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

SACEP

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, SACEP Prof. N.H. Ravindranath and Dr. R.D.Tripathi

Workshop Participants

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

Dr. Rakesh Tuli, Director NBRI delivering his speech of the Workshop

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SACEP, Sri Lanka.

July 2008

Content

राष्ट्रपति
भारत गणतंत्र
PRESIDENT
REPUBLIC OF INDIA

Message

Pratibha Devisingh Patil

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 Patil
(Pratibha Devisingh Patil)

डॉ0 संजय बारू
प्रधानमंत्री के मीडिया सलाहकार
Dr. Sanjaya Baru
Media Advisor to PM
Tel : 23016920

सत्यमेव जयते

प्रधान मंत्री कार्यालय
नई दिल्ली - 110 101
PRIME MINISTER'S OFFICE
New Delhi - 110 101

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

South Asia Co-operative Environment
Programme (SACEP)
No. 10, Anderson Road
Colombo 05
Sri Lanka.

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 - CO_2, O_3, 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

Dr. Rakesh Tuli
Director NBRI
Dear Delegates,

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 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 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 adeep 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 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 iner-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.

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

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

प्रो. वी. एल. चोपड़ा
PROF. V. L. CHOPRA

सदस्य
योजना आयोग
योजना भवन
नई दिल्ली-110 001
MEMBER
PLANNING COMMISSION
YOJANA BHAVAN
NEW DELHI-110 001

February 25, 2008

MESSAGE

I am happy to learn that National Botanical Research Institute Lucknow in collaboration with South Asia Cooperative Environment Programme, Columbo, 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 gasses 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.

VL Chopra

(V. L. Chopra)

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M.S. Swaminathan
M.S. SWAMINATHAN RESEARCH FOUNDATION
Chairman

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

Director General,
The Energy and Resources Institute (TERI),
Darbari Seth Block, IHC Complex, Lodhi Road,
New Delhi - 110 003,
INDIA

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)

सचिव
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Dr. P.S. Goel

Message

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)

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COUNCIL OF SCIENTIFIC &
INDUSTRIAL RESEARCH,
Anusandhan Bhawan, 2, Rafi Marg, New
Delhi- 110001

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

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March 3, 2008

MESSAGE

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 0.74o 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 the Go India towards the implementation of the workshop "Climate Change & it's Impact on Flora in the South Asian 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. Nandita 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 this workshop report is an output of their active and involved brainstorming sessions, inputs and discussions. Also I 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 - CO_2, O_3, 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.

SECTION 02

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.Rravindranath, 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 green house 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 key note address he said that the climate change would also adversely affect the bio-diversity. Prof. N.H.Rravindranath, 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 Cahnge 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 has 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 formulising the work plan on Cliamte Change Issues, they need the help of member countries to institutionalise 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 severly affects the coastal flora.

Lead Lectures

- "Impact of increased anthropogenic activites 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 Sequstration potential Studies in Forest and Ageo-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. Jayarathne, 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, 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 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 adeep 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 iner-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-staring. 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 caters 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.

Key note address, Prof. N.H. Ravindranath, IISc, Bangalore

Prof. N.H. Ravindranath, Centre for Sustainable Technologies, Indian Institute of Science,Bangalore

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 re-finement. 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^{0}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^{0}C) compared to the HadRM3 baseline. The corresponding values of increase for the more extreme A2 scenario are about 300 mm and 4.2^{0}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^{0}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 1. Annual rainfall and temperature changes in the different forest types of India under B2 GHG scenario for the year 2085

Forest type	Number of grids	% area	Mean annual rainfall (mm)	Change in rainfall (mm)	Mean temperature (°C)	Change in temperature (°C)
Blue-pine (Kail)	311	0.88	763.0	223.5	10.5	3.0
Chir-pine	791	2.25	1373.4	437.4	17.1	2.8
Mixed conifer	1071	3.04	930.1	375.9	9.3	3.0
Hardwoods conifers mix	296	0.84	1560.7	585.6	13.1	2.8
Upland hardwoods	881	2.50	1525.8	476.9	16.4	2.7
Teak	3364	9.56	1314.6	353.0	26.1	2.9
Sal	4251	12.08	1435.2	348.3	24.6	2.7
Bamboo forest	567	1.61	2268.3	564.9	23.8	2.7
Mangrove	201	0.57	1734.3	280.8	26.6	2.5
Miscellaneous forest	22359	63.48	1679.8	374.5	23.0	2.7
Western Ghat evergreen forest	163	0.46	3111.3	368.7	25.4	2.4

Source: Forest types and area[11]

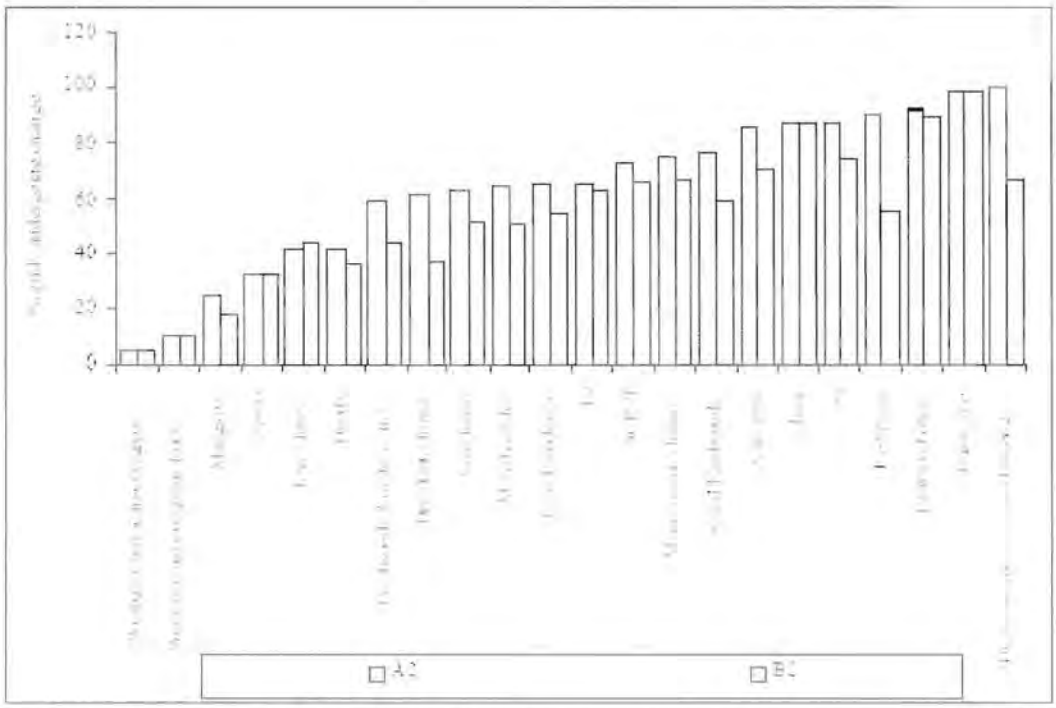


Figure 1: Percentage of grids under different forest types undergoing change in A2 and B2 GHG Scenario.

The changes in temperature also show a striking pattern, with colder forests being subjected to a larger increase of about 3^{0}C, compared to the Western Ghat evergreen forests, which on an average become warmer by only about 2.4^{0}C, compared to the national average of 2.9^{0}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^{0}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^{0}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 the 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 2085. 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 dif- ferent 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 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 snowmelt 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:

1. Ravindranath, N.H., Joshi, N.V., Sukumar, R. and Saxena, A., "Impact of Climate Change on Forest in India" ***Current Science,*** Vol. 90, No. 3, 10 Feb 2006.
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.
3. IPCC, 2007, Climate Change 2007, Synthesis Report.

Country Presentations

Country Presentation Afghanistan

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

Prepared by Saeed Abrahim Sherzai

National Environmental Protection Agency (NEPA)

Afghanistan-Kabul

Afghanistan's biography

- Afghanistan is an arid country that covers 652,089km
- approximately 27% of Afghanistan lies above 2,500m elevation
- The population of Afghanistan in 2005 was around 26 million and the country is divided into 34 provinces with Kabul as the largest city and the administrative capital.
- Afghanistan , 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

CONTENETS

CONTINUE....

- Afghanistan experienced severe drought during the 1998-2005 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.

Afghanistan's climate.

- Afghanistan has arid and semi-arid continental climate with cold winters, not summers
- The climate varies substantially from one region to another due to dramatic changes in topography
- The wet season generally runs from winter through early spring but the country on the whole is dry Falling with in the desert or desert steppe climate classification
- The snow season averages is October- April in the mountains and varies considerably with elevation with very little snow falling in the lowland desert of the southwest

➢ 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 lightening
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

Continue...

3) flooding due to thawing of snow and ice

River levels rise, destruction of river side agricultural and non- agricultural (forest, range, etc.) lands. Land sides, soil erosion, destruction of infrastructure like bridges and gabions

4) Rise in temperature

Increase in levels of incidents of disease that effect humans, agricultural and livestock habitat changes affect wildlife, changes in vegetation cover and associated grazing patterns

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

Continue.....

7) Monsoon and 120-day winds

Desertification, degradation of agricultural lands and crops; destruction of infrastructure, air pollution; spread and transmission of diseases and respiratory problems sedimentation of irrigation systems and springs; local and national economy negatively affected

5) frost and cold spells

Degradation of fruits, crops vegetable and health disease, poor economy and increasing of poverty

6) Hail, thunder and lightening

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

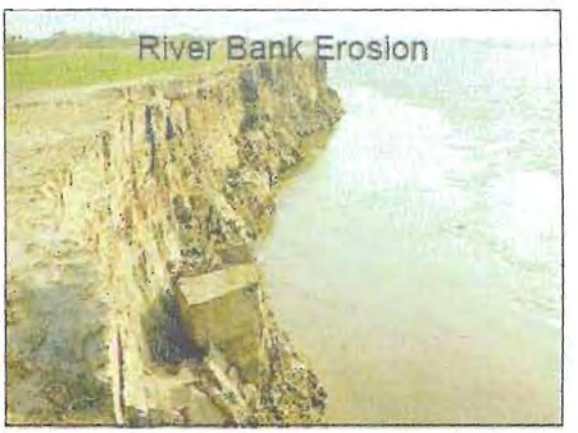
Climate change response, Institution

- Different ministries and agencies
- Climate Change Cell, Department of Environment
- Department of Forest
- Large number of NGO'S
- Different universities and research institutes


Devastation Cyclone Sidr

Flood: capital city Dhaka

River Bank Erosion



Bangladesh innocent victim

Thanks.

Climate Change and its Impact on Flora in Bangladesh

FOREST DEPARTMENT
and
DEPART OF ENVIRONMENT
BANGLADESH

Haradhan Banik
Md. Billal Hossain

BANGLADESH: Forestry

- Land area 14.757 million ha;
- Population is about 135.0 million with density of 918 per km^2.
- GDP contribution from Forestry Sector is 2.1%;
- US$ 15.09 million distributed to 69,381 Social Forestry participants as share from 1999-2007;
- About 17.07% Forestland, including 1.607% Protected Area, of the country's area; per capita forestland is 0.02 ha.;
- Major Forest types: Hill forests, Sal forests, Mangrove forests and village forests
- 4 ecological forest types : Tropical wet evergreen, Tropical semi-evergreen, Tropical moist deciduous and Tropical Mangrove Forests

BANGLADESH: Forestry

- Forest Act 1927;
- National Forest Policy 1994
- Forestry Sector Master Plan (1995-2015)
- Social Forestry Rules 2004
- Forest Management Plans
- Major Forestry sector development programme
  - Social Forestry
  - Co-management of the Protected Areas
  - Coastal Afforestation
  - Industrial plantation
  - Eco-tourism development

Forest Land of Bangladesh

Forest types	Area (m. ha.)	% with respect to country's area
FD managed Forest	1.52	10.300%
Un-classed State Forest	0.70	4.847%
Homestead Forest	0.27	1.830%
Total	2.52	17.077%

Forest Department Managed Forest Land

Forest Types	Area (m. ha.)	% with respect to country's area
Hill Forest	0.67	4.540%
Natural Mangrove Forest	0.60	4.066%
Mangrove Plantation	0.13	0.881%
Sal Forest	0.12	0.813%
Total	1.52	10.300%

Hill Forests

- Total Area of Hill Forests is 6,78,808 hectares, which is 4.65% of country's area and 44% of total forest land managed by the Forest Department Hill Forests spread over the hilly areas of Chittagong, Cox's Bazar, Sylhet and Chittagong Hill Tracts.
- Hill Forests represents Tropical Wet Evergreen Forest and Tropical Semi-Evergreen Forests and rich in diverse of flora and fauna.
- Plantations have been in continuation in this forest area since 1871.

Natural Mangroves: Sundarbans

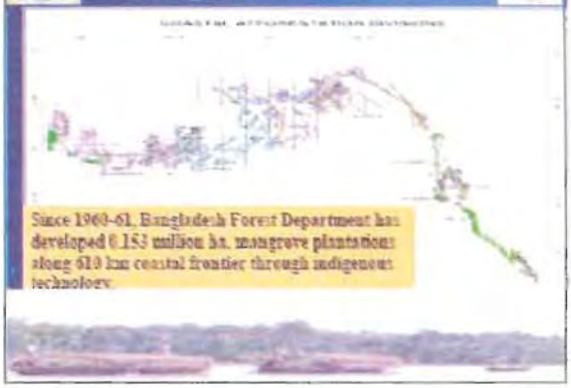
Sundarban is the unique largest tract of mangrove forests.

Total area of Sundarban is 4,01,700 hectares; 4.16% of the Country.

Flora -334 species and Fauna -269 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. Sundri *(Heritiera fomes)*, the most common species occupies 73% of Sundarban.

Mangrove Plantations



Since 1960-61, Bangladesh Forest Department has developed 0.153 million ha. mangrove plantations along 610 km coastal frontier 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 habitations. It is classified as Tropical Moist Deciduous Forest.

Sal Forest area is 1,20,000 hectares, which is 0.83% of 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 3.25 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 produces is being met from homestead forest.

According to the 1981 inventory report the village woodlots have a growing stock of 54.7 million cubic meters. Gross volume has increased from 4.5 cum/ha to 10.5 cum/ha 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 poors.

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 244,175 hectares.

List of protected areas

Sl. No.	Name	Year of establishment	Area (ha)
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
12.			
13.			
14.			
15.			
16.			
17.			
18.			
19.			
20.			

Eco-park, Safari Park and Botanical Garden in Bangladesh

Sl. no.	Name	Year of establishment	Area (ha)
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			

Ecologically critical areas of Bangladesh

Sl.	Name of Wetland	Area (ha)
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		

Source: [illegible]

Environment Management Programme

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:

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 system.
- Preparation of management plans for natural protected areas.
- Creation of an effective environment management process within the Forest Department.

Plant Species diversity in Bangladesh

Despite its small area, Bangladesh is endowed with superb biological diversity in terms of floral species riches. The table summarizes 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.

Categories	Recorded (approx. no.)	Estimated
Algae	3,000	6,000
Bryophytes	200	400
Pteridophytes	200	250
Gymnosperms	5	5
Angiosperms	5,000	7,000

Source: [illegible]

Threatened Species

Bangladesh National Herbarium published the first volume of a Red Data Book of vascular plants in 2001.
Out of the 106 species listed in this book, one is Critically Endangered, one Endangered, two Vulnerable, three Lower Risk, 25 Data Deficient and 74 are not evaluated.

Genetic Diversity

Broad genetic variation occurs among both wild and domesticated plants and animals. 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, taro, 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 forests, mangrove forests, floodplains and char 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

1)coastal and marine ecosystem,
2)inland freshwater ecosystem,
3)terrestrial forest ecosystem and
4)man-made ecosystem (Daniels, 2003).

Nishat et al. (2002), from perspective of synergizing biodiversity and ecology, divided Bangladesh into 12 broad bio--ecological zones, with several sub-zones.

FRA, Bangladesh 2005-07

Biodiversity
In Bangladesh, total number of tree species measured was 238 with 198 species in Villages, 129 species in Forest, 137 species in Cultivated Land, 33 species in Inland water and 28 species are found in Urban areas.

Shannon's biodiversity index (Scale 0.0 (minimum) - 4.6 (maximum))

	Total	Forest	Cult.Land	Villages	Urban Areas	Inland Water

Biomass and Carbon

Land use	Biomass (tons/ha)	Total Above Ground Biomass (1000 tons)	Carbon (tons/ha)	Total Carbon (1000 tons)
Total	47	846,000	26	468,000

Effect of Climate Change : SIDR

In Bangladesh the pressures on biological resources are intense and growing due to high population of 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 152800 ha. forests of the Sundarbans are affected by the Sidr including the Sundarbans East Wildlife Sanctuary. The cyclone caused havoc of plants in the form of burnt, twisted and uprooted. Forest in the eastern 20% have been extensively altered, as evident in recent MODIS and Aster satellite imageries, immediately before and after the SIDR.

Damage of Southeastern part of Sundarbans by the Cyclone Sidr 2007

Type (affected areas)	Area (ha)	Damage (%)	Damages % of the total Sundarbans
Highly affected	16943	11	2.47
Moderately affected	93458	09	15.23
Slightly to not affected areas	26700	20	4.45
Total	152982	100	22.15

Damage of Forest Resources by the Cyclone Sidr 2007

Sl. No	Particulars of Loss	Amount (Million Taka)
1.	Damage of Forest Resources in Sundarbans	10,000,000
2.	Damage of Forest Resources in Coastal Region	83,000
3.	Damage of Forest Resources in Social Forest Region	110,000
	Total	10,193,000

Effect of Sidr on Vegetation

- **The natural vegetation of the Sundarbans is sensitive to mangrove ecosystems.**
- **There are 334 plant species are 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

	Forest	Village	Cultivated land	Built up area	Inland water
Tree species found	129	198	137	28	33

NFA study identified regeneration of 121 species in forest. The study revealed that
8 species in the forests does not have regeneration which is probably due to effect of climate change.

