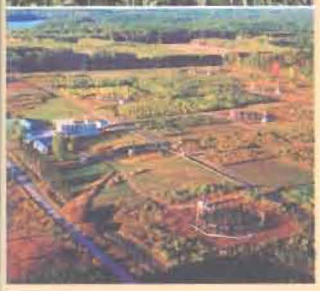

SACEP

International Workshop

on

Climate Change & its Impact on Flora in the South Asia Region

March 9 - 12, 2008

Souvenir & Abstracts

Organized by

National Botanical Research Institute
Lucknow, India

and

South Asia Co-operative Environment Programme
Colombo, Sri Lanka

National Botanical Research Institute, Lucknow
(Council of Scientific & Industrial Research)
(A Premier Institute Engaged in Advance R & D Work in Plant Science)

Technologies & Know-how

Biotechnologies: BT Cotton technology, Tissue culture protocols for trees, ornamental and medicinal plants

Herbal Technologies : Herbal dry colours, Herbal beer, Herbal lipstick, Herbal health drink, Oro-dental care, Brain tonic, Anti-arthritic, Anticigarette, Nutri-jam, Anticough & Antipyretic herbal formulation, Enzyme based anti-oxidant technologies, Herbal black dye, Health protective nutraceutical formulations, Neem-based pesticides & fertilizers.

Microbial Technologies: *Bacillus* and *Trichoderma* based microbial technologies, *Rhizobium* and phosphate solubilising bacteria based technology

Societal benefit technologies/Know-how: Organic cultivation, Dehydration of flowers, Cultivation of *Jatropha curcas* for biodiesel, High Tech Nursery technologies, Neem based products, Biomass generation, Improved varieties of medicinal and industrial plants (Opium poppy, Chrysanthemum, Gladiolus, Amaranth, etc), Betelvine cultivation, Phytoremediation, Ecotoxicology, Reclamation of polluted water bodies and sodic soils, etc.

DESIGNING "PLANTS FOR FUTURE"

By Exploring New Frontiers in

- Plant biodiversity assessment, documentation & conservation, Prospecting plant diversity for genes and metabolic networks for drought tolerance
- Developing transgenic crops of interests to agriculture & industry
- Pathway engineering and system biology
- Discovery and preclinical studies of new bioactive molecules
- Remediation, ecorestoration and cleanup of contaminated soil and water resources
- Exploitation of India's rich microbial diversity
- Plants and plant products for health, agriculture & environment
- Partnerships with herbal & agribiotech industries

National Facilities

- National repository of botanicals: higher & lower plants, Botanic Garden, Floriculture, Herbarium
- Plant Genomics Centre and Central Instrumentation Facilities for genomic and natural products analysis
- NABL Accreditation by DST for performing tests in accordance with ISO/IEC 17025

For details please contact :

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SACEP

International Workshop
on
Climate Change & its Impact on Flora in the South Asia Region

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Organized by

National Botanical Research Institute
Lucknow, India

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Colombo, Sri Lanka

Co-sponsored by

Council of Scientific & Industrial Research,
Govt. of India, New Delhi

Department of Science & Technology,
Govt. of India, New Delhi

Department of Biotechnology,
Govt. of India, New Delhi

Ministry of Environment & Forests,
Govt. of India, New Delhi

Publication Committee

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Mr. Deepak Wahal
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Dr. Pankaj K. Srivastava

Produced by

Mr. Deepak Wahal
Mr. Nirmal K. Saxena

Welcome

Dear Delegates,

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

NBRI is a multi-disciplinary plant research institute under the umbrella 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 role in conserving plant wealth of India and catalysing creative research in growth, development and economic utilisation of plants. Over the years of its progressive growth, NBRI is now a front ranking national centre of excellence for basic and applied research in advanced areas of plant sciences. The Institute has a wholesome expertise in plant biodiversity, biotechnology, bioinformatics, and environmental biology. NBRI is known for its outstanding contributions to enrich the knowledge base on India's plant diversity, particularly in developing globally competent biotech and transgenic technologies, herbal products and bioremediation technologies. The Institute is an important national repository of plant diversity in India.

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 of flora, 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.

Climate change is a vital and widely debated issue at global conventions, world summits, international conferences and symposia. The assessment of impacts of climate changes on natural ecosystems requires more accurate scientific modelling and field studies at regional level. I am sure, this workshop will provide an ideal platform to initiate inter-disciplinary 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 impacts of climate change on flora and vegetation of South Asian region. The workshop should evolve into an important forum to co-ordinate with global agencies to address the climate change challenges to flora in South Asia. It should guide and lead work on the preparedness needed to face the climate change through adaptive and mitigative strategies.

On behalf of NBRI and SACEP, I once again welcome you all to this important event.

