate change in alliance with universities.
3. To organize public awareness programmes through various media.
4. To develop and exchange educational and public awareness materials on climate change.
5. To develop a South Asia Institute for implementation of education and training programmes.

Objective 2: Floral Vulnerability Assessment

Activities:
1. To develop baseline data on climate parameters and floral diversity from existing sources.
2. To assess the present status and distribution pattern of floral diversity at specific study sites.
3. To study the impact of climate change on phenology/reproductive traits.
4. To study vulnerability and adaptive responses of plants to climate change.
5. To prioritize threat -prone and indicator taxa and critical habitats for in situ conservation.

Objective 3: Adaptation and Mitigation Strategies

(A) Adaptation - Identification of economically important crop germplasm (rice) for adaptability to climatic change

Activities:
1. Screening of germplasm
2. Analysis of stress related enzymes/genes
3. Studying responses of targeted species under field conditions using appropriate technologies simulating climate change

(B) Mitigation- Identification of tree species having high carbon sequestration potential

Activities:
1. To study the carbon sequestration potentials of tree species in targeted ecosystems/biomes under different climatic conditions in SA countries
2. To estimate the net biome production / net ecosystem exchange (NEE) patterns in different ecosystems/biomes in SA countries with Eddy Covariance Flux Tower (carbon flux tower observations)
3. To develop strategies for CO₂ mitigation through afforestation / reforestation with selected species

Outputs of the discussion were developed through future activities in close collaboration with participating institutions and following recommendations were emerged from the discussion:

RECOMMENDATIONS

• Official endorsement of the programme by respective governments and nomination of nodal coordinators for each SA country (within one month).
• Detailed project development workshop (within three months). Technical experts who will implement each component activity to be invited for project preparation from each SA country. It may be desirable to invite group of 5-10 experts from each SA country and the venue of workshop may be any SA country.
• It was agreed to identify a strategy to advance discussions on the sustainable financing for initial two years (Phase I) to be decided in next workshop. Depending upon the progress and outcome of Phase I, subsequent project milestones to be developed.
• Representatives suggested the most suitable way to remain in communication and coordination is through the SACEP.
Proposed Project

Impact of Climate Change on Flora: A South Asian Initiative

(Proposal for a coordinated action programme developed at the NBRI-SACEP International Workshop on “Climate Change and its Impact on Flora in the South Asia Region”, NBRI, Lucknow, India, March, 09-12, 2008)
Impact of Climate Change on Flora:
A South Asian Initiative

Preamble:

The reports of Inter-governmental Panel on Climate Change (IPCC 2007) have highlighted the gravity of consequences that the life on earth, including mankind, is to face in coming times. IPCC report predicts that global warming is likely to increase mean temperature up to 5.8°C over the next 100 years, and that it could lead to melting of glaciers, polar ice caps and rise in sea levels. This may also affect species reproductive cycles, growing seasons, and species interaction to impact agricultural productivity, besides changing the natural course of many species, and drive many taxa to the verge of extinction. It is projected that 20-30% of the plants and animal species assessed by IPCC are at increased risk of extinction, if global average temperature exceeds 1.5 to 2.5°C. Impact of climate change on plants are manifested mostly by the upward migration / range shifts of species along temperature-altitudinal-latitudinal gradients, reduction in population size, structure and dynamics of species vulnerable to climate change, changes in phenology and reproductive cycle, range expansion of invasive species, etc. Thus, global climate change poses a serious threat to living organisms and support systems.

Climate change will give rise to environmental pollution and abnormal weather which may lead to decrease in overall growth and productivity of plants. There have been studies to understand plants behaviors to such environmental changes. Predicting the responses of ecosystems to climate change requires scaling up from key mechanisms, such as photosynthesis or growth that are best understood at the organism level. These mechanisms are fundamentally linked to genes, gene networks, and their interplay with the environment.