Climate Change resilient activities in Bangladesh

Sl. no.	Name of the project	Period	Cost (Tk. in lakh)	Comments
1.	Char Development and Settlement Project (CDSP-III)	2009-2013	500.00	On going
2.	Coastal Afforestation Project	2005-2010	1800.00	On going
3.	Climate Change Resilient Afforestation in Bangladesh	2009-2012	65000.00	Searching Donor
4.	Coastal Greenbelt Project	1995-2002	12000.00	Completed
5.	Forestry Sector Project	1997-2006	41500.00	Completed
6.	Participatory Coastal Afforestation Project	2008-2009	24168.13	Submitted to Forest Carbon partnership Facility (FCPF) for Financing
7.	Recovery of Biodiversity in the Devastating SIDR Affected Sundarbans	April 2009 to June 2010	1537.97	Submitted to USDA under Tropical forest Conservation Act, 415(b) CDBO for Financing

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.

www.bforest.gov.bd

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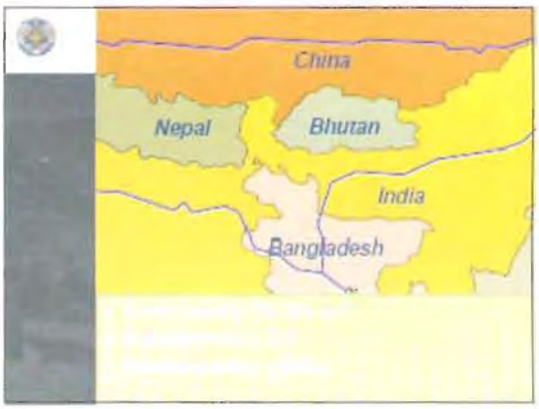
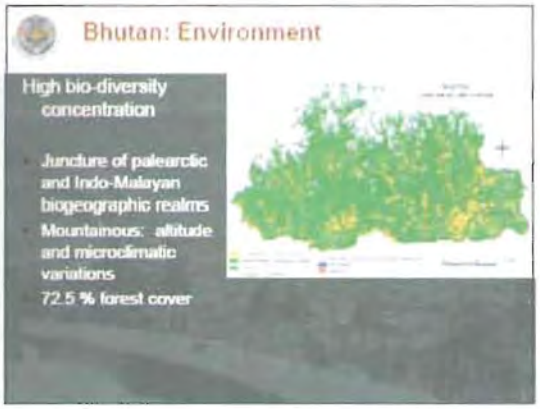
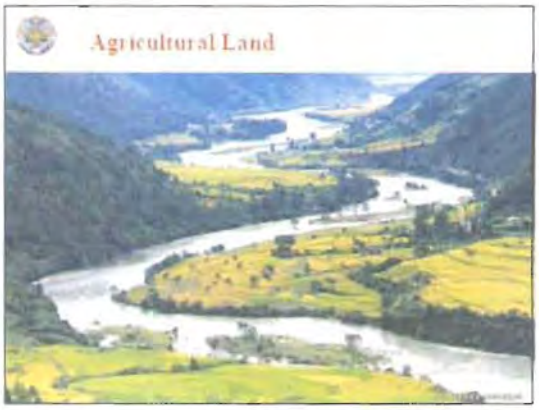
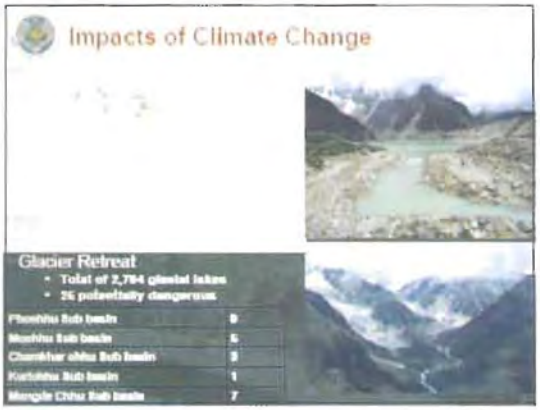
www.bforest.gov.bd

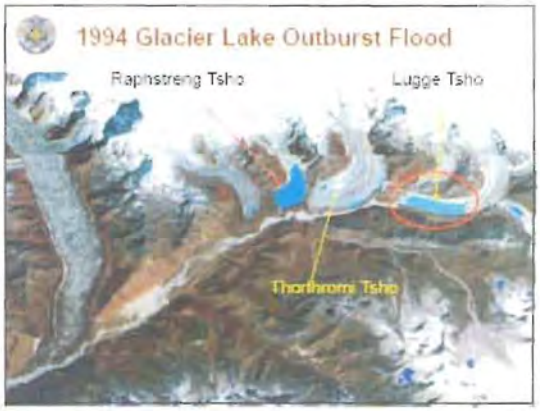
Country Presentation Bhutan



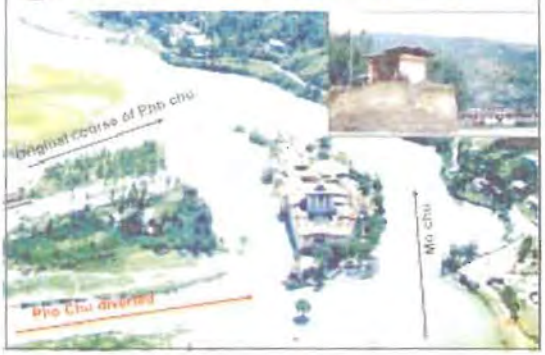








1994 Glacier Lake Outburst Flood



GLOF events in Phochhu Basin

Damage due to 1994 Floods:

- ~1700 acres of agriculture and pasture land
- 5 mills washed away
- 16 yaks washed away
- A loss of food grains destroyed
- 22 people killed
- many houses and infrastructure damaged

Forest Fires

Issues – Climate Change Impacts on Flora

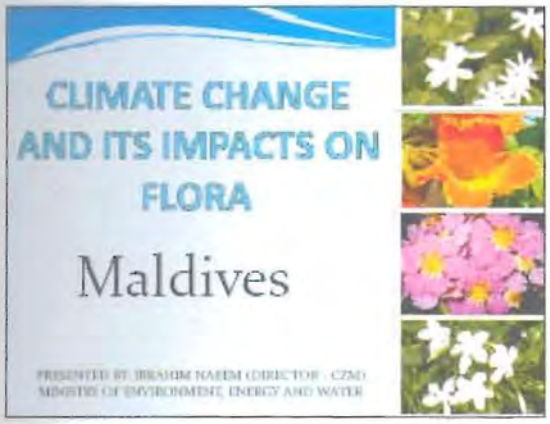
- Forest fires
- Cordyceps sinensis – main economy to highlanders
- Masutake mushroom – declining
- Highland pasture land

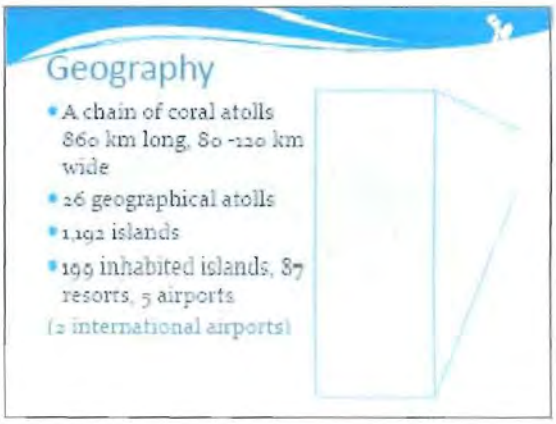
Publication and work

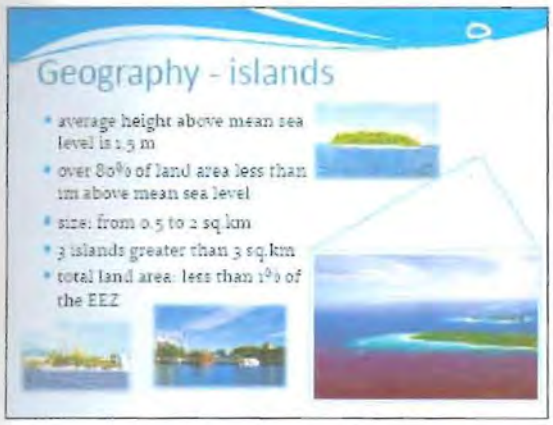
- Bhutan National Adaptation Programme of Action (NAPA)
- Disaster management strategy
- Artificial lowering of Throthomi Glacier lake
- Weather forecasting system to serve farmers and agriculture
- Flood protection of downstream ins & agri area
- GLOF hazard zoning
- Installation of early warning system
- 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

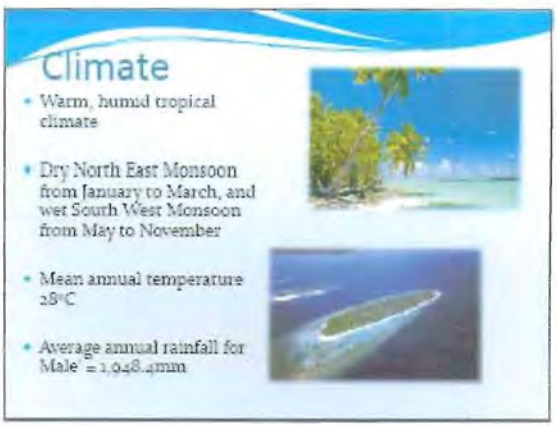

CLIMATE CHANGE AND ITS IMPACTS ON FLORA
Maldives


Geography
A chain of coral atolls 860 km long, 80 -120 km wide
26 geographical atolls
1,192 islands
199 inhabited islands, 87 resorts, 5 airports
(2 international airports)


Geography - islands
average height above mean sea level is 1.5 m
over 80% of land area less than 1m above mean sea level
size: from 0.5 to 2 sq km
3 islands greater than 3 sq.km
total land area: less than 1% of the EEZ


Population
Population 300,000 with annual growth rate of 1.3% (2006 Census)
About 25% of the population live in the capital Male'
Nearly half the islands have densities over 2,000 persons/km²


Economy
Tourism leading sector contributing to 33.1% of GDP
Tourist arrivals increased from 1,097 in 1972 to 563,503 in 2003
25% of population engaged in fishing industry
Decline in fisheries sector contribution to GDP from 22% in 1978 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' = 1,948.4mm

Terrestrial biodiversity

- Limited terrestrial biodiversity
- 583 species of plants- 323 cultivated, 260 native or naturalized, 300 species medicinal
- 2 species of gecko
- 2 species of garden lizard
- 2 species of snake
- 2 species of fruit bats
- 1 species of frog
- 1 species of toad

- The fragile marine and terrestrial environment including the reefs and bio-diversity 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 5.5% in 1986 to 2.7% in 2002

Climate change & sea level rise

- Being low lying makes islands vulnerable to climate change impacts
- Contributes to ONLY 0.001% of global GHG emissions
- Natural disasters

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 reported severe erosion.

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 1989

...daptation Policies to ... risks

National Adaptation Programme of Action - NAPA

- Foster the development process, plans, strategies and approaches to:
  - Avoid or adapt to climate change
  - Minimize the impacts on economic activities, human health, human settlement and critical infrastructure
- Foster development and application of legal and institutional system, 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
- Hulhumale'
- Population and Development Consolidation Strategy
- Safer Islands Development
- Coral mining - banned

A safer island - concept

Cross Section of an Island with Enhanced Mitigation Features

Figure 4: Cross Section of KFZ

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

...n research has been done ... 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 Solidairity in the Divided World

NATIONAL CAPACITY NEEDS SELF-ASSESSMENT, NEPAL

STOCKTAKING REPORT ON CLIMATE CHANGE

Universities in Nepal

- Tribhuvan University
- Kathmandu University
- Mahendra Sanskrit Vishwavidyalaya
- Purbanchan 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

Campuses
- Rampur Campus (Inner Terai)
- Paklihawa Campus (Terai)
- Lamjung Campus (Hill)

Educational Programmes
- B. Sc Program: Agriculture and V. Sc.
- M. Sc. Program: Agriculture, Agriculture, Animal Science, & Veterinary Medicine
- Ph. D. Program: Plant Breeding, Animal Science, Agronomy, Horticulture, Entomology

Rampur Campus

- Departments (...., Environmental Science)
- Farms
- Libray
- SMELC
- Central laboratory
- Local Knowledge & Innovation Resource Centre

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

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

Recent Advances

Course: Environmental Science and Agroecology

6. Climatic change

- 6.1. Concepts of climate change; main 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

Climate Change (2+0)

- Introduction to topography, climate, social and economic conditions, forest 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 mitigating options for energy, non-energy, agriculture and livestock, and solid waste sectors. 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

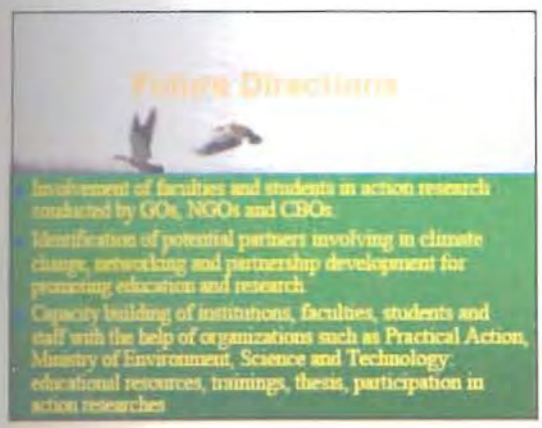
IAAS Partner Organization in a Network (ICIMOD)

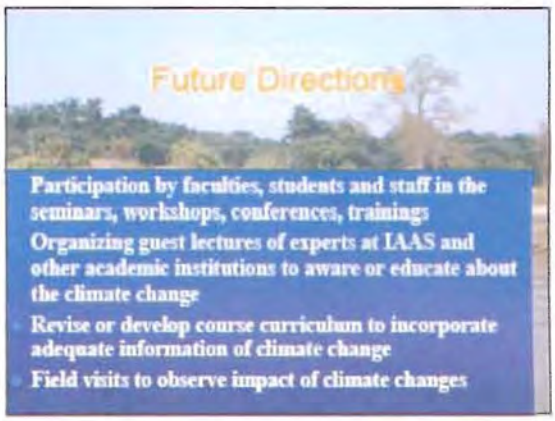
Published Paper

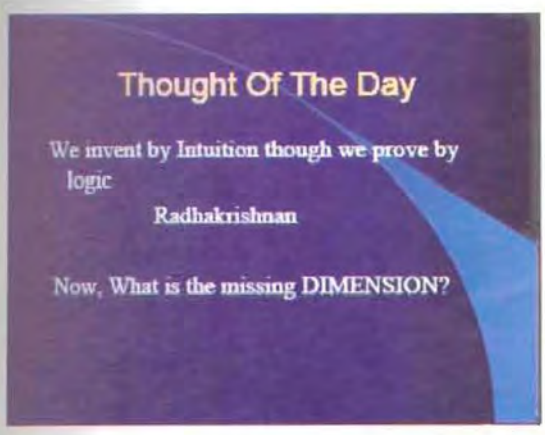
- **Dangol, Dharma Raj. 2007. Climate Change in Agriculture Education at IAAS: Experiences and Future Directions. Namaste Nepal, Year 15, Volume VI (November-December 2007): 3-5.**

Thesis Research on Climate change

- **Kabita Kharel (M. Sc. Ag. Conservation Ecology) (recently initiated)**


Future Directions
Involvement of faculties and students in action research conducted by GOs, NGOs and CBOs
Identification of potential partners involving in climate change, networking and partnership development for promoting education and research
Capacity building of institutions, faculties, 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, Balochi, Sindhi)
- Literacy: 35%
- 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 16.6% and 9.5% 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 Dry 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
- The four warmest years globally – in decreasing order of magnitude – are: 1998, 1997, 1995 and 1990
- Climate models suggest a future warming of 0.2 – 0.3°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

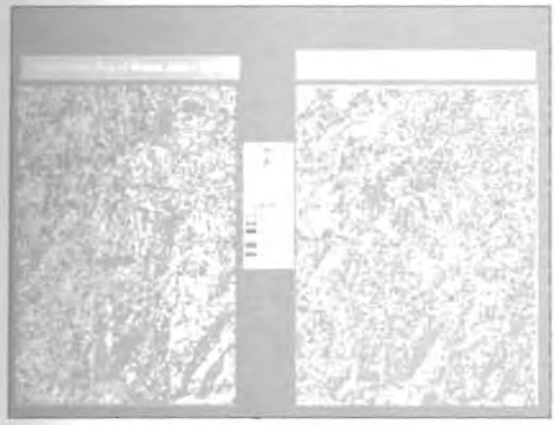
- Our regional countries have one of the highest rates of deforestation
- The threat of extinction now faced by much of the unique and rich fauna and flora are now real
- The known impacts on our biodiversity are likely to be just the tip of the iceberg; owing to lack of research data
- This looming 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 sufficient, mother nature unleashed her fury in the form of severe cold winds
- Results:
  - Mango trees, acacia, bauhinia, and cassia trees died in thousands
  - Almost all the shrubby vegetation got dried
  - Wheat crop was affected so bad that even the livestock wouldn't browse it

Parkensonia ... autumn revisited?

Hedges ... gone dead

... as if burdened with dead leaves

Plumeria 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 (1997)
- The Act has two important responsibilities:
  - creation of institutions; and
  - regulation of activities covering 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 consequence of our (mis) deeds- in a nutshell

The Logical Impacts ... for Pakistan

- Tharparkar has degraded to desert, double in magnitude, in the last 15 years
- The scrubs 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 arrivals, departures, hatchings, hibernations & movements of fauna
- Movement of flora up:
- Scrubs in to Chirpine Zone, Chirpine in to Bluepine Zone; Bluepine in to Fir/Spruce Zone; Fir/Spruce in to Alpine Pastures; and Alpine Pastures in to Glaciers:
  - Reduced glacial sizes
  - Quicker melting
  - Floods
  - Erosion and denudation of hills
  - Devastation
  - Siltation of dams
  - Uneven supply of irrigation water from dams and barrages
  - Lower electricity generation
  - Lower production of manufactured goods
  - Higher manufacturing costs
  - Rising prices
  - Bad economies
  - Poverty ...

Could this be helped?

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

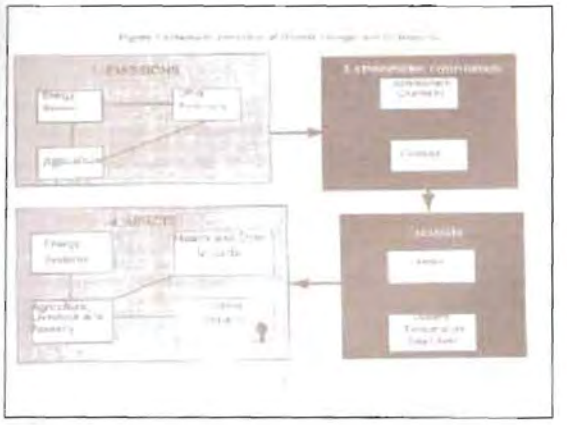
- Save energy: use it judiciously
- Avoid wasteful consumption
- Shift to solar, wind, water, & bio-energy
- GROW more trees: to get CO_2 absorbed

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.



- Climate change and carbon storage

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.

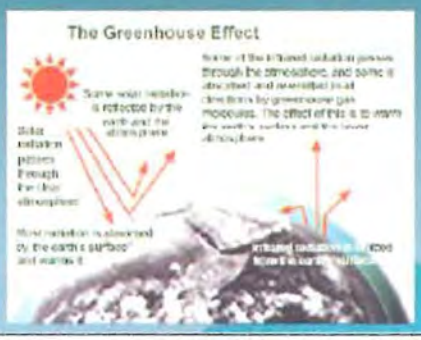
Causes for the Climate Change

- 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
- Gasses-trap the sun's heat in the atmosphere
- Green house gases- $CO_2/CH_4/NOX/SO_2/H_2Og/$ CFC/Halocarbons/

The green house effect



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

gases involved in the greenhouse effect

Greenhouse Gas	Concentration (Beginning of the century)	Present Concentration
Carbon Dioxide	280 ppm	360 ppm
Methane	0.70 ppm	1.70 ppm
Nitrous Oxide	280 ppb	310 ppb
Chlorofluorocarbons (CFCs)	0	900 ppt
Ozone	Unknown	Varies with latitude and altitude in the atmosphere

Population in Sri Lanka

1981	2001
14,846,750	18,797,257

Average Annual population growth rate- 1.2%

Total Land area- 65,610sq km

Land use

- Agriculture – 39 %
- Forest -32 %
- TDF (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

An increase in the frequency of extreme rainfall events is anticipated.

More FLOODS !

More Droughts !