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

From Organizing Secretaries' Desk

Dear Friends,

As you are aware, the "International Workshop on Climate Change & its Impact on Flora in the South Asia Region" is being organized jointly by National Botanical Research Institute (NBRI), Lucknow, India, and South Asia Co-operative Environment Programme (SACEP), Colombo, Sri Lanka during March 9-12, 2008 at NBRI, Lucknow. NBRI, a constituent laboratory of the Council of Scientific & Industrial Research (CSIR), Government of India, is a leading R&D Institute in the field of plant sciences. SACEP is an intergovernmental organization, established in 1982 by the Governments of various countries of South Asia to promote and support protection, management and enhancement of environment in the region. The Govt. of India through CSIR, Department of Science & Technology, Department of Biotechnology and Ministry of Environment & Forests is co-sponsoring this workshop. An international advisory committee, with some of the most reputed and highly distinguished environmental and plant scientists, has been constituted to guide and advise the Organizing Committee in planning and holding this workshop. Delegates are coming from Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka.

This workshop aims to provide an international forum for serious scientific discussion and deliberation to develop projections on climate change and its impact on the flora in various countries of South Asia. We hope that the deliberations will offer the new information about the recent developments in various works being carried out on the climate change impact on vegetation. The workshop will prove to be a milestone in the calendar of the climate change research. The participants will offer you the latest information regarding the scenario of climate change in different South Asian countries.

The organizing committee has been working tirelessly and making sincere and sustained efforts to make your participation enjoyable, memorable and fruitful. The committee is privileged and honoured to have the eminent personalities as advisers, who helped us in shaping this workshop. We gratefully acknowledge the contributions of Prof. J.S. Singh for his valuable suggestions while initiating this venture.

This workshop deliberation is aimed to bring out some strategic issues to combat climate change. We invite suggestions from the participants to evolve a regional declaration and recommendation for developing a regional approach to study the effect of climate change on plant growth and development.

We express our sincere and profound gratitude to all the esteemed members for their support which helped us to discharge our duties as the organizing secretaries of the workshop.

(Nandita Singh) (R.D. Tripathi)

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)

South Asia Co-operative Environment Programme,
Colombo, Sri Lanka

Message

Dr. Arvind Anil Boaz
Director General

It is in fulfilment 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 plant 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. Besides 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, 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 modelling 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 have 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 assess 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.

March 4, 2008

Dr. Arvind Anil Boaz

M.S. SWAMINATHAN RESEARCH FOUNDATION

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Message

Prof. M.S. Swaminathan
Chairman

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 droughts, 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)

R.K. Pachauri, Ph.D.

Director-General,
The Energy and Resources Institute (TERI) &
Chairman,
Intergovernmental Panel on Climate Change (IPCC)
Darbari Seth Block, IHC Complex
Lodhi Road, New Delhi-110003

Message

I am very happy to learn that the National Botanical Research Institute (NBRI), in partnership with South Asia Co-operative 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.

Pachauri

(R. K. Pachauri)

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सदस्य
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योजना भवन
नई दिल्ली-110 001
Member
Planning Commission
Yojana Bhawan
New Delhi - 110 001

Prof. V. L. Chopra

Message

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

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

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

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

V.L. Chopra

February 25, 2008

(V.L. Chopra)

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Prof. Samir K. Brahmachari

Director General, CSIR
& Secretary,
Government of India
COUNCIL OF SCIENTIFIC & INDUSTRIAL RESEARCH
Department of Scientific & Industrial Research
Anusandhan Bhawan, 2, Rafi Marg,
New Delhi - 110001

Message

I am pleased to note that the National Botanical Research Institute, Lucknow, and the South Asia Co-operative 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.

New Delhi
March 4, 2008

(Samir K. Brahmachari)

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MINISTRY OF EARTH SCIENCES
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Lodhi Road, New Delhi-110 003

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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University of Lucknow
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Prof. A.S. Brar
F.N.A.Sc.
Vice Chancellor

Message

It gives me immense pleasure that an 'International Workshop on Climate Change and its Impact on Flora in the South Asia Region' is being organized jointly by the National Botanical Research Institute (NBRI), Lucknow and South Asia Co-operative Environment Programme (SACEP), Colombo, Sri Lanka, during March 9-12, 2008 at NBRI, Lucknow.

The efforts of the NBRI and South Asia Co-operative Programme (SACEP), Colombo are expected to provide an International forum for deliberations to develop projections on climate change and a souvenir is also being published on this occasion. I hope the souvenir will be very useful for the distinguished guests and delegates.

I congratulate delegates and guests who will deliberate on the issue in this International Workshop and give useful recommendations on the climate change. I extend my good wishes for the success of the souvenir.