Despite the remedial measures taken such as cutting the emissions of greenhouse gases by the industrialized Nations, some recent emerging evidence suggests that the heat-trapping gases like carbon dioxide, produced mainly from the burning of fossil fuels, continue to raise temperatures, change the global climate, and affect ecosystems around the World.

South Asia (SA), the most populated continent, is the home for about 50% of the world’s terrestrial plants and animal species, is also one of the rapidly growing economies of the world.

Climate change issues in SA region assume different dimensions in accordance with the changing patterns of ecology, environment, biodiversity, socio-economic settings and anthropogenic interventions. The flora and associated ecosystems/biomes in SA countries are likely to experience different impacts through retreat of glaciers in the Himalayan high ranges (e.g. India, Pakistan, Bhutan and Nepal) or sea level rise and associated floods and salinity intrusion in low lying region and islands (e.g., Bangladesh, peninsular India, Maldives, Sri Lanka). Furthermore, biodiversity in the SA region has already been experiencing unprecedented threats from increased human activities. This is evident from the fact that three out of thirty four global biodiversity hot spots are located in the SA region in the Indian subcontinent: i) Himalayas, ii) Indo-Burma, iii) Western Ghats and Sri Lanka. Threats to the loss of floral and faunal species, especially endemics, and their habitats in these biodiversity hot spots are looming large and
expected to increase at an unprecedented rate as the global temperature continues to rise. Urgent strategic initiatives are therefore required to respond to the challenges of climate change and its most disruptive impacts on floral diversity in SA region. Such initiative should include actions that are necessary to develop adaptive conservation management of plant diversity and associated resource systems through vulnerability assessment, integrated with adaptation and mitigation strategies against climate change.

Development of a realistic and regional specific data base and network on climate change-floral diversity in SA region, and creation of appropriate infrastructure and building enhanced institutional, technological and human resources for addressing climate change issues within and among each SA country are also important elements to be included in the action plan. Education, training and awareness building on climate - plant diversity changes and their impacts to flora and associated resources systems, including forestry, agriculture, health, etc. also assume great importance in the SA region-specific agenda on climate change. The priority ecosystems/biomes demanding immediate attention are the coastal lands, mountainous regions, and wetlands. These are the regions where species, particularly endemic species often have no alternative habitats to migrate to, and thus, the species of these ecosystems are under immediate threat due to climate change. The strategy, therefore, calls for appropriate action to address the issues across the diversity of resilient / sensitive ecosystems, encompassing plant species and populations vulnerable to climate change.

For addressing the modern technological and social issues concerning climate change, it is important that people are familiar with the subject. Scientific knowledge base generated by academicians and scientists should be disseminated for public awareness on the emerging issues. The programme will focus on imparting training, education and awareness to researchers, administrators, policy -decision makers, industry and other stakeholders on global warming and climate change.

With the availability of data sets for the analysis on climate change through the summary for policy makers of IPCC, climate change studies in SA countries have caught attention of researchers and voluntary organizations. Diverse issues such as greenhouse gas emissions, sea level changes along the coast, its relationship with forests and hydrology of river basins, and sustainable development are being addressed in the SA context. Studies targeting natural vegetation in diverse ecosystems/biomes within the SA countries over a considerable period of time are lacking and need urgent attention in terms of compiling relevant data sets from existing information sources as also establishing long-term monitoring mechanism for generating data sets for policy formulations in the region.

Therefore, it is proposed to develop a common programme entitled “Impact of climate change on Flora: A South Asian Initiative” for all the eight SA countries, with the following objectives and activities.
Objectives:

1. Enhancing Capacity Building
2. Floral Vulnerability Assessment
3. Adaptation and Mitigation Strategies

Objective 1: Enhancing Capacity Building

Activities:

6. To organize workshops and training program (short and long term) for researchers, administrators, policy makers, industry and other stakeholders.
7. To sponsor candidates from SA countries for post graduate diploma/degree courses on climate change in alliance with universities.
8. To organize public awareness programmes through various media.
9. To develop and exchange educational and public awareness materials on climate change.
10. To develop a South Asia Institute for implementation of education and training programmes.