Impacts due to extreme weather conditions

Rainfall

with intense rains,

"accelerated" Soil erosion

Rains with intensity > 25 mm/hr can accelerate soil erosion – 'erosive rains'

Landslides

High probability of landslides when daily rainfall exceed 300 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

Sea Level Rise

Sri Lanka

- Has a long coastline of 1600 km
- Coastal zone contains 24% of la
- 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 – 88 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

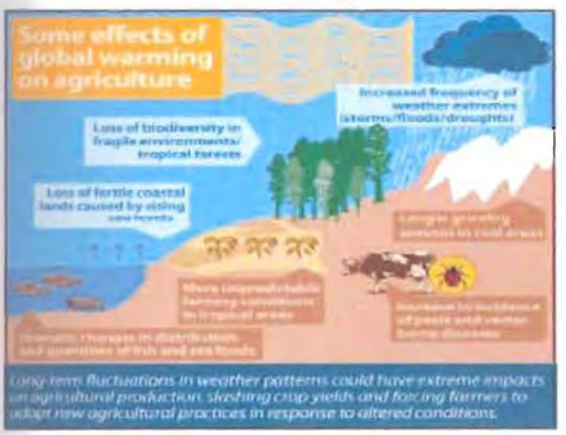
An increase in the amplitude of rainfall extremes will lead to more frequent floods

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

Impacts of climate change on Sri lanka agriculture in 2010

Economic costs of Agricultural Change in Sri Lanak

sub sector	change in production	Price Rs/kg	Value Rs Mn	
Rice	2538 mt	20.9	-1591.81	-2651.0
Tea	223 mt	65.72	0.0	+153.0
Rubber	114 mt	22.95	-52.3	-104.6
Coconut	2523 mt	3.83	-366.3	-540.5
Coarse grain crops	0.5 mt 7.2 mt	15.0 15.2	-132.0	-165.0
Vegetables	20.5 mt	10.0	-205.0	-287.0
Overall agriculture	78498 rs.Mn		-2606.7	-3909.0
Overall economy	283,794 Rs Mn.	-	-3728.3	-4971.1



Long-term fluctuations in weather patterns could have extreme impacts on agricultural production, slashing crop yields 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

FORESTRY SECTOR

SRI LANKA

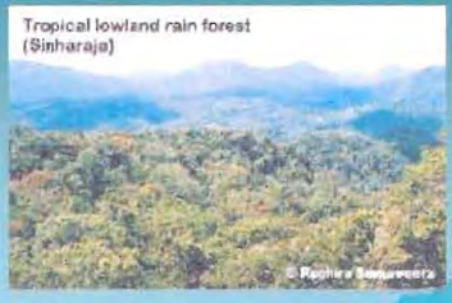
Types of Vegetation in Sri Lanka

- 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 900 m.
- The canopy is dense with evergreen trees rising from 25-45 m.
- The five major plant communities are:

Tropical lowland rain forest (Sinharaja)



Wet Semi Evergreen Forests

- Found in dry zone and Intermediate zone around Badulla and Bibile.
- This is an open plant community of scattered trees amidst a sea of grass.
- The common tree species are
- The two principle types of grass

Moist Semi Evergreen Forests

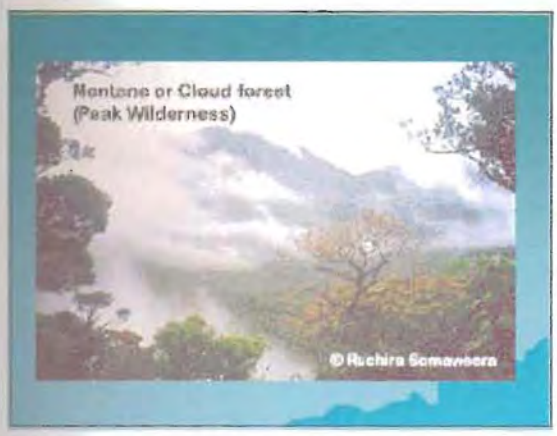
- Found in Intermediate zone (annual rainfall ranges from 1900 mm - 2500 mm) and best developed in the Moneragala District.
- The common tree species

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

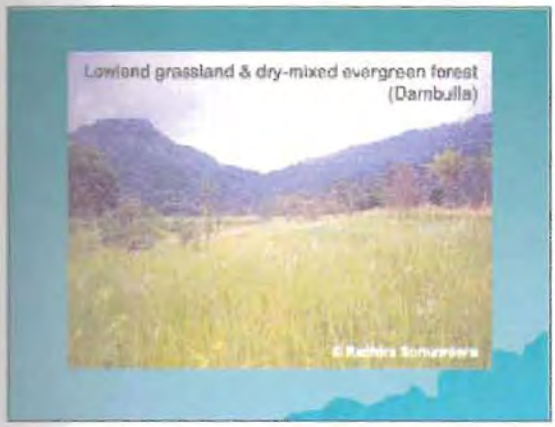
Montane Ever Green Forests

- characteristic of the highland hills above 1500 m in the Wet Zone.
- The forest is low reaching around 13 m in the better sites.
- The trees are in poor form with the dense spread with flat crowns.
- Principal Species



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 [illegible]



Moist Deciduous forests

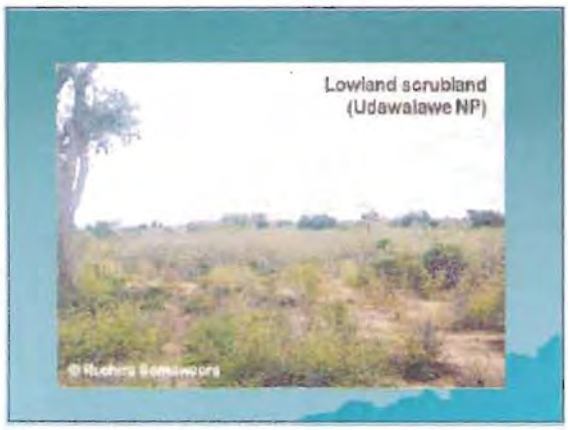
- Occur in the Dry Zone
- The general canopy is 25 m in height
- Most of the emergent species are
  - [illegible]
- Common evergreen species are
  - [illegible]

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
  - [illegible]

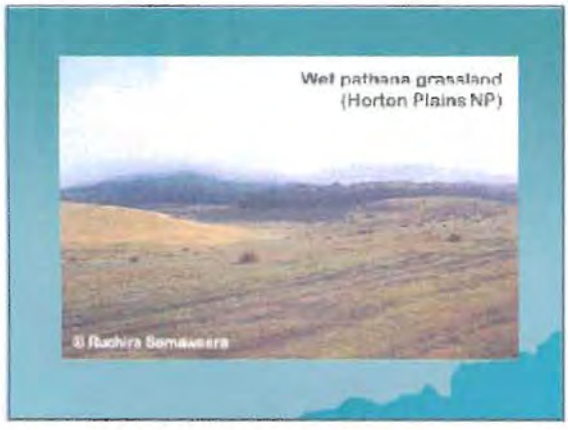
Tropical thorn forests

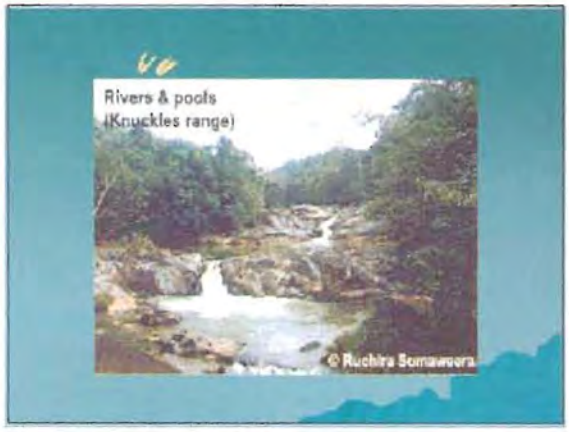
- Found in the oldest areas of the North Western and South Eastern sectors of the country.
- The rainfall is under 1250 mm per annum
- It is a low open thorny scrub with isolated patches of trees.
- The common species are
  - [illegible]



Grasslands

- Grasslands comprise four main types-
  - Savannas
    A Savannah type vegetation found in the lowland dry zone
  - Villu
    A grassland often associated with wetland conditions around abundant irrigation tanks, river banks, water holes and flood plains
  - Patnas
    Patnas have been classified as wet and Dry lands depending on locations
  - Talawas
    It is found in the low country wet zone 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

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 area

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 product

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

Possible Mitigation option for Sri Lanka

Forestry sector

project title	Key Objective of the project	Rationale for project priority	Non-Quantifiable benefits
Fuel wood for self sufficient	enhance self-sufficient renewable energy for villagers	reduce pressure on natural forest	Indirect benefits from reforestation
potential strategies for private sector involvement in forest sector carbon sequestration program	promote role of the private sector in reforestation	private sector participation	Indirect benefits from reforestation
Urban Forest to Reduce Energy demand for city cooling and to Enhance carbon sinks	promote carbon sinks and reducing power energy in Colombo and vicinity	save energy green city	less pollution and indirect benefits from trees
Chemical Treatments to Reduce Methane in Rice production	reduce methane emission from rice production	major emitter of methane	reduce methane

THANK YOU

SECTION 03

10.03.08 (Day 2)

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 Cliamte Cahnge 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 CDM (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 I 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 CO_2 and its impact 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, Jadhavpur 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 worming" 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 detail 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 Uprety, 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 it's 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 Lucknow Statement 2008

This 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 it's 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 actoivities 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.

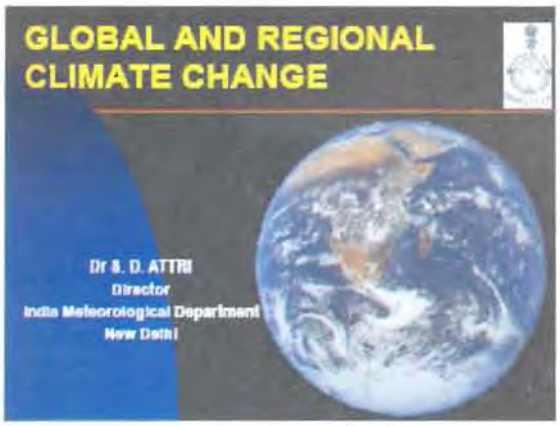
Believing that regional cooperation can provide the best solution for regional problems, we the delegates at the NBRI – SACEP International Workshop on Climate Change and its Impact on Flora in the South Asian Region, hereby support the Lucknow Statement on the effect of global climate change on South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

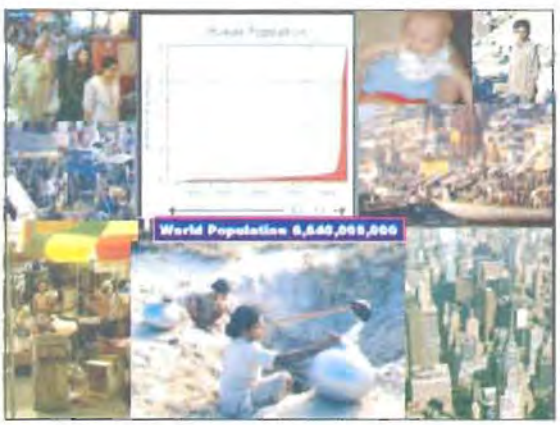
i. Establish of a South Asia Forum for Climate Change Challenges to Flora in South Asia (FC3F-SA)to support and guide the development of regional and local strategic plans by working closely with global, regional and local governmental and non-governmental partners. This Strategic Plan will be developed 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 floral 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.

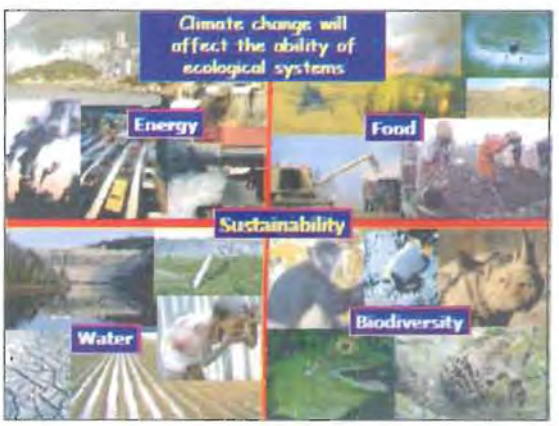
Research on models for scale up of carbon balance from experiments to ecosystems, life cycle green house gas analysis of biofuel and crop production systems, climate stress response of plant growth and development, ecosystem dynamics and climate impact modeling in hot spots to prioritize adaptation opportunities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

Workshop Presentations

Dr. S.D. Attri, India Meteorological Institute





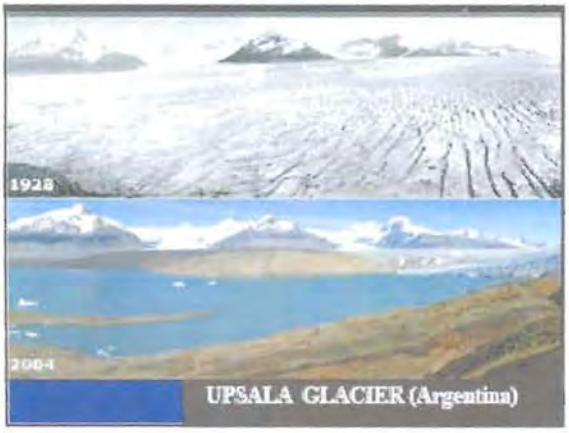


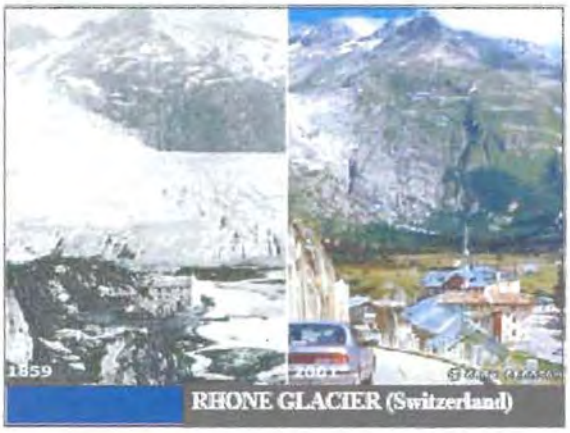
SIGNALS OF CLIMATE CHANGE ?

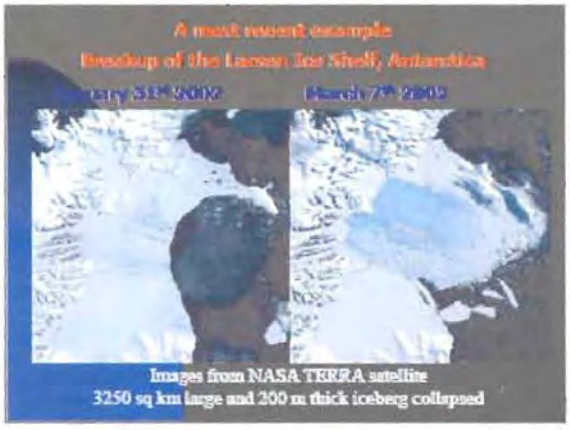
- 40 % of world population now faces chronic shortage of fresh water for daily needs.
- Half of the world's wetlands have been lost.
- One-fifth of the 10,000 fresh water species have become extinct.
- Contaminated water kills around 2.2 million people every year.
- Air pollution has now become major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

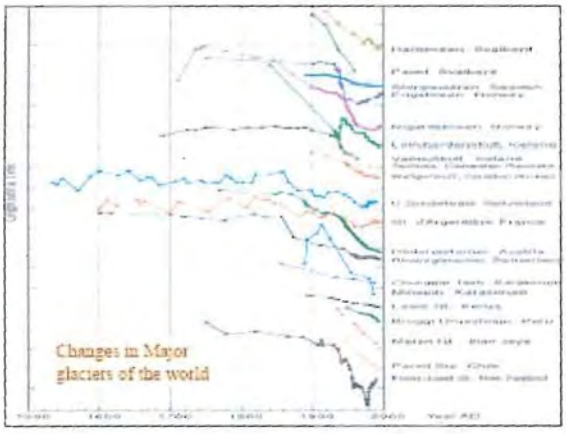
Contd.

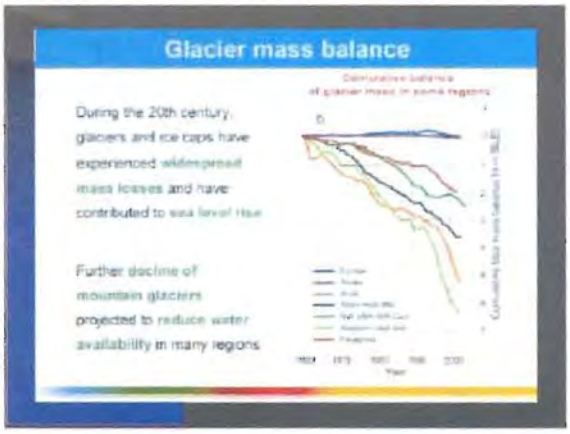
- Since 1990, 24 % of the world's forests have been destroyed. The rate of loss is 90,000 sq. km every year.
- Half the world's grasslands are overgrazed.
- 800 wildlife species have become extinct and 11,000 more are threatened.
- Almost 75 per cent of the world's marine captures is over fished or fully 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.


1928
2004
UPSALA GLACIER (Argentina)


1859
2001
RHONE GLACIER (Switzerland)


A most recent example
Breakup of the Larsen Ice Shelf, Antarctica
March 7th 2002
Images from NASA TERRA satellite
3250 sq km large and 200 m thick iceberg collapsed


Changes in Major
glaciers of the world


Glacier mass balance
During the 20th century, glaciers and ice caps have experienced widespread mass losses and have contributed to sea level rise
Further decline of mountain glaciers projected to reduce water availability in many regions

What is 'climate change'?

- Climate change is a shift in 'climate' relative to a given reference time period
- It is caused by:

Natural factors

- -Solar variability
- -Volcanic dust levels
- -Internal variability
- -Geological change

Human factors

- - Greenhouse gases
- - Aerosols
- -Ozone depletion
- -Land use change

Other natural reasons for climate variation

Mount Pinatubo, Philippines, 1991

Dust cloud caused world-wide cooling

Composition of the atmosphere

Major Permanent gases (99%)

Nitrogen	78.1%	Oxygen	20.9%

Other permanent gases

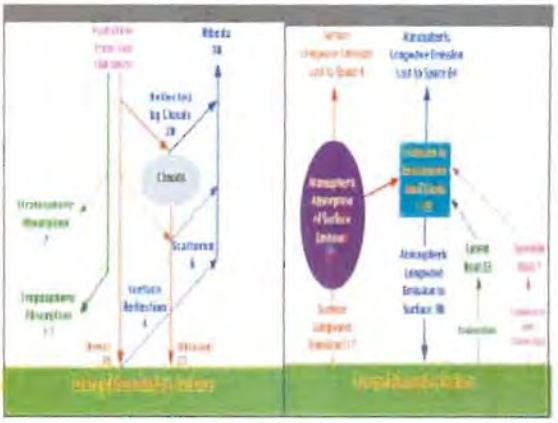
Argon	0.9%	Neon	0.002%
Helium	0.0005%	Krypton	0.0001%
Hydrogen	0.00005%		

Variable gases in the atmosphere

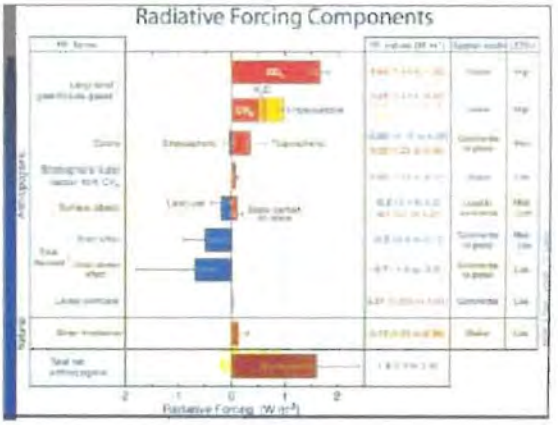
Water vapour	0 to 4%
Carbon Dioxide	0.035%
Methane	0.0002%
Ozone	0.0000004%

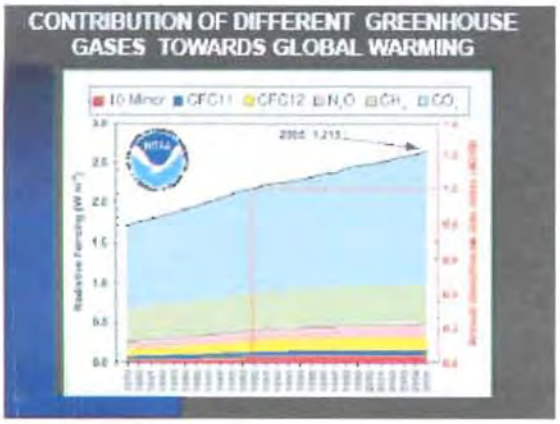
The variable gases are the main cause of Climate Change

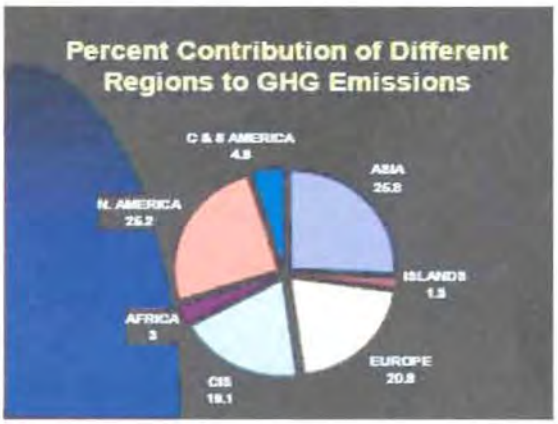
Chlorofluorocarbons & Perfluorocarbons – Trace