February 22, 2008

(A.S. Brar)

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(Formerly Industrial Toxicology Research Centre)
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Lucknow – 226 001(U.P.) India

Dr. Ashwani Kumar
Acting Director

Message

I am extremely happy to note that the International Workshop on 'Climate Change & its Impact on Flora in the South Asia Region' is being held at National Botanical Research Institute, Lucknow. Lucknow is a scientific hub with a large number of research institutions, and universities. It is a timely event, as global warming has become an important concern all over the world. This workshop will help in evaluating the probable consequences of such a climate change and its impact especially on flora of the region and subsequently suggest remedial measures to overcome its effects.

I wish the workshop a grand success.

Ashwani Kumar

(Ashwani Kumar)

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Dr. Tapan Chakrabarti
Acting Director

Message

In the fourth assessment report of IPCC (IPCC AR4) the rise in mean annual surface air temperature all over the globe is projected to be in the range 1.4 to 5.4 °C and for South East Asian region the range is 1.5 to 3.6 °C. The predicted impact of climate change is mainly manifested by the shrinking glaciers, lengthening of seasons, altitudinal shifts of plants and decline of plant populations. Many plant species respond to climate change by advancing the onset of leaf burst, flowering and fruiting and delayed leaf-shedding. Natural systems are also vulnerable to climate change. Besides, the life support systems on earth, coastal zones and marine systems are also susceptible to the impacts of global climate change.

Climate change is a vital and widely debated issue globally. South Asian countries, including India, show a wide range of variation in climate, altitude and physiography. The assessment of impacts of climate change on natural ecosystems would require more accurate scientific modelling or field studies at various levels.

The issues of vulnerability and adaption of biodiversity, agriculture and forestry due to climate change will be discussed in this Workshop. This will be an ideal forum to share the knowledge and information related to climate change. The deliberations and discussions in the Workshop would certainly assist in developing appropriate strategic action plans to assess the impacts of climate change on flora and vegetation and promote mitigation and adaptation mechanism to climate change in South Asian countries.

This is extremely important and is being organised by NBRI, Lucknow, at an appropriate time. I wish the Workshop all success !

T. Chakrabarti

February 20, 2008

(Tapan Chakrabarti)

Biotech Park in Biotechnology City, Lucknow
Where Cutting Edge Science Prospers
(Promoted by Department of Biotechnology, Government of India and
Department of Science & Technology, Government of U.P.)

Prof. P.K. Seth, Ph.D
FNASc, FNA, FAMS

Chief Executive Officer
Biotech Park, Lucknow &
Former Director, ITRC
Sector-G, Jankipuram, Kursi Road
Lucknow – 226021 (U.P.), India

Message

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

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

The whole world is in our hands--the outcome and existence of life will be determined by our actions. This is our opportunity to make the Earth, a better place. In this context, the present workshop assumes a great significance. I am sure the outcome of the workshop will go a long way in drawing some tangible action plan.

I wish all success to the workshop and congratulate the organizers for selecting such an important topic of current interest.

March 3, 2008

(P.K. Seth)

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Patrons

Dr. Rakesh Tuli, Director, NBRI Dr. A. A. Boaz, DG, SACEP

Organizing Secretaries

Dr. Nandita Singh & Dr. R. D. Tripathi, NBRI

Advisory Committee

Prof. J. S. Singh	Prof. C. K. Varshney	Dr. Subodh Sharma
Prof. S.P. Singh	Prof. R. S. Tripathi	Dr. K. J. Ahmad
Dr. P. K. Seth	Dr. D. C. Uprety	Prof. R. S. Dubey
Dr. Ashwini Kumar	Mr. Hiran TilakRatne	Dr. S. C. Sharma
Prof. M.N.V. Prasad	Dr. S. N. Singh	Dr. P. Chandra
Dr. Madhoolika Agarwal	Dr. D.V. Amla	Dr. U. Pathre
	Dr. Bajrang Singh	

Local Organizing Committee

Convener : Dr. P. B. Khare

Administration & Finance :	Mr. A.K. Seth, Mr. D. Kumar, Mr. G. Mishra, Mr. G. D. Chakraborti
Publication :	Dr. K. N. Nair (Chairman), Mr. Deepak Wahal, Dr. P. K. Trivedi, Dr. Vivek Pandey, Dr. Pankaj K. Srivastava
Scientific Programme & Hall Management :	Dr. U. N. Rai (Chairman), Dr. S. Behera, Dr. D. Chakraborthy, Dr. Sanjay Dwivedi, Ms. Sarah Jamil
Photography :	Mr. A. C. Little, Mr. Alok Kumar
Food :	Dr. J. K. Johri (Chairman), Mr. Nirmal K. Saxena
Accommodation :	Dr. D. K. Upreti (Chairman), Dr. S. Mallick, Dr. V. S. Baghel
Transport :	Mr. S. K. Dhamija (Chairman), Dr. A. K. Asthana, Mr. Sandip Behera, Mr. Vinay Sahu, Mr. M. K. Shukla
Reception & Registration :	Dr. Sarita Sinha (Chairperson), Dr. K. Kulshreshtha, Dr. Seema Mishra, Dr. L. Tyagi, Mr. Geet Govind
Cultural Programme :	Dr. P. B. Khare
Press & Media :	Dr. S. K. S. Rathore (Chairman), Dr. A. K. Gauniyal, Dr. R. N. Gupta