Objective 2: Floral Vulnerability Assessment

Activities:

6. To develop baseline data on climate parameters and floral diversity from existing sources.
7. To assess the present status and distribution pattern of floral diversity at specific study sites.
8. To study the impact of climate change on phenology/reproductive traits.
9. To study vulnerability and adaptive responses of plants to climate change.
10. To prioritize threat-prone and indicator taxa and critical habitats for in situ conservation.

Criteria for site selection:

- Unique biomes of different SA countries
- Availability of past floristic and climatic data
- No or minimum anthropogenic disturbance
- Topographic/Altitudinal gradients
Objective 3. Adaptation and Mitigation Strategies

(C) Adaptation

Identification of economically important crop germplasm (rice) for adaptability to climatic change

Activities:

4. Screening of germplasm
5. Analysis of stress related enzymes/genes
6. Studying responses of targeted species under field conditions using appropriate technologies simulating climate change

(D) Mitigation

Identification of tree species having high carbon sequestration potential

Activities:

4. To study the carbon sequestration potentials of tree species in targeted ecosystems/biomes under different climatic conditions in SA countries
5. To estimate the net biome production / net ecosystem exchange (NEE) patterns in different ecosystems/biomes in SA countries with Eddy Covariance Flux Tower (carbon flux tower observations)
5. To develop strategies for CO\textsubscript{2} mitigation through afforestation / reforestation with selected species

**Note:** Study sites will be selected in Ecosystem/biome as proposed in Fig. 1.

**Approaches**

1. Identification of unique ecosystem/biome for each of the SACEP countries. Ecosystem will be identified depending upon the importance of the ecosystem services and/or vulnerability of the ecosystem towards climate change.
2. Development of long-term study plots.
3. Development of capacity among different SACEP countries by:
   a. Constituting key faculty team for imparting training.
   b. Imparting common training to all the involved partners.
   c. Developing common SOPs.
   d. Generating all the results to common output platform for simulation modellin.
4. Development of infrastructure for SACEP partners
5. Implementation of the proposal
6. Prioritization of the activities
7. Activity phasing
8. Imparting awareness and education among masses and educating policy makers.
9. Setting up a Forum for Climate Change Challenge to Flora in South Asia
   
   FC3F-SA web portal for member countries for data base development, project implementation and information exchange.

**Strategy**

For implementing such an interknit programme, it is proposed to develop an appropriate implementation structure as shown in Fig. 2.
In order to develop a common system for collection of relevant environmental parameter relevant to climate change, it is proposed to install Eddy Covariance Flux Stations to monitor climate variables viz. fluxes of PAR, heat, water, CO2, evapotranspiration and other trace gases. One Eddy Covariance Flux Tower is proposed to be established in each representative ecosystem in each SA country.

Partners will be trained by competent regional and international experts to collect common ecological and physiological parameters, which include:

- community structure,
- population abundance,
- plant phenology,
- mortality and natality,
- species recruitment and eplacement,
- invasion pattern,
- root/shoot partitioning,
- carbon/nitrogen analysis in both plant and soil,
- estimation of carbon sequestration (SLA, LAI, gas exchange)
- water relation parameters.

The following presents a larger scope to be adopted by the partners:

- Collection of previous data from protected areas (National parks/BR/sanctuary) on species composition, population dynamics and the environmental variables to develop time series models.
- Past satellite vegetation maps, if available, can be used in simulation modeling.
- Past meteorological data sets need to be collected.
- Climate simulation studies using appropriate technologies, like FACE and FATI.
Annexure

ANNEX 1 – Workshop Agenda
ANNEX 2 – Press Coverage
ANNEX 3 – List of Participants
## ANNEX 1  SACEP-NBRI Workshop Agenda