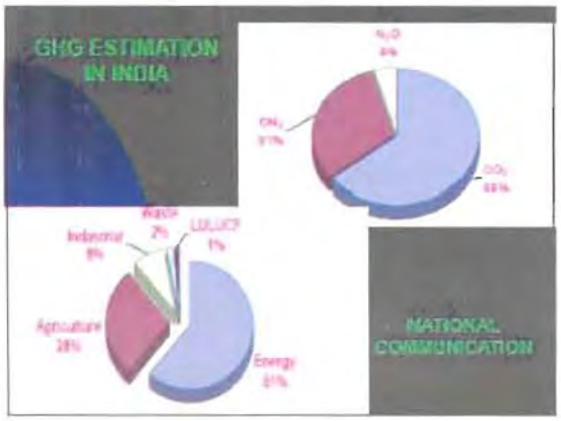


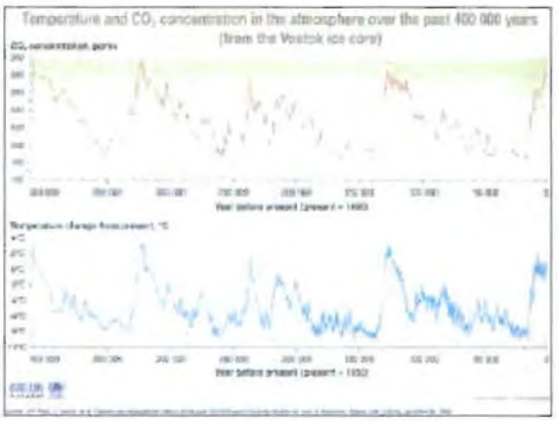
MAIN GREENHOUSE GASES (WMO 2007)						
Gas	Pre-Industrial conc.	Present Conc	Conc Change/ year	Life time years	Anthropogenic sources	GWP
CO_2	280ppm	381.2	1.5	5-200	Fossil fuel, land use changes, cement production	1
CH_4	700ppb	1745	7.8	12	Fossil fuel, rice paddies, livestock, waste dumps	21
N_2O	270ppb	320.1	0.8	114	Fertiliser, industrial process	310
CFC11	0 ppt	256	-1.4	45	Liquid coolants Foams	126-163
HFC_{23}	0 ppt	14	0.55	260	Liquid coolants	126
CF_4	0 ppt	80	1.0	50000	Alum. production	23900



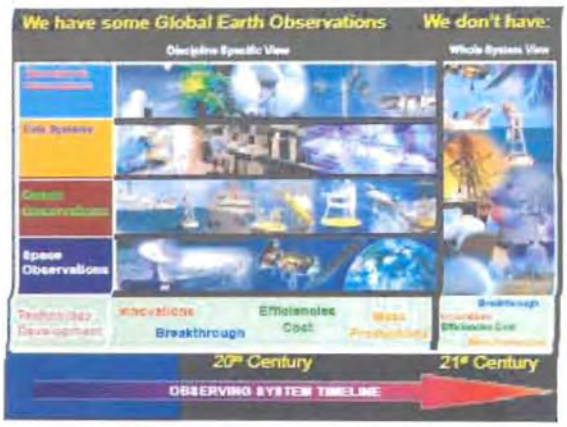

CONTRIBUTION OF DIFFERENT GREENHOUSE GASES TOWARDS GLOBAL WARMING


Percent Contribution of Different Regions to GHG Emissions
C & S AMERICA 4.8
ASIA 25.8
N. AMERICA 25.2
ISLANDS 1.5
AFRICA 3
EUROPE 20.8
CIS 19.1


GHG ESTIMATION IN INDIA
NATIONAL COMMUNICATION


Temperature and CO2 concentration in the atmosphere over the past 400 000 years
(from the Vostok ice core)


Observations


We have some Global Earth Observations
We don't have:
Space Observations
Innovations
Breakthrough
Efficiencies
Cost
20th Century
21st Century
OBSERVING SYSTEM TIMELINE

1988 - The establishment of the IPCC WMO, UNEP

1990 - First IPCC Assessment Report

1992 - IPCC Supplementary Reports

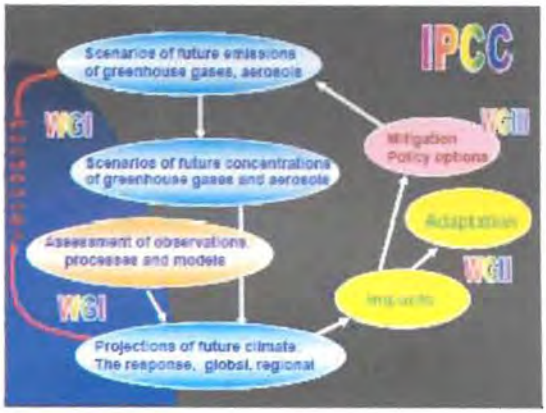
1994 - IPCC Special Report

1995 - Second IPCC Assessment Report

1996 - COP-2

2001 - Third IPCC Assessment Report

2007 - Fourth IPCC Assessment Report



The Nobel Peace Prize (2007)

Oslo, 10 December 07

The Intergovernmental Panel on Climate Change and Albert Arnold (Al) Gore Jr. were awarded of 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".

Nobel Peace Prize winner Intergovernmental Panel on Climate Change (IPCC) team with the Prime Minister Dr Manmohan Singh in Prime Minister House, New Delhi on November 26, 2007

Observed Climate Change (IPCC 2007)

- The earth has warmed by 0.74 [0.56 to 0.92]°C during last 100-years (1906–2005)
- Eleven of the last twelve years (1995 -2006) rank among the 12 warmest years in the instrumental record
- Av. 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

Contd.

- 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

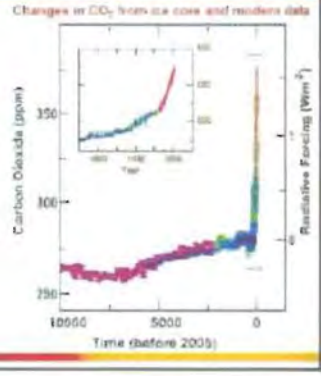
Contd.

- 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

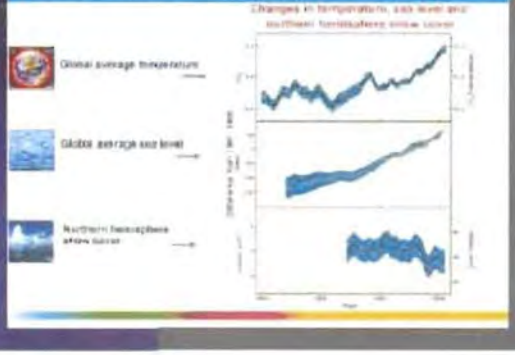
Human contribution to climate change

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

In 2005 concentration of CO_2 exceeded by far the natural range over the last 650 000 years

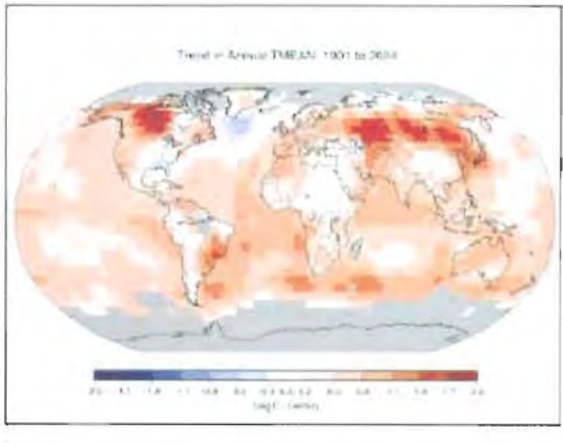


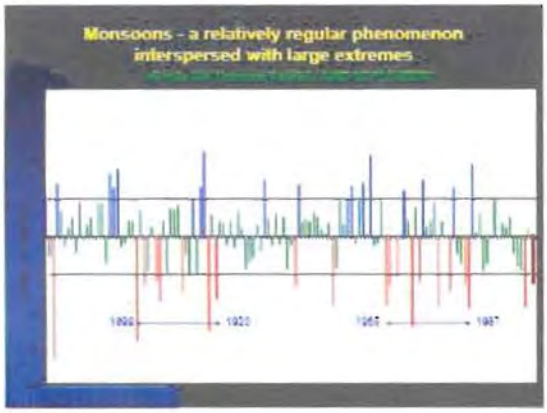
Direct observations of recent climate change

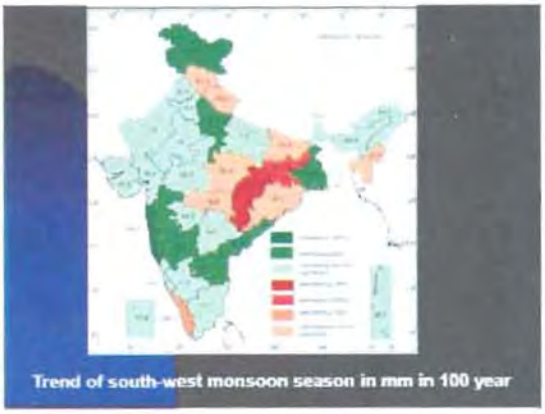


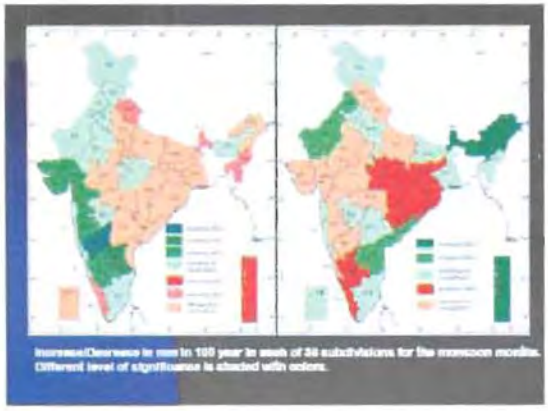
Heavier precipitation, more intense and longer droughts....

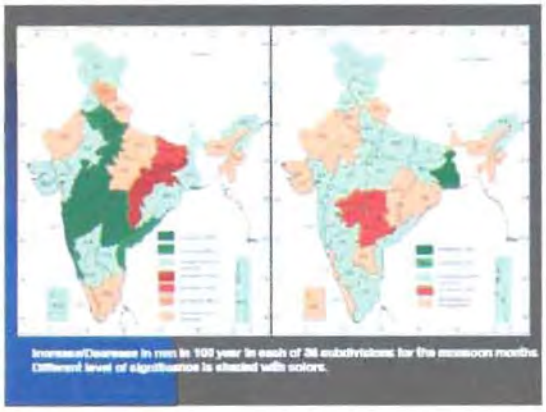
Coastal settlements most at risk

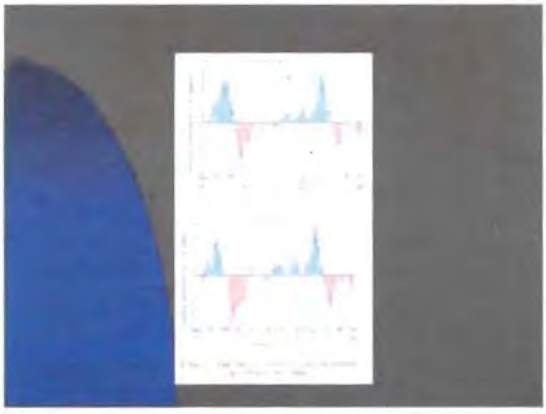


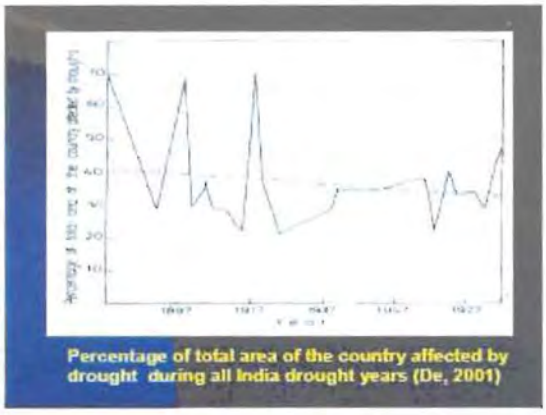


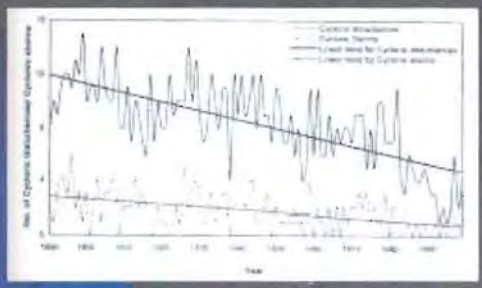

Trend of south-west monsoon season in mm in 100 year


Increase/Decrease in mm in 100 year in each of 36 subdivisions for the monsoon months. Different level of significance is shaded with colors.


Increase/Decrease in mm in 100 year in each of 36 subdivisions for the monsoon months. Different level of significance is shaded with colors.




Percentage of total area of the country affected by drought during all India drought years (De, 2001)



Frequencies of monsoonal cyclonic disturbances and cyclonic storms (June- September) alongwith their trends over north Indian Ocean during the period 1890-1999
(O.P.Singh, 2001)

TROPICAL STORMS

- Number of cyclonic and severe cyclonic storms shows a distinct decadal variability North Indian Ocean.
- Frequency of T C over the north Indian Ocean as a whole, the Bay of Bengal and the Arabian Sea for different seasons, generally, shows a significant decreasing trend (1891-2004).
- There is sharp decrease in the frequency during the monsoon season.
- An increasing trend in the frequency of T C over BOB during May and November is observed.
- Satellite data also show similar results during for the last four decades

CLIMATE PREDICTION

SERS

A1: Rapid Growth till Mid-century – decline through efficient technologies
A1F1(fossil fuel intensive)/ A1T (non-fossil)/ A1B (bal)

A2: increasing populations, no global convergence, fragmented tech growth

B1 convergent, efficient, stable populations

B2: increasing population, intermediate Economic growth, less rapid technology changes

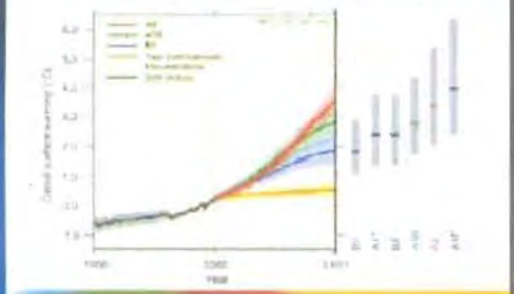
IPCC (2007) Projections

- 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.

Averaged warming and sea level rise by 2090-99 relative to 1980-99 for different model surface cases

	Temperature Change (°C)		Sea Level Rise (m)
Case	Best	Likely range	Model projections
Constant Year 2000 (Conc)	0.6	0.3-0.9	N/A
B1	1.8	1.1-2.9	0.18-0.38
A1T	2.4	1.4-3.8	0.20-0.45
B2	2.4	1.4-3.8	0.20-0.43
A1B	2.8	1.7-4.4	0.21-0.48
A2	3.4	2.0-5.4	0.23-0.51
A1F1	4.0	2.4-6.4	0.26-0.59

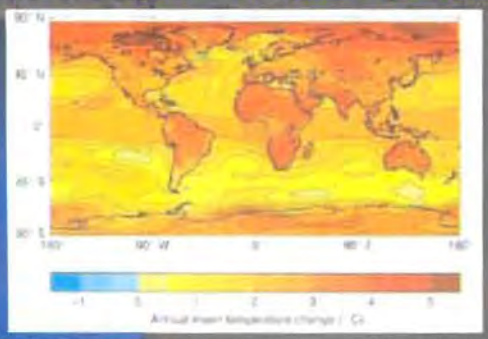
Ranges for predicted surface warming



Key vulnerabilities to climate change

- Some regions will be more affected than others
  - The Arctic (ice sheet loss, ecosystem changes)
  - Sub-Saharan Africa (water stress, reduced crops)
  - Small islands (coastal erosion, inundation)
  - Asian mega deltas (flooding from sea and rivers)
- Some ecosystems are highly vulnerable
  - Coral reefs, marine shell organisms
  - Tundra, boreal forests, mountain and Mediterranean regions
  - 20-30% of plant and animal species at risk of extinction

Projected Changes in Annual Temperatures for the 2050s



INDIAN SCENAIO

- The rate of sea level rise has been observed to be between 1.08-1.75 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

How climate change affects world regions

Climate change threatens world ecosystems

Adaptation and Mitigation

TROPMET 2007 (17-19 December, Bhopal)


Save Earth: Governor to scientists

TROPMET 2007 (17-19 December, Bhopal)

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 70% from 1970–2004

Mitigation needs to start in short term, even when 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

Characteristics of stabilization scenarios

445 – 490	2.0 – 2.4	2000 – 2015	2000 – 2030	30 to 60
490 – 535	2.4 – 2.8	2000 – 2020	2000 – 2040	30 to 85
535 – 590	2.8 – 3.2	2010 – 2030	2020 – 2060	10 to +5
590 – 710	3.2 – 4.0	2020 – 2060	2050 – 2100	+10 to +60
710 – 855	4.0 – 4.9	2050 – 2080		+25 to +85
855 – 1130	4.9 – 6.1	2060 – 2090		+90 to +140

- 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

Efficiency; fuel switching; renewable; hydropower, solar, wind, geothermal and bioenergy; combined heat and power; nuclear power; early applications of CO_2 capture and storage

More fuel efficient vehicles; hybrid vehicles; biofuels; modal shifts from road transport to rail and public transport systems; cycling, walking; land use planning

Efficient lighting; efficient appliances and equipment; improved insulation; solar heating and cooling; alternatives for fluorinated gases in insulation and equipment

Key policies to reduce emissions

- Appropriate incentives for development of technologies
- Effective carbon price signal to create incentives to invest in low-GHG products, technologies and processes
- Appropriate energy infrastructure investment decisions, which have long term effects on emissions
- Changes in lifestyle and consumption patterns, especially in building, transport and industrial sectors

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-CO_2 / less CO_2 producing sources of energy.

Phasing out of CFCs.

Sustainable use of forests & extensive afforestration – Net deforestation 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

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 idling engine for long period, especially at crossings & during a traffic jam by switching off the engine.

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

Manage vehicular traffic better to reduce fuel consumption.

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

Turn off all lights, television, fans, ACs, computers and other electrical appliance 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, CO_2 is released.

TSUNAMI DISASTER

Tsunami Relief Operations

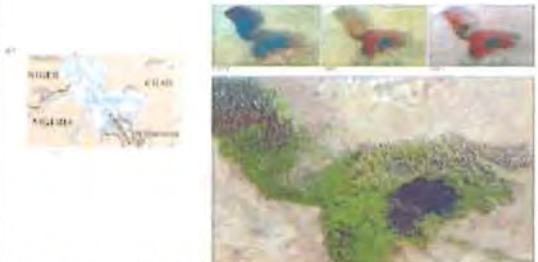
Hurricane Katrina

Hurricane Rita

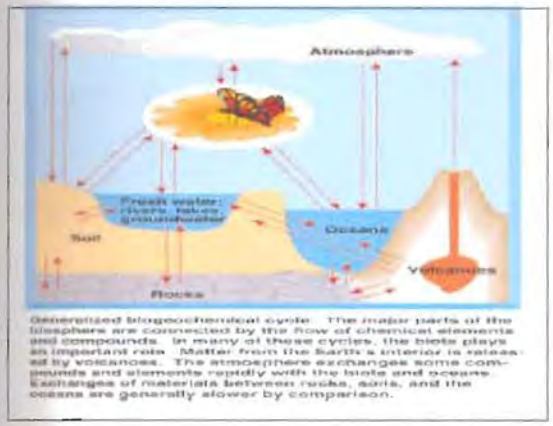
The Dead Sea. "Sea of Salt is a salt lake between the West Bank and Israel to the west, and Jordan to the east. It is said to be the lowest point on Earth, at 420 m (1,378 feet) below sea level.[1]

http://www.usgcrp.gov/usgcrp/images/ocp2006/pages/ocp06-fig1.htm

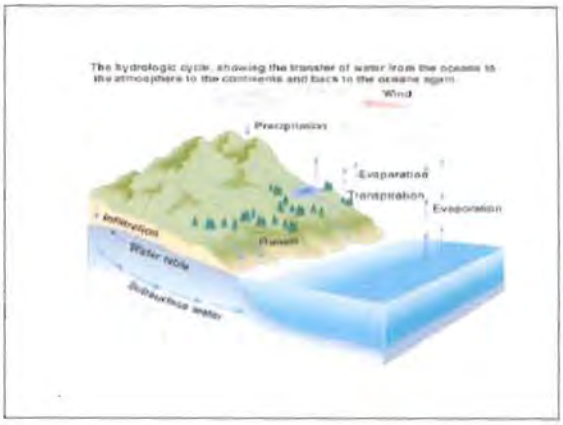
Lake Chad in a 2001 satellite image, with the actual lake in blue, and vegetation on top of the old lake bed in green. Above that, the changes from 1973 to 1997 are shown

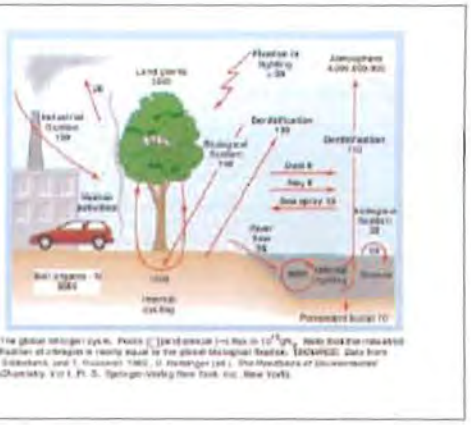


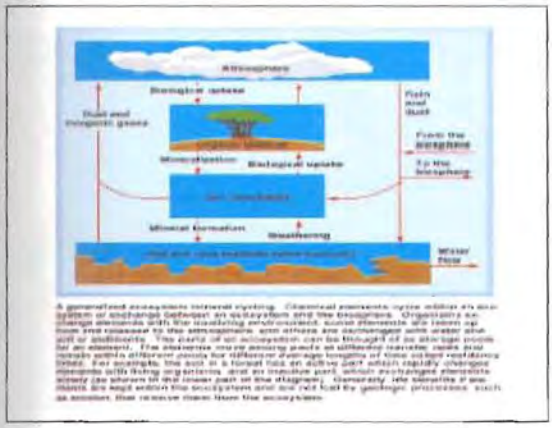
http://www.usgcrp.gov/usgcrp/images/ocp2006/pages/ocp06-fig1.htm



Generalized biogeochemical cycle. The major parts of the biosphere are connected by the flow of chemical elements and compounds. In many of these cycles, the biota plays an important role. Matter from the Earth's interior is released by volcanoes. The atmosphere exchanges some compounds and elements rapidly with the biota and oceans. Exchanges of materials between rocks, soils, and the oceans are generally slower by comparison.