South Asia Co-operative Environment Programme (SACEP)

An Overview

South Asia Co-operative Environment Programme (SACEP) is an inter-governmental organization, established in 1982 by the Governments of South Asia to promote and support protection, management and enhancement of the environment in the region. Eight countries, namely; Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka have ratified the Articles of Association of SACEP. All member countries of SACEP belong to the developing world, and five have been classified as least developed. Most of these nations share many similar environmental problems, stemming from poverty and its consequences on natural resources.

Since its inception, SACEP has promoted sustainable development in the region by implementing a number of projects and programmes in the fields of environmental education, environmental legislation, biodiversity, air pollution, and the protection and management of the coastal environment with the assistance of various bilateral and multilateral funding agencies. It is a multilateral organization registered with the UN Secretariat in accordance with article 102 of the charter of the United Nations. Its mission is to promote and support protection, management and enhancement of the environment in the region.

SACEP is hosting the South Asian Seas Programme which is one of the eighteen regional seas programmes of the UNEP. The Malé Declaration on control and prevention of air pollution and its likely transboundary effects for South Asia is another significant effort which encourages intergovernmental cooperation to combat the transboundary air pollution problem. SACEP has long term experience of working in collaboration with several multilateral and bilateral agencies and number of MoUs signed with organizations *viz.* UNEP, WMO, UNESCO, IUCN, IMO, ICRAN, UNEP-GPA, SAARC, TRAFFIC, RECOFTC, TRADA, etc.

Vision and Objectives

The SACEP was created to fulfill a vision based on the following five assumptions :

1. The types and scales of environmental degradation taking place in the South Asian Region is positively dangerous not only to economic development but also to the survival of the humans inhibiting it.
2. The greed of the rich and the needs of the poor continue to cause irrevocable damage to the fragile ecosystems and their ability to regenerate themselves.
3. There is an urgent need to reduce environmental degradation and pollution, while giving equal emphasis to the elimination of the root causes of environmental degradation such as poverty, over population, over consumption and waste production.
4. Environment and development are two sides of the same coin and therefore integration of environmental concerns in to development activities should be recognized as an essential prerequisite to sustainable development.

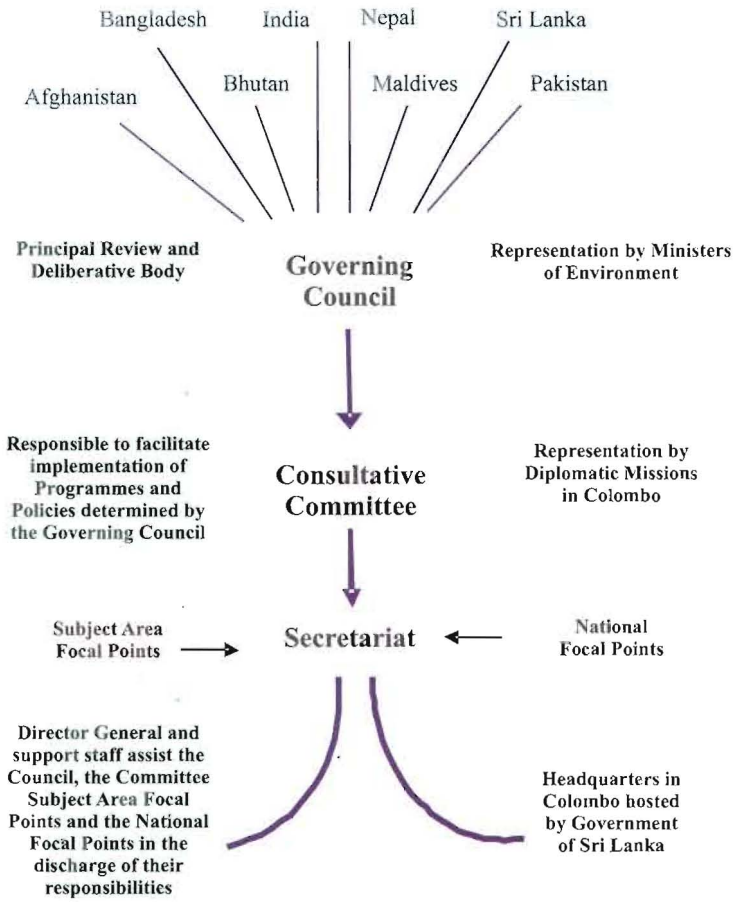
5. The ecological and development problems of the South Asian Region transcend national and administrative boundaries; hence co-operative action is needed to effectively address them.