### 09.03.08 (Day 1)  
**Inauguration**

**Inaugural Session**

<table>
<thead>
<tr>
<th>Time</th>
<th>Event</th>
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| 09.00-09.30 | Lightening of the Lamp  
- Welcome address, Dr. Rakesh Tuli, Director, NBRI  
- Inaugural address, Dr. A.A. Boaz, DG, SACEP |
| 09.30-10.00 | Theme Introduction, Dr. C.K. Varshney, JNU, New Delhi  
- Key note address, Prof. N.H. Ravindranath, IISc, Bangalore  
- Vote of Thanks, Dr. R.D. Tripathi Scientist, NBRI & Organising Secretary |
| 11.05 | **Tea Break** |

**Session 1**  
**Climate Change – Scenario in different countries**

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| 11.30 to 11.30 a.m | Chairperson: Prof. N.H Ravindranath, IISc, Bangalore  
- Rapporteur: Prof. A.S. Raghuvashti, BHU, Varanasi |
| 11.30 to 11.30 a.m | Lead Lectures  
- Dr. J.S Pandey, NEERI, Nagpur  
- Prof. C.K Varshney, New Delhi (20 Min.)  
- Dr. C. Sharma, NPL, New Delhi |
| 12.45-14.00 | **Lunch**  
Country Presentations (20 min. each) Afghanistan, Bangladesh, Bhutan, Maldives |

**Session 2**  
**Climate Change and Biodiversity**

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<th>Time</th>
<th>Event</th>
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| 04.00-05.30 | Country Presentations (20 min. each) Nepal, Sri Lanka, Pakistan  
03.30-04.00 | **Tea Break** |
| 04.00-05.30 | Chairperson: Mr. Sandeep Tripathi, ICFRE, Dehradun  
- Rapporteur: Dr. V. Nath, NBRI, Lucknow |
| 04.00-05.30 | Lead Lectures  
- Dr. Baban Ingole, NIO, Goa  
- Dr. J.P.N. Rai, G.B.P.U.A & T., Pantnagar  
- Prof. Uma Melkania, Pantnagar University, Pantnagar |
| 10.03.08 (Day 2) | **Group Discussion (45 Min.)**  
Close of Meeting |

**Session 3**  
**Climate Change and Forestry Sector**

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| 9.30-11.00 a.m | Chairperson: Dr. P.S. Ahuja, IHBT, Palampur  
- Rapporteur: Dr. Baban Ingole, NIO, Goa |
| 9.30-11.00 a.m | Lead Lecture  
- Mr. Sandeep Tripathi, ICFRE, Dehradun (20 Min.)  
- Mr. V.R.S. Rawat, ICFRE, Dehradun (20 Min.)  
- Prof. S.P. Singh, Garhwal University, Srinagar, Uttarakhand |
| 11.00 -11.30 a.m | **Tea Break** |
### Session 4  Climate Change & Agriculture Sector

**11.00-12.30**
- **Chairperson:** Dr. S.P. Sharma, MoEF, New Delhi
- **Rapporteur:** Dr. Bajrang Singh, NBRI, Lucknow

**Lead Lectures**
- Dr. D.C. Uprety, IARI, New Delhi
- Dr. A.A Nambi, MSSRF, Chennai
- Dr. A.R. Khan, ICAR, Patna
- Dr. Akhilesh Gupta, Advisor, Ministry of Science and Technology & Earth Sciences
- Dr. P. Krishnan, CRRI, Cuttack

**Group Discussion (30 Min)**

**12.30-14.00**  
**Lunch**

### Session 5  Environmental Issues Related to Climate Change

**02.30 -03.30 p.m.**
- **Chairperson:** Dr. Akhilesh Gupta, Advisor, Ministry of Science and Technology & Earth Sciences
- **Rapporteur:** Dr. A.P. Dixit, Chairman, Sustainable Development Foundation, New Delhi

**Lead Lectures**
- Dr. Joyshree Roy, Jadavpur University, Kolkata
- Dr. Unnikrishnan, NIO, Goa
- Prof. M.N.V. Prashad, Hyderabad University, Hyderabad