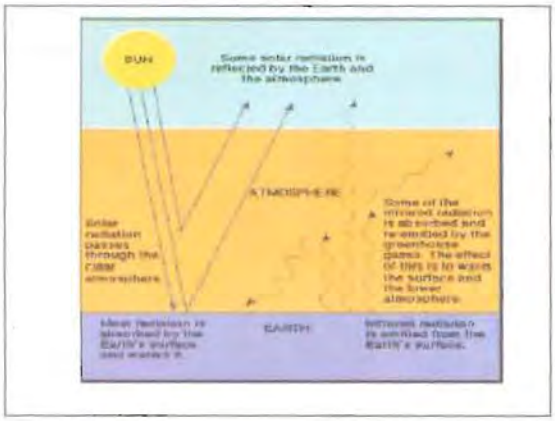




A generalized ecosystem nutrient cycling. Chemical elements cycle within an ecosystem or exchange between an ecosystem and the biosphere. Organisms exchange elements with the surrounding environment; some elements are taken up from and released to the atmosphere, and others are exchanged with water and soil or sediments. The parts of an ecosystem can be thought of as storage pools for an element. The elements move among parts at different rates; rates and routes within different pools for different average lengths of time (called residence times). For example, the soil in a forest has an active part which rapidly changes elements with living organisms, and an inactive part which exchanges elements slowly (as shown in the lower part of the diagram). Generally, the benefits of elements are kept within the ecosystem and are not lost by geologic processes such as erosion, that remove them from the ecosystem.

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.



Human Development Index : Methodology

- In general to construct a new variable, say z, which is a unit free index between 0 and 1 (which allows different indices to be added together), the following formula is used:
- z index = (x - min(x))/(max(x) - min(x))
- where min(x) and max(x) are the lowest and highest values the variable x can attain, respectively.
- The Human Development Index (HDI) then represents the average of the following three generic indices:
  - Life Expectancy Index (LEI) = [LE - 20]/[85-20]
  - Education Index (EI) = 2/3(ALI) + 1/3(CGEI)
    - Adult Literacy Index (ALI) = [ALR - 0]/[100-0]
    - Gross enrollment index (GEI) = [CGR - 0]/[100-0]
  - GDP Index (GI) = [log(GDPpc) - log(100)]/[log(40000) - log(100)]
- Therefore
- HDI = [LEI + EI + GI]/3
- Where, LE = Life Expectancy, ALR = Adult Literacy Rate, CGR = Combined Gross Enrolment Index, GDPpc = GDP per capita in US$

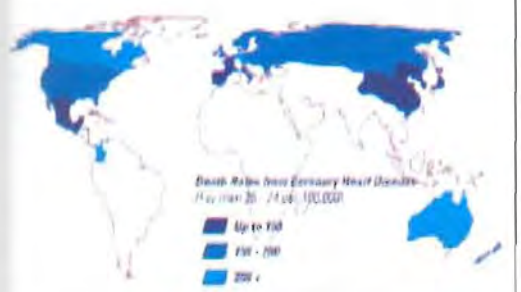
Human Development Index

World map indicating Human Development Index (2004)

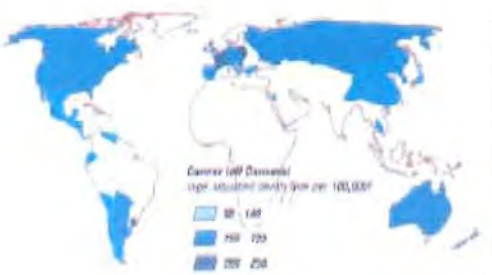
Malaria Risks

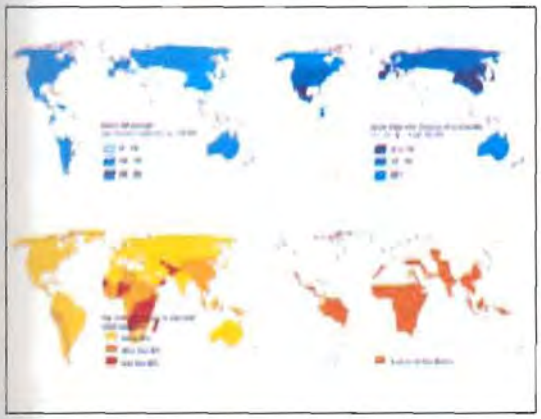
Cholera Risks (Indicator of Water Pollution)

Coronary Heart Disease (Air Pollution?)

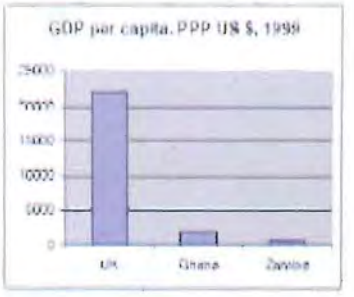


Cancer Risks (Air Pollution Mainly)

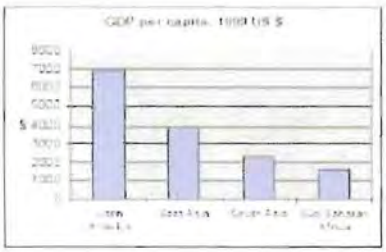


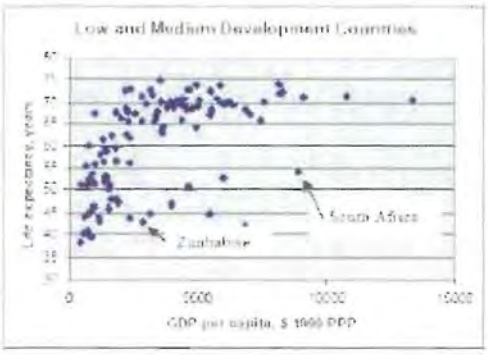


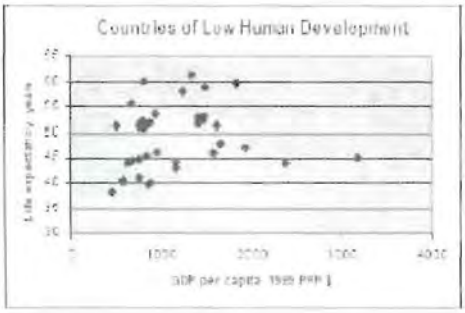
GDP per Capita : Developed & Developing Countries



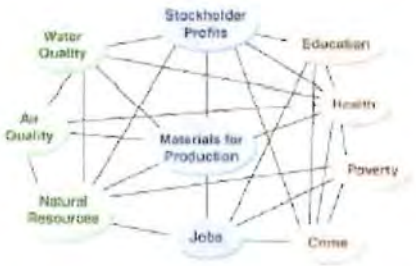
Another Comparison







Interactive Web of Sustainability Indicators

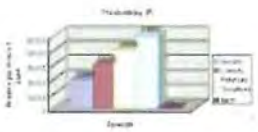


Global Ecological Footprint

How much land is required for :

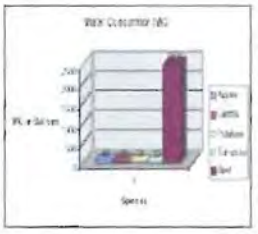
- *Waste Management*
- *Energy Requirements*
- *Water Needs*
- *Transportation*
- *Food Requirements and*
- *Housing*

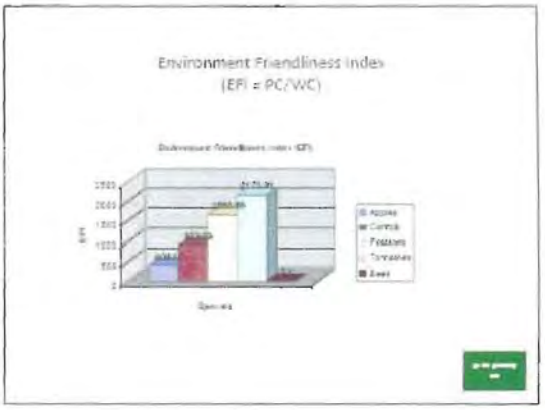
One Acre Of Prime Land Can Produce (Pc)



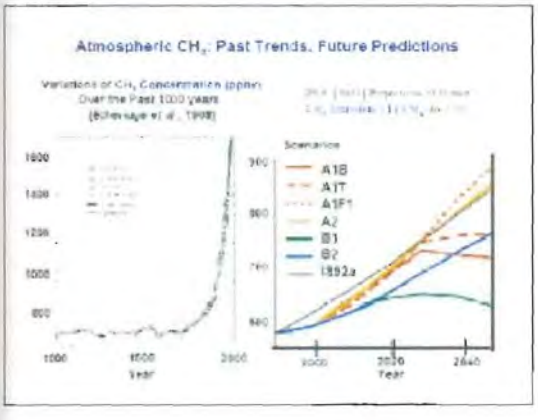
The number of gallons of water needed to produce one pound of edible product:

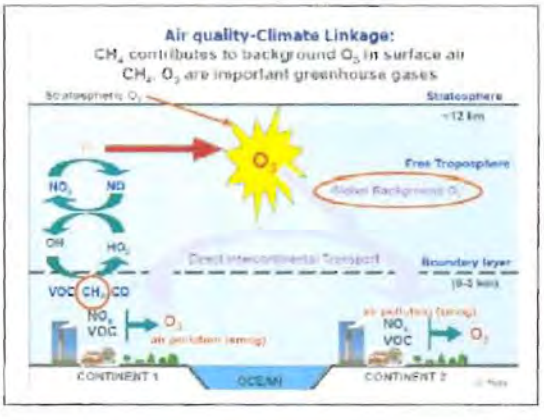
- Apples 49
- Carrots 33
- Potatoes 24
- Tomatoes 23
- Beef 2,500

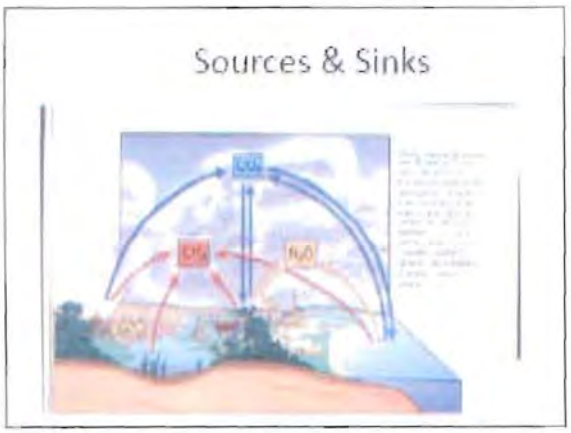


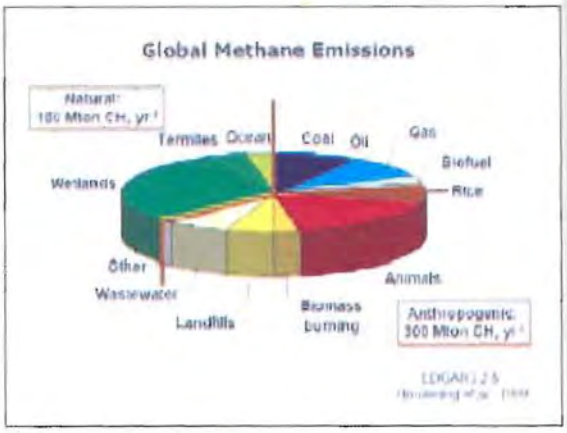


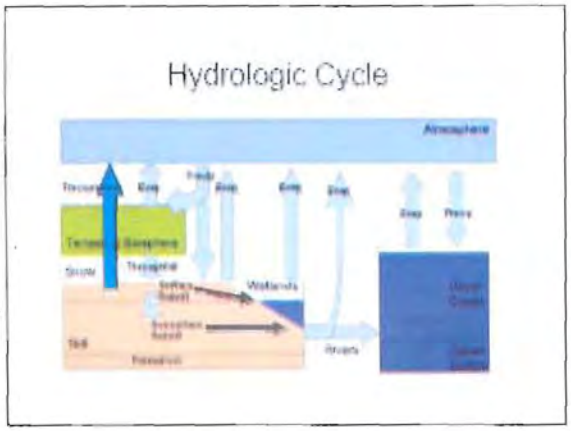
TYPE	SOURCES	HEALTH EFFECTS
CO (CARBON MONOXIDE)	Motor vehicles; road machinery; parking garages; tunnels; heavy traffic	Dizziness; dizziness; fatigue; death; brain damage
NITROGEN OXIDES	Motor vehicles; power plants; burning fossil fuels; coal burning stoves	Lung problems; acid rain; forest damage; damaged buildings and statues; smog
PARTICULATE MATTERS	Diesel engines; power plants; industries; dust in the wind; wood burning stoves	Lung problems; eye problems; discolored buildings and statues; reduced visibility
SULFUR DIOXIDE	Coal burning power plants and factories; coal burning stoves; refineries	Lung; eye problems; lung damage; kills life in lakes and rivers; acid rain; damages buildings and statues
LEAD	Pesticides using leaded gasoline; metal refineries	Health damage; kidney damage

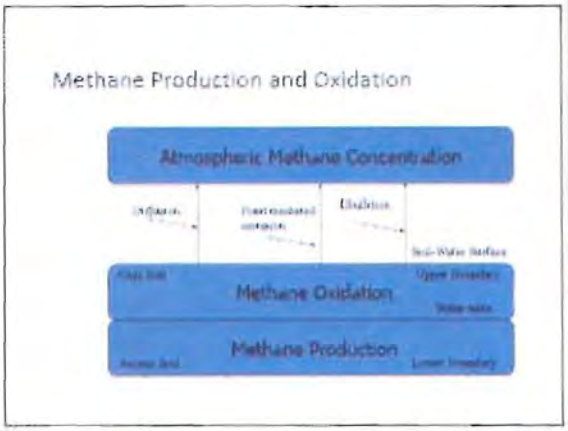


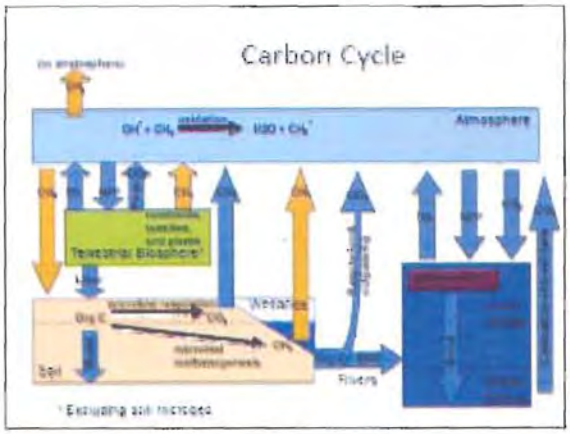


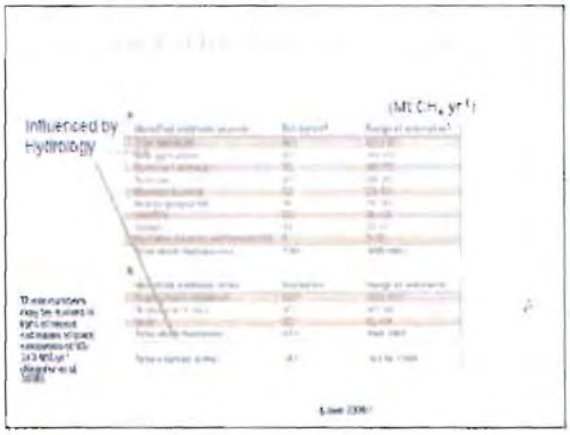

Sources & Sinks


Global Methane Emissions
Natural:
Termites
Ocean
Coal
Oil
Gas
Biofuel
Rice
Wetlands
Other
Wastewater
Landfills
Biomass burning
Animals
Anthropogenic:


Hydrologic Cycle
Atmosphere
Wetlands
Rivers


Methane Production and Oxidation
Atmospheric Methane Concentration
Methane Oxidation
Methane Production


Carbon Cycle
Atmosphere
Wetlands
Rivers


Influenced by Hydrology

Wetlands

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

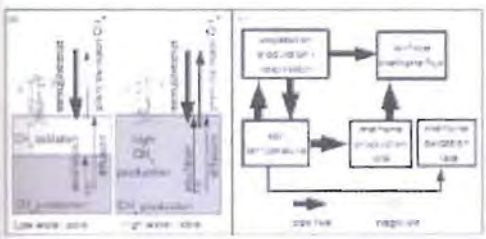
Hydrology plays key role:
- Wetland extent
- Balance between CO_2, CH_4

Terrestrial Carbon Modeling Issues (cont.)

To adequately model water-mediated processes, carbon models need sophisticated soil hydrological components:

- Hydraulics
- Thermodynamics
- Snow formulation
- Realistic stream flow
- Lakes/wetlands
- Permafrost

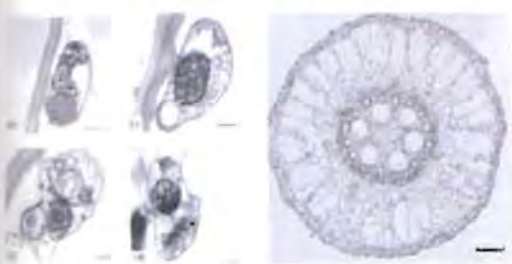
Wetland CH_4 Emissions



(Huttunen 2004)

Aerenchyma—Lifelines for Living Underwater

Aerenchyma



Issue of Green House Gas Emissions

- Fearnside (2002, 2004) argues that reservoirs in the tropical regions are producing as much greenhouse gas as a conventional power station.
- Whereas International Hydropower Association (IHA, 2003) suggests that emissions from hydroelectric power are up to 40 times lower than from thermal power plants, and can absorb and store more CO_2 than they emit.
- On the other hand International Rivers Network (IRN) reasons out that the flooded areas may be sources of GHG's rather than being their sinks (Parekh, 2004; McCully, 2004).

Parameters Which Affect Methane Emissions : Wide variations in the estimate of Brazilian reservoirs

Mainly because of the following factors :

- Temperature,
- Measurement point depths,
- Wind speed,
- Sunlight,
- Physical and chemical water parameters,
- Biosphere composition, and
- Dam operating systems

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, 94% of the contribution comes from flooded water.

Relative Contributions

- Macrophyte mats, open water and exposed soils make very small contributions
- In any of these areas, ebullition (bubbling) accounts for approximately 65% of emissions and diffusion about 35%.

How to extrapolate from site-measurements to regional estimates?