Functions

The functions of SACEP are to promote co-operative activates which would be beneficial to member countries in priority areas of mutual interest, facilitate exchange of knowledge and expertise and provide local resources for implementation of priority activities while mobilizing maximum constructive and complementary support from donor countries and agencies.

Organizational Arrangement

The Secretariat is based in Colombo, Sri Lanka. Colombo Declaration and Articles of Association of SACEP constitute the legal basis for SACEP. The principle organs of the governance structure (organization structure) of SACEP are the Governing Council (GC), Consultative Committee (CC), National Focal Points (NFP), Subject Area Focal Points and the SACEP Secretariat.



In accordance with the Articles of Association, the Organizational arrangement of SACEP is made up of five main sub units; The Governing Council, Consultative Committee, National Focal Points, Subject Area Focal Points and the Secretariat.

National Focal Points

Each Member State has designated a National Focal Point to facilitate the work of the Secretariat and to function as the main communication link between the Secretariat and the respective country. National Focal Points are expected to implement and monitor national programmes in co-operation with the Secretariat.

Recent Milestone Events of SACEP

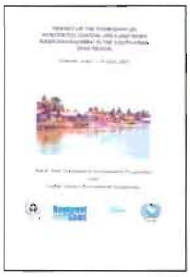
The emergence of The South Asian Co-operative Environment Programme was the culmination of years of deliberation by the countries concerned, on the feasibility of regional co-operation on environmental oriented development activities. Following are the milestone events of SACEP from 2005 to 2008 in its efforts for regional co-operation in environment protection and management of the South Asia.

Year	Events
2005	• 25th August, Thimphu, Bhutan - Third Intergovernmental Meeting of Ministers of SAS • 25th August, Thimphu, Bhutan – Ninth Governing Council Meeting of SACEP • 3 – 6th October, Chennai – Regional Workshop on measures to collect, handle, treat and dispose of f waste generated in applying AFS • 5 – 7th October, Colombo – UNEP/SACEP/FIELD South Asia Workshop for MEA Negotiators • 22nd November, Colombo – Signing of MOU with World Meteorological Organization • 12th December - MOU between UNEP Regional Office on SACEP and SENRIC Activities • 16th December, London – Signing of Letter of Agreement with International Maritime Organization ensuring maximum co -ordination of work and activities of common Interests
2006	• 16 – 20th January – Colombo Regional Sem inar/Workshop on Ratification and Implementation of The OPRC -HNS Protocol, The AFS Convention and Identification and Establishment of PSSA's • 9th May – MOU under Phase III Implementation of Male Declaration on Control and Prevention of Air Pollution an d its Likely Transboundary Effects • 27th July – EU Project on Long term Management and Conservation of Marine and Coastal Protected Areas in South Asia – MOU signed with UNEP GPA • 9th August – MOU between SACEP and IUCN World Conservation Union Asia Region on Complementary and Mutual Support • 18 – 28th August – Colombo South Asian Games – Waste Management Campaign • 18th September – Observance of Coastal Cleanup Day under the Marine Litter Project

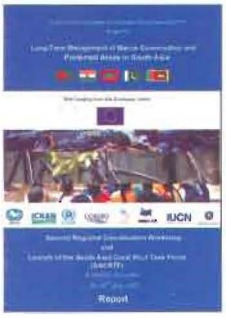
	• 27 – 28th September, Colombo – SACEP – ICRAN Regional Resource Co ordination and Mobilisation Workshop on Long term Management and Conservation of Marine and Coastal Protected Areas in South Asia • 25th October – Signing of Contract with the Royal Belgian Institute of Natural Sciences (RBINS) on "Capacity Building for the Clearing House Mechanism of the Convention on Biological Diversity in South Asia, through informing the Public and Training Post Graduate Students: A Case Study for Sri Lanka" • 27 November – 1st December – Basel Convention COP 8 Decision on Establishment of a Regional Centre at SACEP
2007	• 10th January – Scoping Exercise on Adaptation to Climate Change held in Colombo, Sri Lanka. • January Chennai – Workshop on Livelihood Application under th e SACEP – ICRAN Regional Resource Co -ordination and Mobilisation Workshop on Long term Management and Conservation of Marine and Coastal Protected Areas in South Asia • CHM Workshop with Royal Belgium Institute for Post Graduate Students, March 26-29, 2007. • SIDA funded UNEP -SACEP Malé Declaration Project, the National Stakeholders forum of Sri Lanka was held on 12 th June 2007 at the Auditorium of the Central Environmental Authority of Sri Lanka. • A School Environment Awareness Programme on SACEP's priority ar eas was conducted in Sri Lanka in collaboration with the CEE, with the participation of several schools in Colombo municipal area. The Award ceremony was held on 16th of July, 2007 at the Mahaweli Center Auditorium, Colombo 07. • Second Regional Workshop was held from 25 – 27 July 2007 workshop titled "Regional Resource Coordination and Mobilsation Workshop for the Long -term Management and Conservation of MCPAs in South Asia" • A Regional Workshop on Development of a Regional Activity on Marine Litter for the South Asian Seas Region was held on 20 – 21 August 2007 in Colombo, Sri Lanka. • Establishment of BASEL Convention Regional Centre at SACEP - September 2007, Open Ended Working Group at Hague • Market Based Instrument Study, Sri Lanka with support from UNEP -GPA • UNESCO-SACEP Gulf of Mannar Workshop, Chennai, 21 -22 Sep, 2007 • UNESCO SACEP MoU for CHM Workshop • First coordination meeting of the South Asia Coral Reef Task Force (SACRTF)" Under the European Union (EU) funded project, Preparations are made to hold the first coordination meeting of the South Asia Coral Reef Task Force (SACRTF) on 21st December 2007 . • Various MoUs -UNESCO, TRAFFIC, TRADA, RECOFTC, UNEP for mutual collaborations • Scoping Exercise on E -Waste Management in South Asia, New Delhi, India, on 21st Dec, 2007.
2008	• South Asia Regional Strategic Plan on Wildlife Trade has been drafted. A Ministerial meeting to initiate the process of Regional co -operation and Developing Regional Strategy and Action Plan held in January 2008 in Kathmandu, Nepal.