**Group Discussion (30 min.)**

**03.30-04.00 p.m.**  
**Tea Break**

**04.00 -06.00 p.m.**
- **Chairperson:** Dr. A.A. Nambi, MSSRF, Chennai
- **Rapporteur:** Prof. R.S Tripathi, INSA, Lucknow

**Invited Lectures**
- Climate Change, GHG emissions & Agriculture, Indian & South-Asian efforts for quality data to meet future Challenges
  - Dr. A.K. Attri, JNU, New Delhi
  - Prof. A.S. Raghubanshi, BHU, Varanasi

**Group Discussion (15 min.)**

**Close of Meeting**
### 11.03.08 (Day 3)
#### Session 6  
**Environmental Issues Carbon Sequestration & Clean Development Mechanism**

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<th>Time</th>
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| 09.00-11.00 | Chairperson: Prof. S.P. Singh, VC, Gharwal University  
Rapporteur: Dr. P. Krishnan, CRRI, Cuttack |

**Invited Lectures**
- Prof. B.C. Tripathy, JNU, New Delhi: Use of higher plants and algae for carbon sequestration *(20 min.)*
- Mr. S. Pal, Genesis Technologies, Thane: FACE Technology *(20 min.)*
- Dr. P.S. Roy, NRSA, Hyderabad
- Dr. S.D. Attri, IMD, New Delhi
- Dr. Vivek Kumar, TERI, New Delhi
- Mr. B.K. Patnaik, PCCF, U.P., Lucknow
- Mr. S. Pal, Genesis Technologies, Thane

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<tr>
<td>11.00-11.15</td>
<td>Group Discussion (15 min.)</td>
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<td><em>Tea Break</em></td>
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#### Session 7  
**Strategic Paper and Project Formulation**

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<th>Activity Details</th>
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| 12.30-01.30 | Chairperson: Dr. A.A. Boaz, DG, SACEP  
Steering Committee  
Prof. S.P. Singh, VC, Gharwal University *(20 min.)*  
Dr. P.S. Ahuja, Director, THBT, Palampur  
Dr. D.C. Uprety, Emeritus Scientist, IARI, New Delhi *(20 min.)*  
Dr. R. Tuli, Director, NBRI, Lucknow *(20 min.)* |

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<th>Time</th>
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<tr>
<td>01.30-02.30</td>
<td><em>Lunch</em></td>
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#### 12.03.08 (Day 4)

<table>
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<th>Time</th>
<th>Activity Details</th>
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| 09.30 a.m. - 12.30 p.m | Project Finalization  
Lucknow Declaration on "Climate Change & its Impact on Flora in the South Asian Region" |

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<tr>
<th>Time</th>
<th>Activity Details</th>
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| 12.30 to 01.30 | Valedictory Session  
Presentation of network summaries  
Special comments by partners from neighbouring countries  
Concluding remark by Dr. A.A. Boaz, DG SACEP, Dr. Rakesh Tuli (Director NBRI) |
"Regional models needed to forecast climatic variations"

"Climate change to make N-W drier"

"Forest database needed: Hussain"

"Scientists raise concern over consequences of climate change"

"Climate change will affect S Asia most: Expert"

"Uttar Pradesh left with only 2 pc forest cover"
ANNEX 3 List of Participants

Afghanistan

Mr. Saeed Ibrahim Sherzai,
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kijgme@yahoo.com

India

PARTICIPANTS (other than NBRI participants)

1. ARVIND KUMAR PATHAK-EXE.ENG (UP POWER CORPORATION LIMITED, SHAKTI BHAWAN, LKO)
2. ER. PRAVEEN MALHOTRA-SUPRIDENDENT. (UP POWER CORPORATION LIMITED, SHAKTI BHAWAN, LKO)
3. ER. RAGHAV SHANKAR-CHIEF ENGR. (UP POWER CORPORATION LIMITED, SHAKTI BHAWAN, LKO)
4. J.P. RAI
5. DR. RANA PRATAP SINGH-PROF. & HEAD (BBRAU, RAEBARELI ROAD, LKO)
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