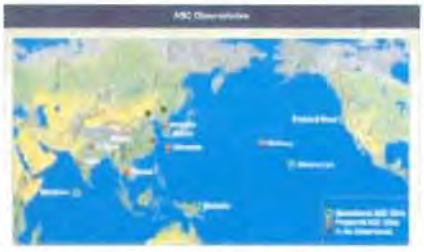
- From sampled points, when one extrapolates the results to obtain regional-level estimates, maximum uncertainty is associated with the estimation of flooded or inundated forest zone, which has been reported to contribute as much as 85% of total methane emissions
- So the estimation of flooded and inundated forest zones should be very carefully carried out

Methane Emission Routes

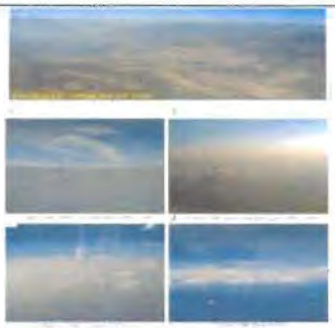
- Diffusion across the air-water interface
- Ebullition, and
- Through the the stems of plants

Atmospheric Brown Cloud

Atmospheric Brown Cloud (ABC) network. Map of operational and planned observations that comprise the Atmospheric Brown Cloud (ABC) network. May 2005. Credit: [illegible] United Nations Environment Programme



http://www.unep.org/unep/images/ocp2006/pages/ocp06

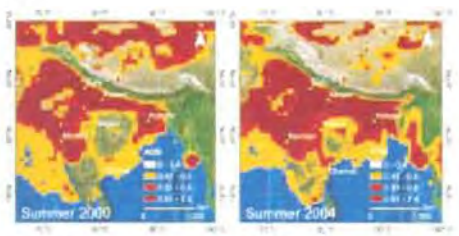


V. Ramanathan et al. 2002. Current Science, Vol. 83, p. 947-955

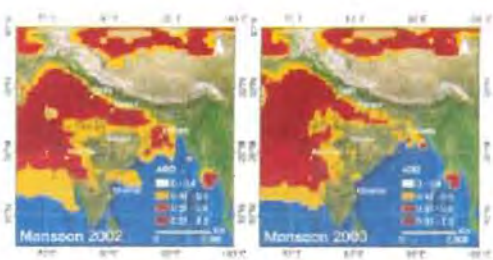
Aerosol Optical Thickness

"Aerosol Optical Thickness" is the degree to which aerosols prevent the transmission of light. The aerosol optical depth or optical thickness (τ) 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).

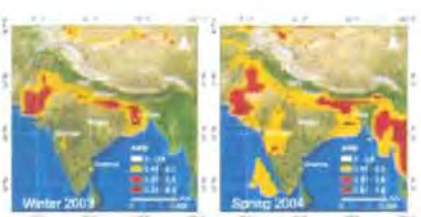
Figure



Prasad. A.K. et al. 2004. Journal of Indian Society of Remote Sensing Vol. 32, p



Prasad. A.K. et al. 2004. Journal of Indian Society of Remote Sensing Vol. 32



Prasad. A.K. et al. 2004. Journal of Indian Society of Remote Sensing Vol. 32

Fresh Water (?)

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 (?)

Same Questions & Different Answers

- 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 years!"
- "True," Einstein said, "but this year all answers are different."

Journey from natural jungles to concrete jungles

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

Brazil's View from Sky

How to locate sustainable development ?

- Where is it – between sand and trees ?

Occasionally we had some natural disasters like volcanoes (Now you can easily compare it with the copper mining (photograph on the right).

Floods in Bangladesh [Do We Remember Mumbai Floods and Plastics?]

Ship in search of Sustainable Development !!

Confusing Steps Towards Sustainable Development !!

rediff.com

9 per cent growth feasible?

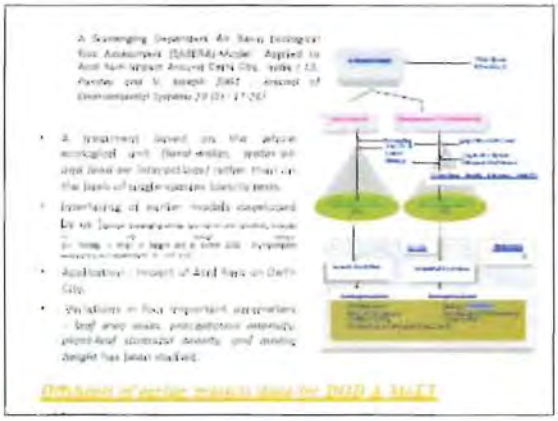
Nitin Desai BS | December 21, 2006 | 10:43 IST

The government has opted for a 9 per cent growth path for the Eleventh Plan. The Approach Paper even speaks about reaching a 10 per cent level by the end of the Plan. Some of this optimism rests on a projection of the high growth of recent years, though the Paper does identify the major policy changes required to get to this high growth path. The most question is whether these substantial changes can be effected.

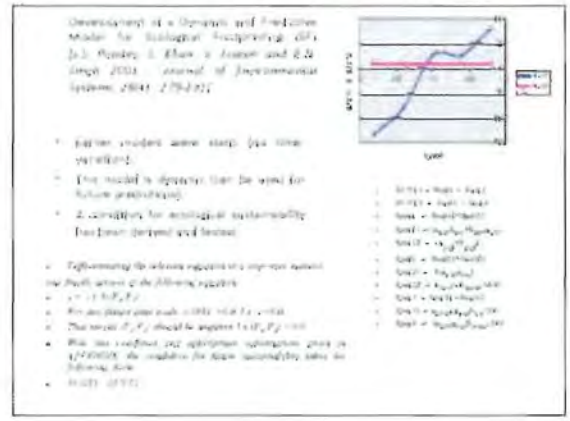
Peaks of Development : Which one is Sustainable ?

Just have a look at this !

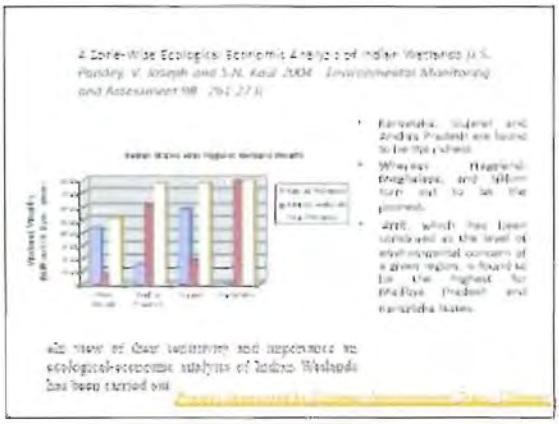
- Does it charm you ?
- How to plan for this journey ?
- Shall we aim at an eco-system like this?



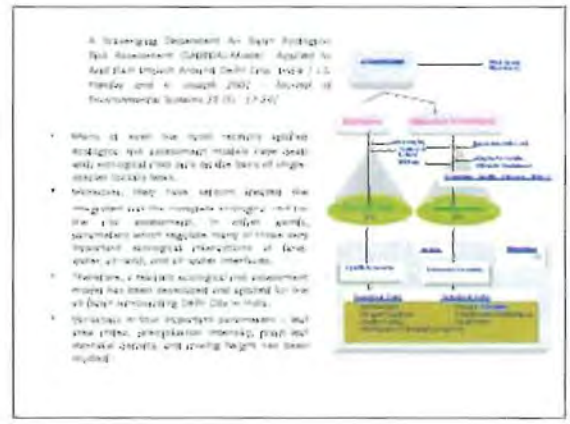
- A framework based on the above ecological unit (land-water system as one basic unit) for interpretation rather than on the basis of single-species toxicity tests.
- Interfacing of earlier models developed by us [illegible]
- Application : Impact of Acid Rain on Delhi City.
- Variations in four important parameters - leaf area index, precipitation intensity, plant-leaf stomatal density, and growing height has been studied.

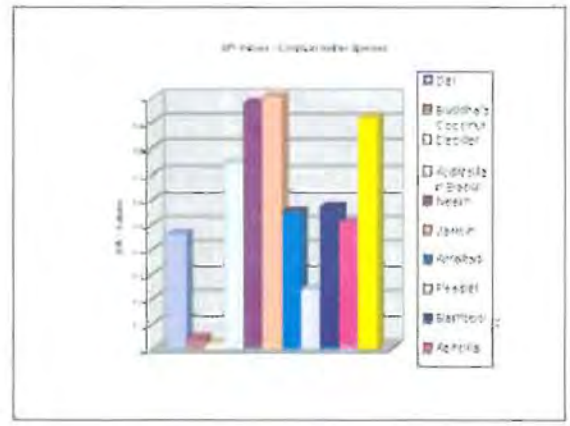


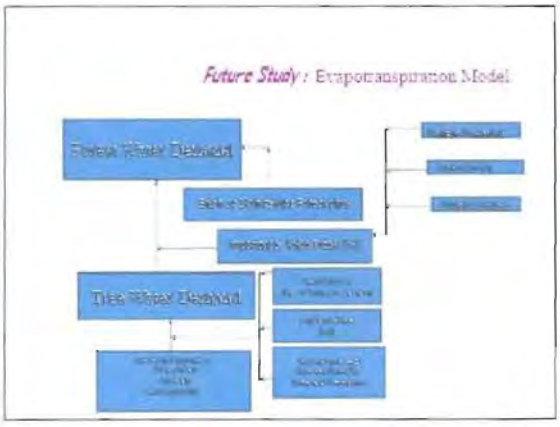
- Earlier models were static (no time variation).
- The model is dynamic (can be used for future predictions).
- A corrective for ecological sustainability has been derived and tested.

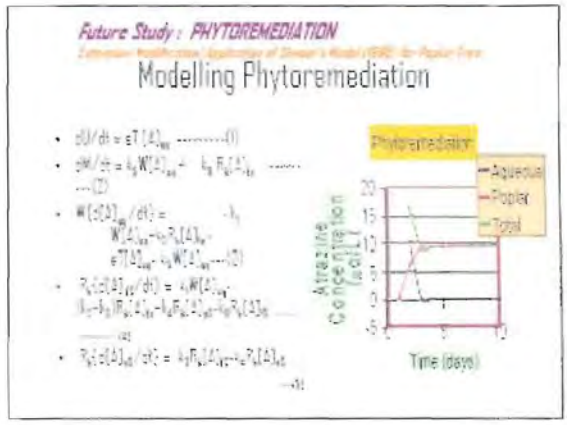


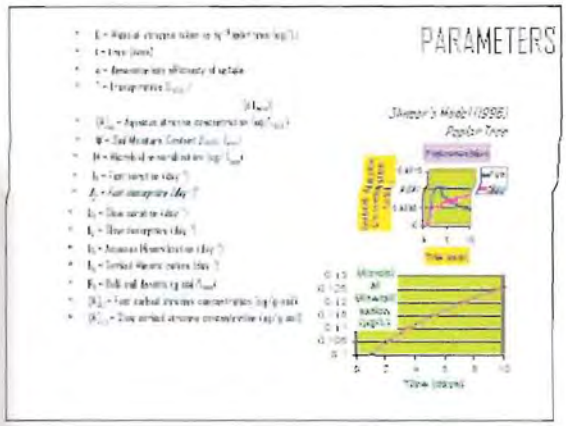
- Karnataka, Gujarat and Andhra Pradesh are found to be the richest.
- Whereas Rajasthan, Meghalaya, and Uttaranchal turn out to be the poorest.
- AHP, which has been considered as the level of vital ecological concern of a given region, is found to be the highest for Madhya Pradesh and Karnataka States.



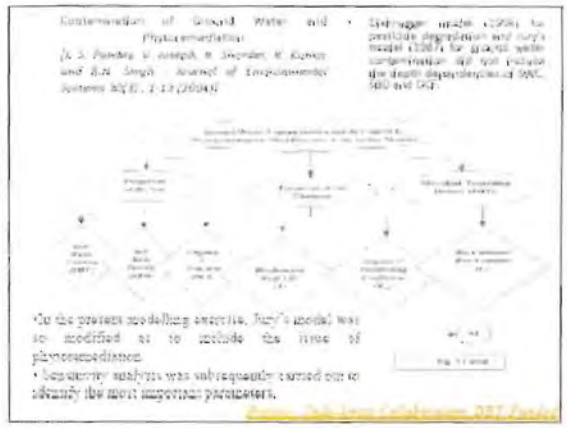



Future Study : Evapotranspiration Model


Future Study : PHYTOREMEDIATION
Modelling Phytoremediation
Phytoremediation
Aqueous
Poplar
Total
Atrazine concentration (ug/L)
Time (days)

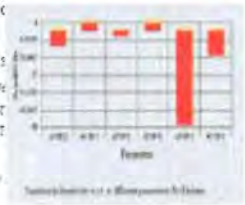

PARAMETERS
Shoeib's Model (1998)
Poplar Tree
Time (days)


FUTURE ACTIVITIES
Exposure Model
Dose – Response Model
Exposure Frequency


Contamination of Ground Water and Phytoremediation
• On the present modelling exercise, Jury's model was so modified as to include the term of phytoremediation.
• Sensitivity analysis was subsequently carried out to identify the most important parameters.

Contamination of Ground Water and Phytoremediation contd.. .

- Modifications in earlier moc (Jury et al., 1987)
- Results of Sensitivity Analysis
- *Contamination has strong dependence on t parameters, that represent t underground gradient microbial population density*



ESSENCE
Structural Modelling Approach

- Problem Definition
- Model Purpose Definition
- Verbal Model
- Identification of Systems Elements
- Structural Interconnections (State Variables, Intermediate Variables, Parameters, Exogeneous Forcing Functions etc.)
- Causal Loop Diagram (Cause-Effect Relationships)
- Functional Relations and Quantification
- Computer Programming and Simulation
- Testing and validation (Structural, Behavioural, Empirical and Application Validity Tests)

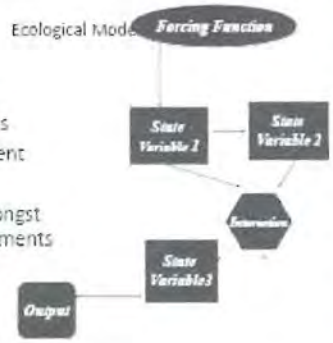
Models

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

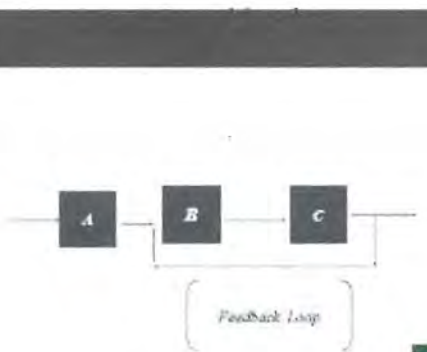
Ecological Properties

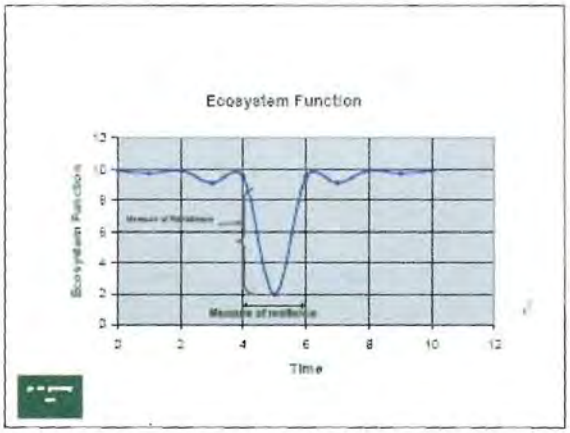
- *Collective Properties (Summation of behaviour of the components , e.g. birth rate)*
- *Emergent Properties (Properties of the whole not reducible to the sum of properties of the parts , e.g. Boiling point of water ($H_2 + O_2 = H_2O$)*

Ecological Model

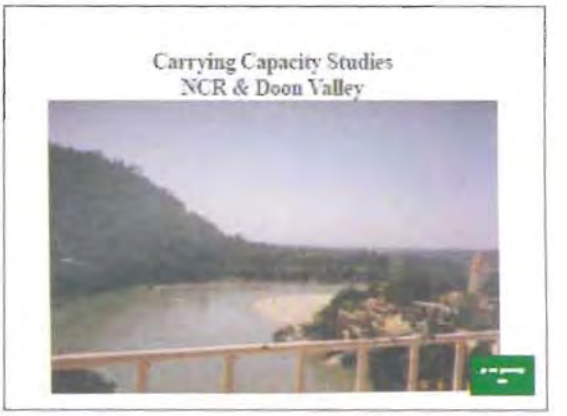


- State variables
- Forcing Functions
- Inter-compartment Flows
- Interactions amongst various compartments






ATMOSPHERIC ENVIRONMENT

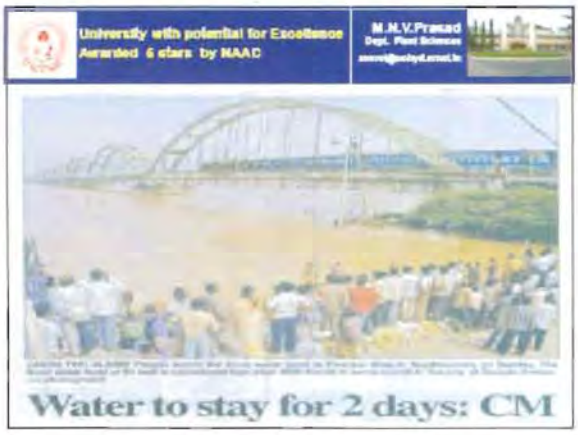

Carrying Capacity Studies
NCR & Doon Valley

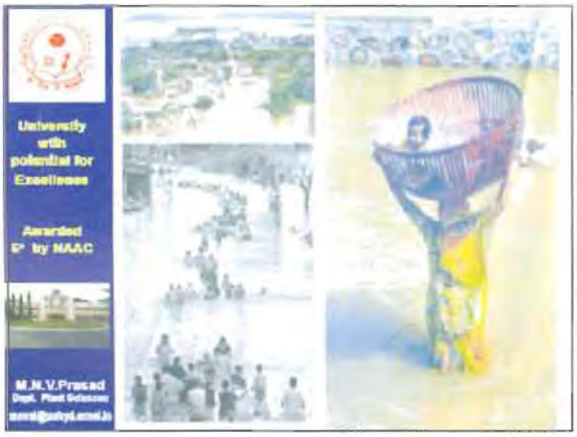

Depletion in Forest Areas

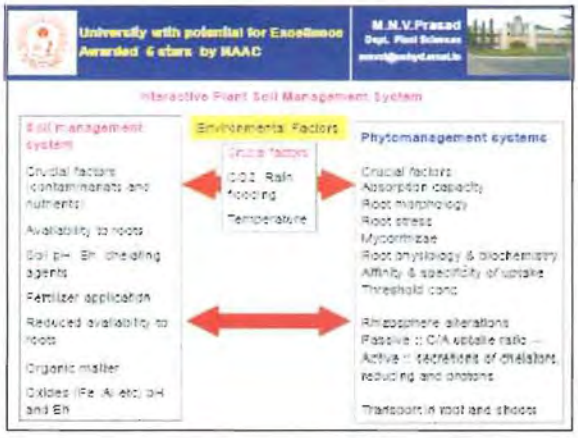

ThankYou
Credit: NASA

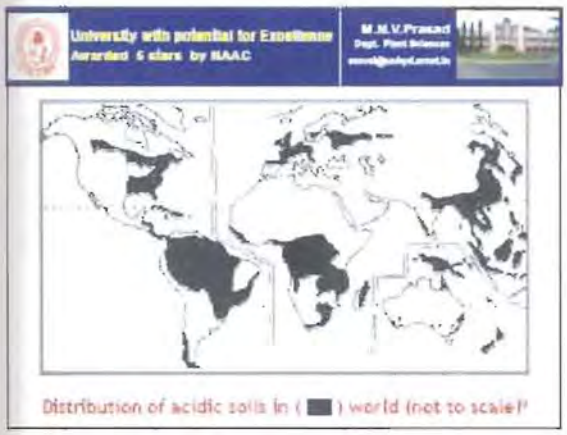

Thank You
(Articles are invited for our Hindi Magazine (PARYAVARAN PATRIKA)

Climate change impact on trace metals in soil and plants
Prof. M.N.V. Prasad, Dept. of Plant Sciences