Recent Publications

Report of the Workshop on Integrated Coastal Area and River Basin Management in the South Asian Seas Region: Chennai, India. This report is a compilation of workshop proceedings, ICARM case studies and pilot project proposals presented at the workshop .



Silver Jubilee souvenir



Report of the Workshop on Long-term Management and Conservation of MCPAs in South Asia held in Colombo, Sri Lanka. This report is a compilation of workshop proceedings, and Coral Reef Task Force information presented at the workshop.

Workshop Report: South Asia Workshop for MEA Negotiators, October 2005, Colombo, Sri Lanka. The report is the compilation of workshop proceedings and case studies presented during the workshop.

Leaflets published for Marine and Coastal Protected Areas & Solid Waste Management programme for South Asia

10th Governing Council (GC) of SACEP

The Tenth Meeting of the Governing Council (GC) of SACEP was held in Kathmandu, Nepal on 25 th January, 2007. Chief Guest, H.E. Dr. Ram Sharan Mahat. (L) handing over a souvenir to the Chairman – Hon. Man Bahadur Vishwakarma. Dr. A.A. Boaz Director General of SACEP in the center

SACEP signed a MoU with UNESCO Asia Region MoU

SACEP and UNESCO signed MoU on March, 2007. Dr. A.A. Boaz, Director General o f SACEP and Dr. Minja Yang, Asia representative of UNESCO exchanging the MoU at New Delhi on 21st March, 2007

Lucknow - The Host City

B.R. JUNEJA

Ex- Scientist, National Botanical Research Institute, Lucknow

There was a time, and it wasn't very long ago, when the very name of Lucknow conjured up, almost all over the North India, a vision of a beautiful city of *nawabs* (Kings), decked out in their majestic splendour, of their grand *darbaars* (courts), of courtiers and courtesans, of their harems, full of innumerable queens and concubines and guarded by eunuchs as per the muslim tradition, of their royal pursuits like *kabootar-, bater-* and *patang-bazi* (pigeon, partridge and kite-flying, respectively), cockfights, elaborately arranged and never-ending games of chess, of heady perfumes and *itra,* of mouth-watering *kababs* and *biryani,* of out-of-this world cuisine, of dance and music *mehfils,* of mushairas and romantic urdu poetry, of heart-warming social graces and fine etiquettes, not of the royals alone, but, of the common man as well, and of a leisurely pace of life in general. It was the time when *Pahle Aap* (you first or after you, please), *nafaasat* (refinement and sophistication of taste, even in mundane activities), *nazaakat* (delicacy or tenderness of gesture and feelings) and *balaaghat* (eloquent and elegant speech) truly epitomized the social life of Lucknow. Added to all this was the famed Ganga-Jamuni culture of its populace, implying not merely social co-existence, but complete social and cultural integration of various communities and classes, inhabiting Lucknow, as one highly cultured people!

Lucknow of today is certainly a metro town in its own right. It has come to have a population of over two million, over a dozen R&D institutions of international repute, five universities, plus the latest addition of university of music, and number of management and coaching institutes, medical colleges and state-of-art hospitals and nursing homes, 3-, 4-, 5-star, multi-cuisine hotels, cafes and restaurants, etc.