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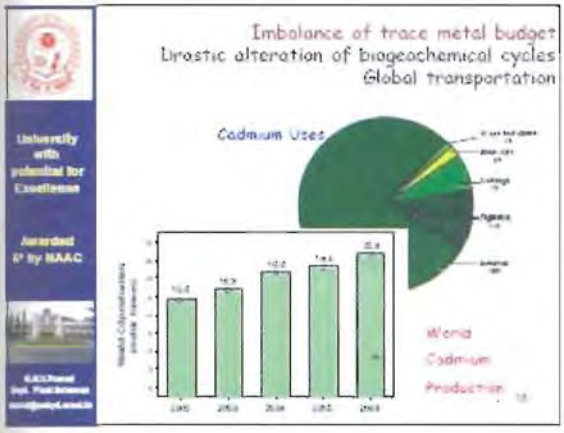
M.N.V.Prasad
Dept. Plant Sciences
Distribution of acidic soils in ( ) world (not to scale)


Two sides of the same coin (essentiality and toxicity)
Deficiency / Disease
Excess / Disease
Se
Keshana (China), bone, arthritis, CV and Cancer.
Zn
Dwarf ness (Iran & Egypt) infertility, impaired taste and smell
Cu
Anemia, skeletal defects
Cr
Glucose metabolism, kidney function, cholesterol disorders
I
Goiter
F
Dental caries
Mg
Depression, nervous system
Mo
Mouth/esophageal cancer
Co
Anaemia
Fe
Anaemia
Na
Coma
Hg
Mina-Mata, neurological disorders
Cd
Itai-Itai, Bone cripping, Cancer — prostrate, lung, renal and heart problems
F
Yellowing of teeth, skeletal Deformities
Pb
Lung cancer, neurological disorders
Mn
Paraplegia = skeletal deformations — paralysis
As
Skin, lung cancer


Imbalance of trace metal budget
Drastic alteration of biogeochemical cycles
Global transportation
Cadmium Uses
World Cadmium Production
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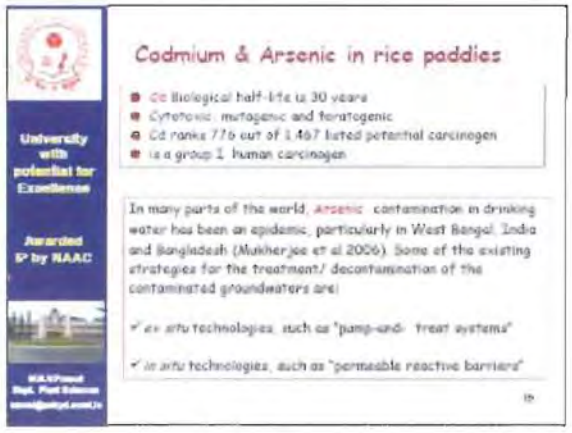
Cadmium & Arsenic in rice paddies
Cd Biological half-life is 30 years
Cytotoxic, mutagenic and teratogenic
Cd ranks 7th out of 1,467 listed potential carcinogen
is a group 1 human carcinogen
In many parts of the world, Arsenic contamination in drinking water has been an epidemic, particularly in West Bengal, India and Bangladesh (Mukherjee et al 2006). Some of the existing strategies for the treatment / decontamination of the contaminated groundwaters are:
ex situ technologies, such as "pump-and- treat systems"
in situ technologies, such as "permeable reactive barriers"
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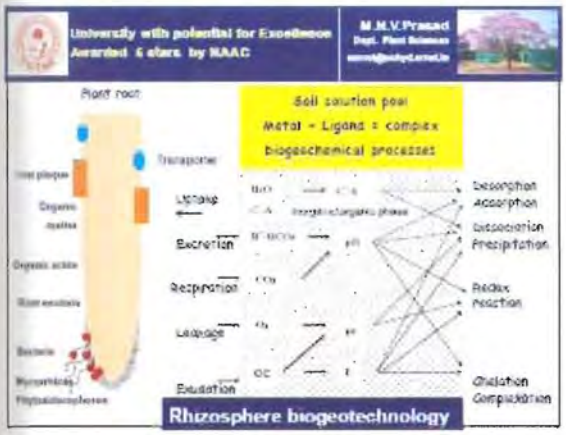
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Dept. Plant Sciences
Plant root
Soil solution pool
Metal + Ligand = complex
biogeochemical processes
Transporter
Lysing
Excretion
Respiration
Leakage
Exudation
Desorption
Adsorption
Dissolution
Precipitation
Redox Reaction
Oxidation
Complexation
Rhizosphere biogeotechnology


Nutritional security and quality of agricultural produce including healing plants
Several of the trace elements serve as essential nutrients and are the constituents of biomolecular as cofactors for various enzymes and in a variety of metabolic functions.
Certain trace elements accumulated in medicinal plants have the healing function to some ailments and disorders for e.g. zinc - neurochemical transmission; Cr and Mn can be correlated with therapeutic properties against diabetic and cardio-vascular diseases. Certain transition group elements regulate hepatic synthesis of cholesterol.
Bioorganic farming takes total micronutrient care and is an important soil management practice for fortification of crop produce with essential nutrients for the health of humans as well as livestock.
Nutrinogenomics and pharmacogenomics, Medical geology (geomedical science), metallomics are emerging as new areas of research with challenging tasks ahead.
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Dept. Plant Sciences

Food security vs. nutrition security

Food security means that all people at all times have access to the basic food they need to meet their energy requirements. Nutrition security means that every individual has access to a balanced diet that includes all essential nutrients (e.g. proteins/amino acids, vitamins, nutritive trace elements). Nutrition security cannot be achieved in the absence of food security. The "farming for health" concept has to be developed to meet nutrition security.


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Medical geology (agranic farming) - relevance to nutrition security and quality of agricultural produce

Supplementation


Strategies for nutrient deficiency alleviation

Fortification

Diet modification/ Diversification

Efficacy and effectiveness of these measures is being researched for cost-effectiveness and acceptability

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Benefits and agronomic approach

Accumulation due to differences in the solubility of biosolids or inorganic salts applied to wide range of soils

Detected metals are transferred along simplified food chains

Identification of genes for nutrient fortification; genetic and molecular analysis of mineral accumulation

21

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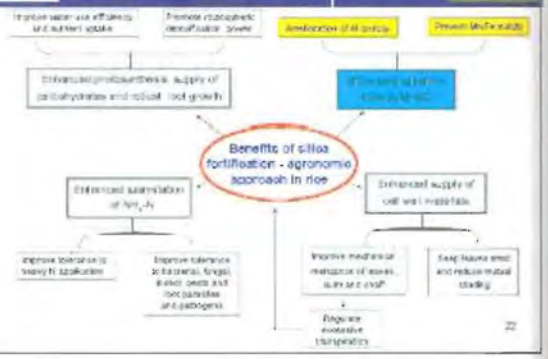

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The international consortium is contributing to the field of biofortification (the furnished list is not an exhaustive list)

CIAT	Int. Centre for Tropical Agriculture
CIMMYT	Int. Maize and Wheat Improvement Ctr
CIP	Int. Potato Centre
ICARDA	Int. Centre for Agricultural Res. in the Dry Areas
ICRISAT	Int. Crops Research Inst. for the Semi-Arid Tropics
IFPRI	Int. Food Policy Research Institute
IITA	Int. Institute of Tropical Agriculture
IRRI	Int. Rice Research Institute
WARDA	Africa Rice Centre
IPGRI	Int. Plant Genetic Resources Institute
INIBAP	Int. Network for the Improvement of Banana and Plantain
NARES	National Agricultural Res. and Extension Systems
NHRIS	National Health Res. and Implementation systems

23

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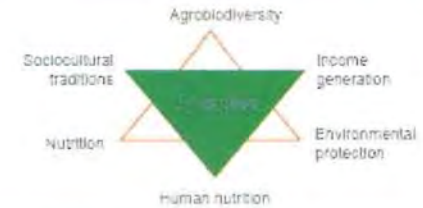
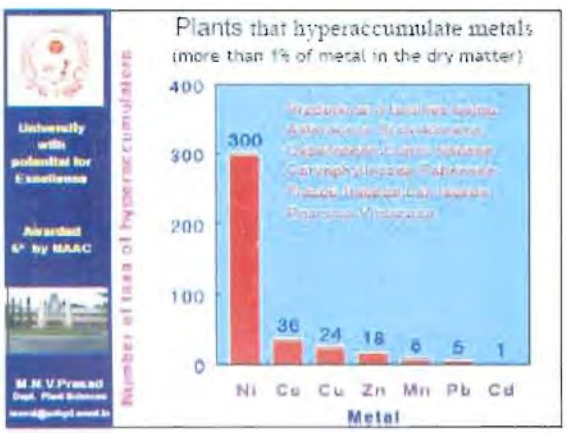
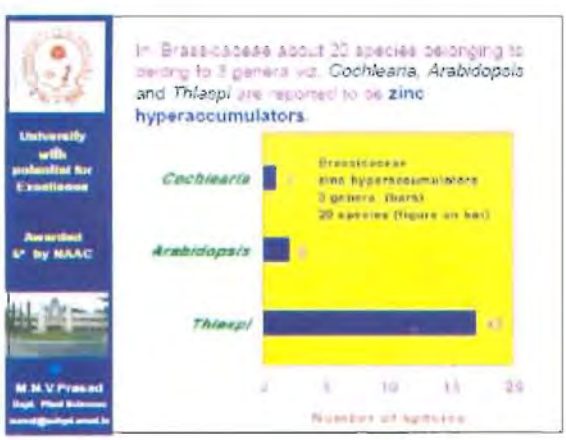


Linking biofortification with socio-economics and possible impact on agrobiodiversity

Biofortification may attract the risk of transferring fitness-enhancing traits into the noxious weeds (Sorghum vs. Johnson grass)

24





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.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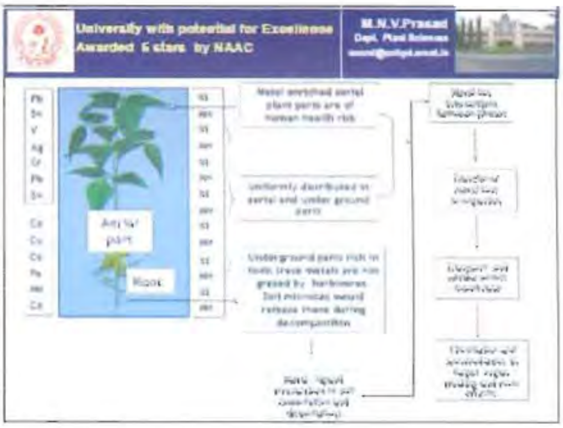
Electroporation, PEG mediated DNA uptake, particle bombardment, microinjection, Agrobacterium cocultivation etc. successful
Brassicaceae are the best candidates for phytoremediation and are amenable to biotechnology
Arabidopsis thaliana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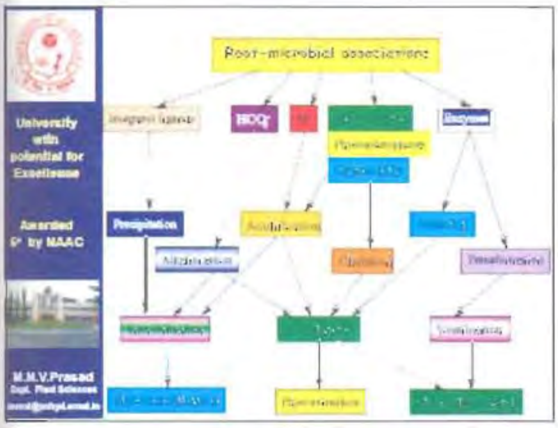
Root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Root-microbial associations
Precipitation


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Dept. Plant Sciences
Adaptive ecophysiological, biochemical and molecular basic for fostering metallomics
2. Heat shock proteins
Reddy and Prasad 1993; Reddy and Prasad 1995
3. Vacuolar compartmentation
Prasad 1995, 1997, 1999
4. Metal transporters (cation efflux family + cation diffusion family)
Prasad 2002a, 2003a


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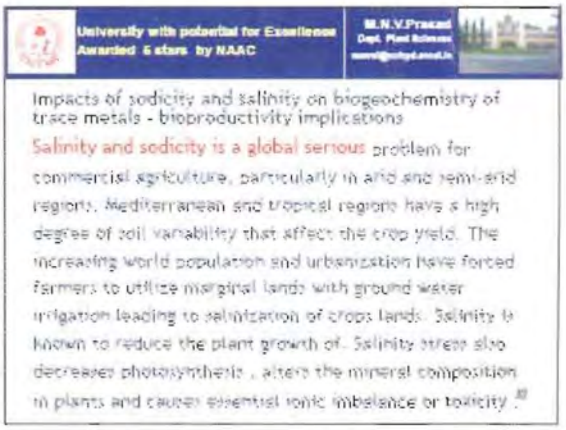
Contd... previous slide
in Prasad and Hagemeyer 1999
in Prasad 2004 Prasad and Strzalka 2002
7. Mycorrhizae
Prasad 2001, Prasad and Freitas 2003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Dept. Plant Sciences
Impacts of sodicity and salinity on biogeochemistry of trace metals - bioproductivity 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.

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Sodicity refers to the amount of sodium in soils. It develops through a process whereby sodium ions build up in preference to other soil cations (particularly 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 sodicity 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 sodicity, movements of water influence salinity. Hence, salinity has been related to clearing and irrigation development 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.

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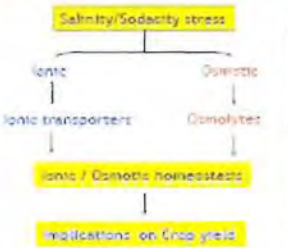
Severe salt stress disrupts homeostasis in water potential and ionic balance of crop plants. This disruption of homeostasis occurs at both the cellular and the whole plant levels. Drastic changes in ion and water homeostasis lead to molecular damage, growth arrest and even death. To achieve salt tolerance, three interconnected aspects of plant activities need to be investigated. (see the figure).



1. Damage must be prevented or alleviated
2. Homeostatic conditions must be established in the stressful environment
3. Conducive conditions must be established for optimum growth or crop yield

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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 bioproductivity of agro-forestry systems as well as brackish/estuarine and wetland ecosystems

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Mangrove forests in in A.P. Conservation and management

Anderson, C.W.N., et al., Harvesting a crop of gold in plants.

Ma, L.Q. et al., A fern that hyperaccumulates arsenic, a hardy, versatile, fast-growing plant helps to remove arsenic from contaminated soils.

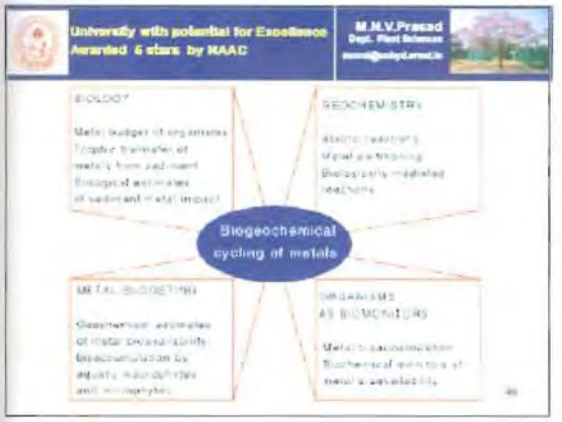
Salt marsh: a pure stand of Spartina maritima.

Saline water

Salt marsh based bioreactor for treatment of saline water

Useful for irrigation

Argonne National Lab, IL, USA


University with potential for Excellence
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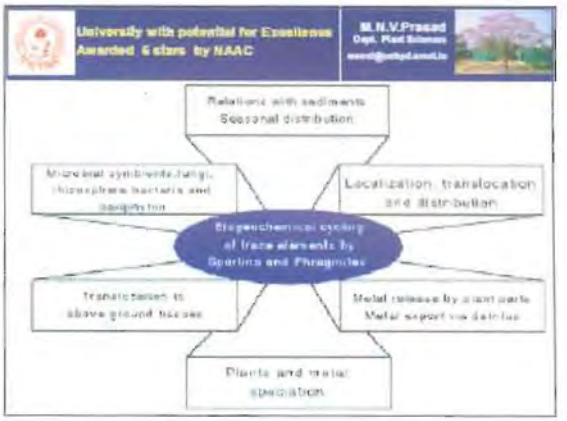
Dept. Plant Sciences
BIOLOGY
GEOCHEMISTRY
Biogeochemical cycling of metals
METAL BIODETING
ORGANISMS AS BIOMONITORS


University with potential for Excellence
Awarded 6 stars by NAAC
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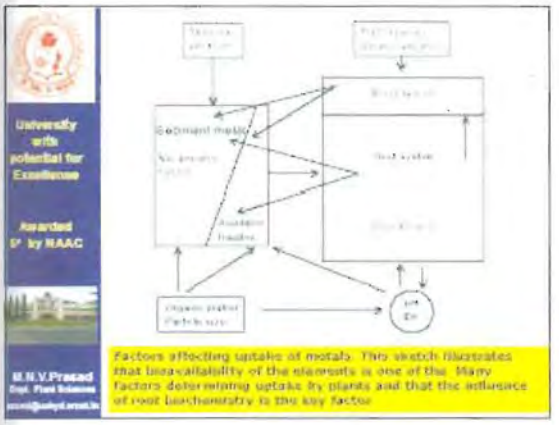
Relations with sediments
Seasonal distribution
Localization, translocation and distribution
Biogeochemical cycling of trace elements by Spartina and Phragmites
Translocation to above ground tissues
Metal release by plant parts
Plants and metal speciation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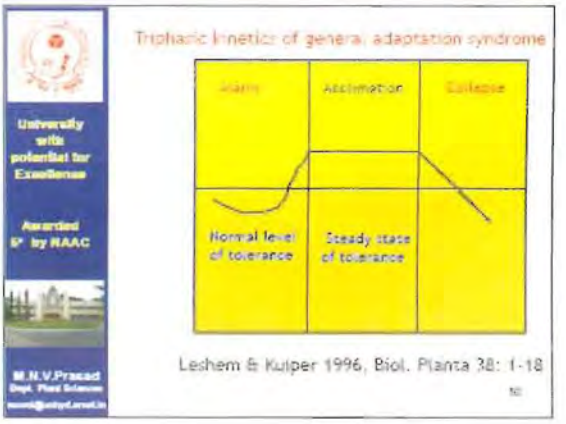
Factors affecting uptake of metals. This sketch illustrates that bioavailability of the elements is one of the many factors determining uptake by plants and that the influence of root biochemistry is the key factor


University with potential for Excellence
Awarded 5* by NAAC
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Trophasic kinetics of general adaptation syndrome
Alarm
Acclimation
Collapse
Normal level of tolerance
Steady state of tolerance
Leshem & Kuiper 1996, Biol. Plantarum 38: 1-18


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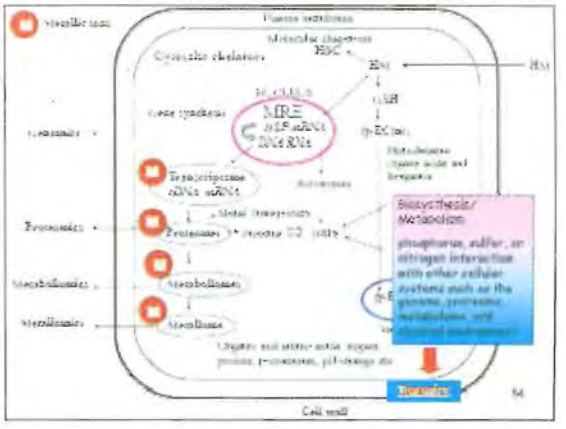
Trace Metal Tolerance in Plants
Ernst et al 1992 Acat Bot Neerl 41: 229-248
1. Comparative plasmology (cells' ability to plasmolyse and deplamolyse in 1M glucose)
2. Tolerance Index: Root growth in metal solution Root growth in control solution
3. Whole plant analysis - ability to accumulate TM


Cell wall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Conclusion
Less dependent
Solar driven
Green technology
Strong government support in developed nations
High public support
Vast potential for environmental cleanup
SCOPE
LIMITATION


2008
2006
2004
2004
TRACE ELEMENTS in the ENVIRONMENT
Plant Ecophysiology
2002
2001
1999
1996

Modeling Plant Response to Climate Change

Opportunities & Research Needs

Model

- A simplified representation of real system

System

- A group of objects (components or factors) that interact with one another in an organised manner, and the net result of their interactions produces the system's behaviour, function and purpose.