However, the story of Lucknow and its people neither began with its *nawabs* and their times, nor does it end with the preceding paragraphs. It is a very lengthy, but absorbing story, inter-woven with prehistoric events, changing dynasties, shifting fortunes, acts of valour and heroism, of patriotic fervour, of deceit and intrigue, of development and promotion of architecture, fine arts and handicrafts, of amusing social customs, hobbies and interests of unique sites and smells, of religious and communal harmony rarely seen elsewhere, of the *pauranic,* and hence sacred river Gomti, once embanking and now running through the middle of the town, of prestigious seats of learning and scholarship and, lately, of all round scientific and technological development of unimaginable proportions!

HISTORY

Traditionally, the origin of the city is dated during the period of the great epic, 'Ramayana'. It is believed to have been founded by Lord Rama's younger brother, Lakshman, (ca. 1950 B.C.) after whom it was named as Lakshmanpuri. Supporting this traditional origin is the presence of an ancient mound, called Lakshman Tila, to the north west of the town, near the Hardinge Bridge. The antiquity of the town, however, is also authenticated by the recovery of certain archaeological objects, dating back to 7th century B.C., from the chance diggings at this mound. Recorded history, however, mentions Lucknow as a part of the mighty Koshala kingdom, which flourished during the first and second centuries B.C.

Another view, however, links the origin of Lucknow to an architect named Lakhna who, sometimes during the medieval period, built a fort, at the site where now stands the present Chtrapati Sahuji Maharaj Medical University (formerly King George's Medical college) and which came to be known as *Qila Lakhna.* Gradually, a township grew up around the fort and this began to be called *Lakhnau,* replacing the old name Lakshmanpuri. *Lakhnau* was later anglicized by the British, as Lucknow.

Akbar's historian, Abul Fazl, is all praise for the Lucknow environs and its climate, its flowers, fruits and other cultivations, particularly, different varieties of rice, which were matchless for their whiteness, freshness, fragrance and taste. Lucknow immensely gained its political importance when Nawab Asaf-ud -Daula, the builder of Great *(Bara)* Imambara, shifted the capital of Avadh from Faizabad to this town and since then it has enjoyed this pre-eminent position in one form or another. After independence also, Lucknow was made the capital of Uttar Pradesh, the largest State in the country.

During the first war of Independence, misnamed by The British as the Sepoy Mutiny of 1857, along with Delhi, Meruth and Kanpur, Lucknow was a major battle front between the patriotic Indian soldiers and the British forces. The 87-day long siege of the British Residency is a well-known episode in the annals of the battle of Lucknow and bears eloquent testimony to the grit, determination and organization of the freedom fighters. The battle front of Lucknow remained active for almost full one year and finally fell to the British by mid-March, 1958. The victorious British forces behaved no better than the notoriously barbaric soldiers of the likes of Changhez Khan, Timur Ling and Ahmed Shah Abdali and indulged in large-scale looting of palaces and manshions, vandalism and genocide. Finally, with the British Crown taking over the administration of India, on November 1, 1859, Lucknow became a major city of British India.

HISTORICAL MONUMENTS AND OTHER BUILDINGS OF TOURIST INTEREST

Most of the historical buildings of Lucknow were constructed within a short span of about 100 years during the *nawabi* era and the construction materials mostly used were brick and mortar instead of stone and marble. And it goes to the credit of the architects of that period that these buildings have withstood the ravages of time remarkably well. A brief account of the notable historical monuments and other buildings of interest is given below:-

The Rumi Darwaza : Rumi Darwaza (gate) is to Lucknow what the Gateway of India is to

Mumbai, the symbol of the city! Built during 1784-86, and designed to replicate one of the gates of Constantinople, it stands about 20 metres high and straddles the main road leading to the Bara and Chhota Imambaras.

The Bara (big) Imambara : Built by *nawab* Asaf-ud-Daula in 1784, this grand building impresses one with its sheer expanse and high terraced approach. Its grand hall, without any support of any sort, except its 4.5 m (16 feet) thick walls measures 49.5m x 16m x 15m (162 ft x 53 ft x 50 ft) and is the largest vaulted hall in the world! Its whispering gallery and the Bhool Bhulaiyaan (labyrinth) are additional attractions. The *nawab* and his queen are buried here. Its construction is said to have been started by the *nawab* as a charitable gesture, to provide means of livelihood to the people of Lucknow, which had been hit by the worst famine during his reign.

The Chhota (small) or Hussaini Imambara : Situated close to the *Bara* Imambara, *Chhota* Imambara is comparatively much smaller, less old and less grand, but, more picturesque and has verses from the Quran inscribed all over it. Imported, folding glass chandeliers, gilt-framed mirrors, silver pulpit, fine specimens of Arabic and Urdu calligraphy and a few other curio pieces are its added attractions. King Mohammed Ali Shah and his mother are buried here. In the courtyard of this Imambara is a raised water tank, which is flanked, on either side, by a small replica of the Taj Mahal!