Model

- A simplified representation of real system
  - Pictorial
  - Conceptual or verbal
  - Physical
  - Mathematical
    - e.g. maize yield (Y, kg ha^{-1}) responds to the nitrogen fertilizer rate (N, kg ha^{-1}):

      $Y = 1143 + 31.77N - 0.084N^2$

Models

provide

- a quantitative description of the system
- a way of bringing together knowledge about the parts to give a coherent and holistic view of the system

thus

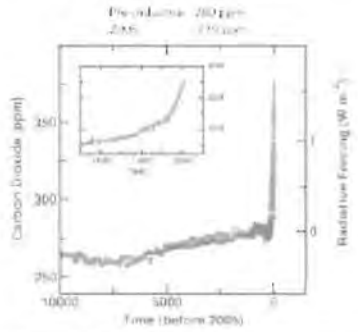
- helps us to understand, predict and control a system in a more organised or methodological manner

Global Carbon Budget

Reservoirs (GTonne)		Fluxes (GTonne/yr)	
Atmosphere	720	Land photosynthesis	(122)
Ocean	38,000	Respiration and decay	120
Land biosphere	560	Oceans	in (107)
Soils	1,500		out 105
		Fossil fuels	6
		Biomass burning	2
			4
		Atmospheric increase	3.5

1 GTonne = 10^9 Tonne = $10^9 \times 10^3$ kg = 10^{12} kg

Carbon Dioxide



Missing Sink

- Models → sink is located 30 –90°N
  - Reforestation?
  - Peat bogs?
  - CO_2 fertilization?

Modeling Ecosystem Responses to Climate Change

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

Modeling Ecosystem Responses to Climate Change

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

Approaches to Assessing Ecosystem Responses to Climate Change

- Equilibrium Models
  - [illegible] between climate and vegetation used to predict future vegetation under climate scenarios
- DGVMs (Dynamic Global Vegetation Models)
  - couple vegetation to carbon, nutrient cycles
  - simulate water, energy, carbon exchange with atmosphere
  - simulate vegetation distribution, structure
  - simplify vegetation into plant functional types
  - include fire as disturbance
  - forced by climate, CO_2, output from GCMs

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

- Uses daily time step, driven by daily values for maximum and minimum temperatures, precipitation, solar radiation, and air humidity.
- Model requirement definitions
  - Vegetation
  - Climate
  - Site characteristics

Biome-BGC

- 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 gray literature
  - data collection methodologies and units differ substantially for some parameters making standardization difficult

Ecophysiological Parameters

- 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 Effect

- Observations of many communities and locations are typically averaged across broad vegetation classes (e.g. evergreen needleleaf, broadleaf deciduous etc) 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 Parameters
- Carbon to Nitrogen Ratios
- Decomposition Constant
- Use Efficiencies
  - Nutrient Use Efficiencies
  - 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
  - Labile, 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
- Livewood
  - actively respiring woody tissue; that is, the lateral sheathing meristem of phloem 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

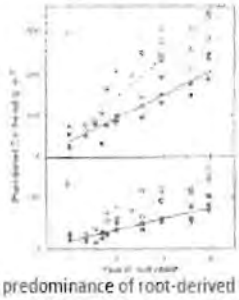
FRC:LC

- 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 increases in below-ground biomass, i.e. losses through root death are not considered
- *in situ* tracing of root-derived C, using $^{14}CO_2$ pulse labelling in the field

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



BALESDENT and BALABANE (1996)

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

Belowground Allocation

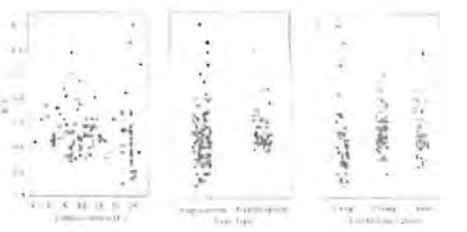
- Ability of models to predict C balance could be improved with better estimates of annual residue inputs, particularly the below-ground part

Belowground Allocation

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

Wheat	0.13-0.20
Oat	0.37-0.42
Barley	0.41-0.59

Root biomass allocation in the world's upland forests



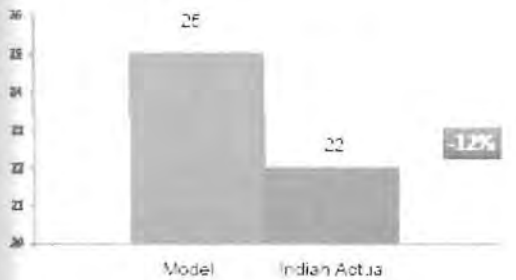
Carbon to Nitrogen Ratios

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

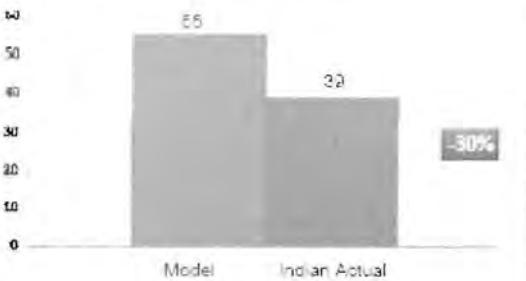
$C:N_{lv}$

- 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



Decomposition Constant

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

$$M_t / M_0 = e^{-kt}$$

Use Efficiencies

- Nutrient use efficiency
  - ratio of organic matter produced to nutrient taken up. For long-lived plants, it is also a measure of how long a nutrient is retained in the plant to be used for carbon fixation.
- Product on 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 of leaf carbon mass
- Projected leaf area
  - leaf area projected horizontally on the ground surface
- all-sided leaf area
  - total surface area of leaves
  - The all-sided to projected leaf area ratio can be used to convert projected leaf area to all-sided leaf area, which is important for some physiological approximations such as canopy water interception (Barclay 1998)

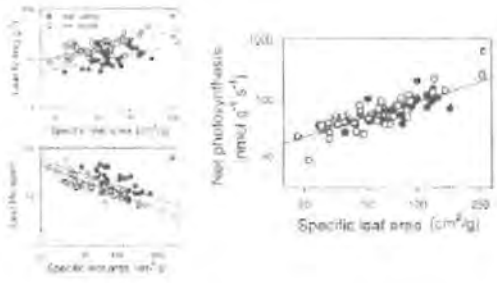
LAI measurement

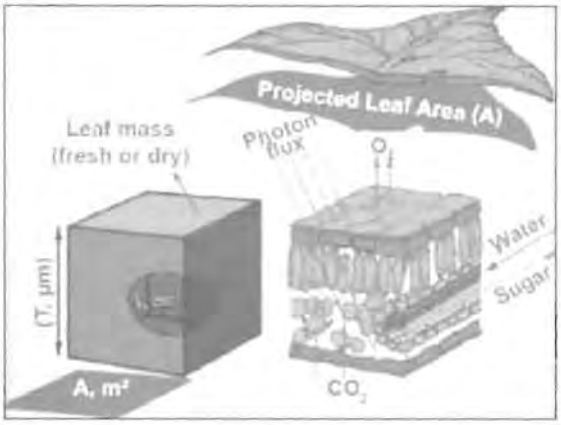
- Wide range of field techniques
  - radiation transmittance (Chen et al. 1997),
  - sapwood allometrics (Samoson and Smith 1993),
  - foliage biomass
- Remote sensing

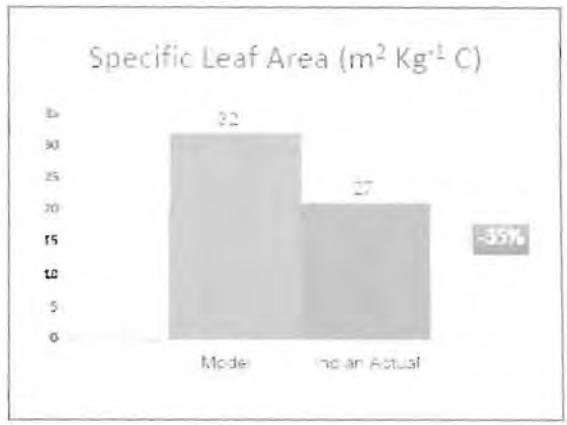
SLA

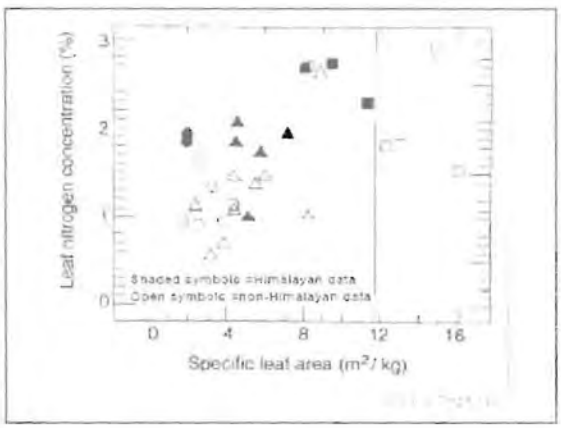
- Defines leaf area per unit mass
- Thin, light leaves, such as grass blades, have a higher SLA than dense conifer needles
- Model needs
  - Shaded SLA sunlit SLA

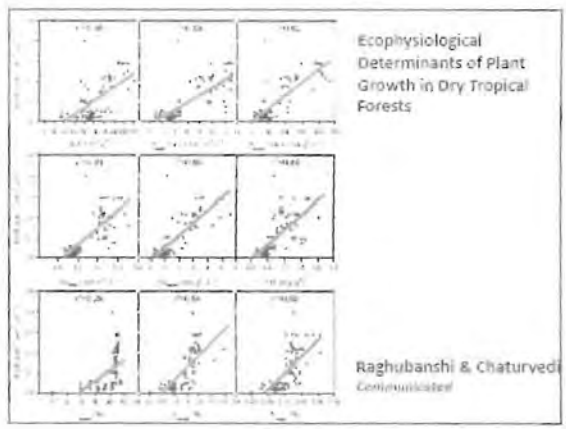
Leaf Traits











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/FACE experiments

Thank You

SECTION 05

12.03.08 (Day 4)

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 stake holders.
2. To sponsor candidates from SA countries for post 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 CO_2 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, polic / decision makers, industry and other stake holders.
7. To sponsor candidates from SA countries for post graduate diploma / degree courses on climate chang 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

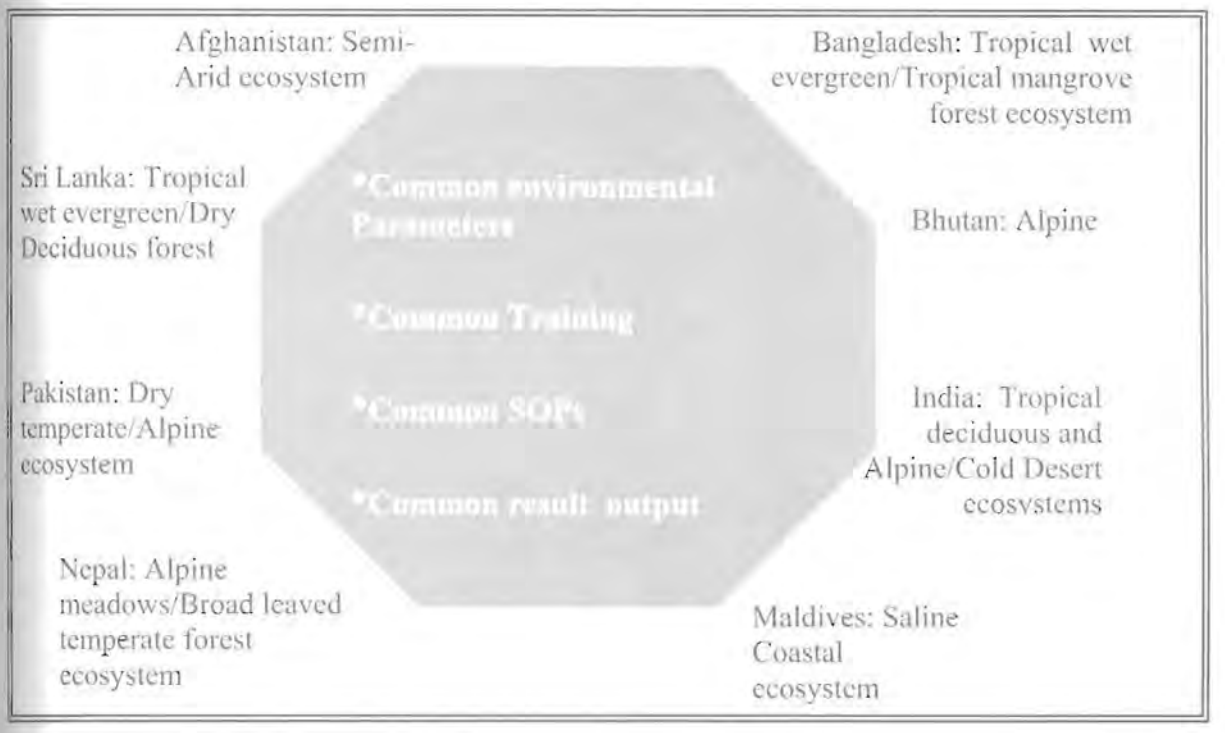


Fig. 1. Proposed Ecosystems/Biomes for identification of specific study sites

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)

6. To develop strategies for CO_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 modelling.
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.

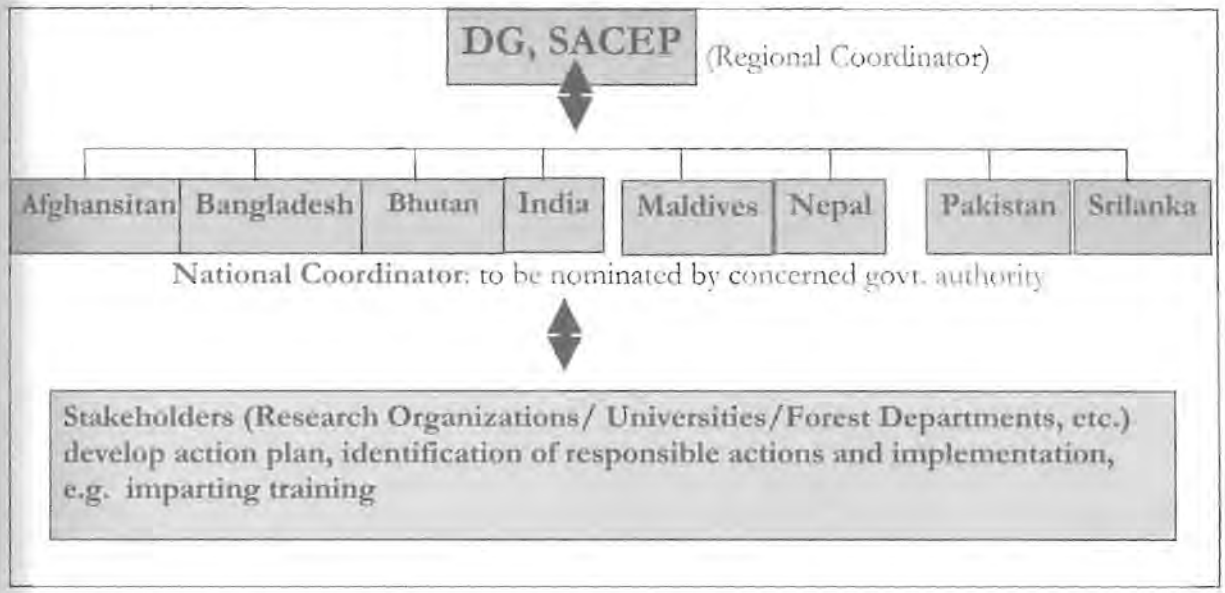


Fig.2. Proposed implementation structure for the proposed programme

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 replacement,
- ✓ 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) Inaugural Session	**Inauguration**
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 10.00-10.30	• 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 & Organisinng Secretary
11.05	*Tea Break*
Session 1	**Climate Change – Scenario in different countries**
11.30 to 11.30 a.m	• **Chairperson** : Prof. N.H Ravindranath,IISc, Bangalore • **Rapporteur** : Prof. A.S. Raghuvanshi,BHU, Varanasi **Lead Lectures** • Dr. J.S Pandey, NEERI, Nagpur • Prof. C.K Varshney, New Delhi *(20 Min.)* • Dr. C. Sharma, NPL, New Delhi
	Country Presentations *(20 min. each) Afghanistan, Bangladesh, Bhutan, Maldives*
12.45-14.00	*Lunch*
Session 2	**Climate Change and Biodiversity**
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 ***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 **Group Discussion** ***(45 Min.)*** **Close of Meeting**
10.03.08 (Day 2)	
Session 3	**Climate Change and Forestry Sector**
9.30-11.00 a.m.	• **Chairperson : Dr. P.S. Ahuja, IHBT, Palampur** • **Rapporteur : Dr. Baban Ingole, NIO, Goa** ***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* **Group Discussion** ***(30 Min.)***
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, Jadhavpur 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**
9.00-11.00	• **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 **Group Discussion (15 min.)**
11.00-11.15	***Tea Break***
Session 7	**Strategic Paper and Project Formulation**
12.30- 01.30 p.m.	• **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 Uprety, Emeritus Scientist, IARI, New Delhi *(20 min.)*** **Dr. R. Tuli, Director, NBRI, Lucknow *(20 min.)***
0130-02.30 p.m.	***Lunch***
14.00-16.00	**Presentation of Strategy Plan** **Formation of 04 Groups** **Group Discussion**
16.00-15.45	***Tea Break***
15.45-17.00	Presentation of Sub-Group discussion and Finalisation of the Strategy and Action Plan
12.03.08 (Day 4)	
09.30 a.m. - 12.30 p.m	**Project Finalization** **Lucknow Declaration on** "Climate Change & its Impact on Flora in the South Asian Region"
12.30 to 01.30 p.m.	**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)**

ANNEX 2 – Press Coverage

The Indian EXPRESS

'Regional models needed to forecast climatic variations'

pioneer

Climate change to make N-W drier

city pioneer

Weather

Forest database needed: Hussain

THE TIMES OF INDIA

Scientists raise concern over consequences of climate change

Hindustan Times

Climate change will affect S Asia most: Expert

Hindustan Times

WORKSHOP ON CLIMATE CHANGE AND ITS IMPACT ON FLORA IN SOUTH ASIA REGION

'Uttar Pradesh left with only 2 pc forest cover'

दैनिक जागरण

सड़कों की सफाई हृदयरोग लायी

नवभारत, मंगलवार, 11 मार्च, 2008

युनाइटेड भारत

पर्यावरण फसलों की उत्पादकता का महत्वपूर्ण मुद्दा

एनबीआरआई में देश विदेश के वैज्ञानिकों का जमावड़ा

स्वतंत्र भारत

'जलवायु परिवर्तन से फसल उत्पादन भी प्रभावित'

राष्ट्रीय हिन्दी दैनिक

डेली न्यूज़ ऐक्टिविस्ट

डेढ़ सौ वर्षों में सबसे गर्म रहे बीते 11 वर्ष

हिन्दुस्तान

ऐसे तो डूब जाएगा सुन्दरवन!

जंगल लगाकर किसान कमाएँगे डॉलर

राष्ट्रीय सहारा

राजधानी में तालाब व झीलें भी उगल रहीं मीथेन

राष्ट्रीय

सहारा

जलवायु परिवर्तन का असर झेलेंगे दक्षिण एशियाई

हिन्दुस्तान

जलवायु परिवर्तन से विलुप्त हो जाएँगी वनस्पतियाँ

गोमुख पर भी मिले प्रदूषण के संकेत

अमर उजाला

भविष्य में बढ़ेगा पानी का और संकट

अगले सौ वर्षों में दो से छह डिग्री तक तापमान वृद्धि सम्भव

डेली न्यूज़ ऐक्टिविस्ट

एक डिग्री तापमान कम करता है दस फीसदी कृषि उपज: प्रो. रवीन्द्रनाथ

जलवायु परिवर्तन के दुष्प्रभावों पर विचार-विमर्श के लिए एनबीआरआई में शुरू हुई अन्तर्राष्ट्रीय कार्यशाला

समुद्रों में सबसे अधिक कचरा भारत से: डा.बोज़

■ मौसम प्रदूषण से निपटने को एक हुए साउथ एशियाई देश

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