The Picture Gallery : Originally built as *Baradari* (a rest house with 12 doors) and situated at a short distance away from the *Chhota* Imambara, it is in poor condition now, but the collection of well maintained, life-size oil portraits of all the *nawabs* of Avadh, housed here, is worth a visit.

The Residency : The construction of this famous building, on a mound overlooking the river Gomti, was taken in hand by Asaf-ud-Daula and completed by *nawab* Saadat Ali Khan in 1800. Originally meant to be a rest house for the English visitors, it became the permanent residence of the British Resident and his paraphernalia. Later, a number of other buildings and apartments were constructed around it and the whole

campus became an exclusive European settlement. It was heavily bombarded and damaged during its siege and what remains now are only its ruins. Of course, there is an underground museum housing relics of the First War of Independence.

The Shaheed Smarak (Martyrs Memorial) : Thoughtfully constructed opposite the Residency and in a well laid-out park along the Gomti bank, this candle-shaped tower of pure white marble was erected in the memory of all those who laid down their lives in the cause of India's Independence. The white marble flame, atop the tower is lit red at night and is visible as a red flame (of Independence) from far and wide. It is a post-independence addition to the worth-seeing places of Lucknow. Every year, in a very impressive and touching *'deepdan'* ceremony, held late in the evening, earthen lamps are floated in the river Gomti and prayers are held for the martyrs of India's Independence.

The Bari (large) Chhatar Manzil: Situated almost in the heart of the town, along an arterial road, this large and spacious mansion draws its name from the golden umbrella, a sign of regal splendour, fitted on its top. Right opposite it was constructed the *Chhoti* (small) Chhatar Manzil and both these *manzils* or mansions were used as the royal harems. Bari Chhatar Manzil had an ingenious device for cooling it during summer and it consisted of a network of underground chambers, which were filled with the Gomti water, drawn in through specially laid-out conduits, directly connected with the river. It now houses the Central Drug Research Institute.

The LaMartiniere College : Situated on the outskirts of Lucknow, this vast, sprawling building is unique in its concept and architecture. It was built around 1800 by Lord Claude Martin, a French general, who had come to Lucknow as a small-time soldier and rose to become one of the richest men of that time. He wanted it to be his lordly mansion but died before the building was completed. He, however, had the consolation of getting buried here. He had willed the building to be used as a model educational institution and that is what it has come to be.

The Vidhan Bhavan or the Council House : A very fine and impressive example of fusion of eastern and western styles of architecture, and made of Mirzapur sand stone, the Vidhan Bhavan building is, comparatively, of recent origin, having been built in 1922. It houses the bicameral legislature and the secretariat of the State Government and lies along the local highway, the Vidhan Sabha Marg.

The Charbagh Railway Station : It is the main rail junction of Lucknow and its building, constructed around the same time as the Vidhan Bhavan, is considered to be one of the most beautiful among those of the other railway stations of the country. Again, a brick and mortar structure, its old-worldly architectural grandeur, with symmetrical small minarets and domes of different sizes, make it a very attractive and impressive building.

The Globe : A huge globe in concrete, arched by zodiacal signs and supported by a fish placed in the midst of a water pond, is a modern landmark of Lucknow. A gift by an erstwhile mayor of the town, it is situated in a rather obscure corner of the Begum Hazrat Mahal Park, opposite the *Chhoti* Chhatar Manzil. It is put in rotation on certain occasions.

The Shri Ram Krishna Temple : The latest addition to the worth-seeing buildings of Lucknow is the Shri Ram Krishna Temple, built recently within the Ram Krishna Math at Nirala Nagar. The temple has the architectural beauty of its own, built in a typical temple style of Bengal, but with a touch of modernity.

PARKS AND GARDENS

Lucknow has always enjoyed the reputation of being a city of parks and gardens and a large number of its localities and bazaars are named as such e.g., Alam Bagh, Charbagh, Kesar Bagh, Lal Bagh, etc. However, most of the parks and gardens, lovingly laid out here by the *nawabs* of Avadh, have gradually faded away, and in their place several new parks and garden-cum-amusement parks have been established, thanks to the State and town administrations and some private enterprises. Prominent among these are the Buddha Park, *Haathi Park, Gulab Park,* Lakshmana Park, *Suraj Kund Park,* Zoological gardens, Din Dayal Upadhyay Park, Ambedkar Jayanti Park and the Kukrail Picnic Spot. While huge mechanical joy rides, paddle boats and swings at the Buddha and *Haathi Parks* are a great draw with the children, Kukrail Picnic Spot boasts of a crocodile breeding station, a deer

sanctuary and a rehabilitation centre for certain endangered animal species. The Ambedkar Jayanti Park, still under development, is an ambitious project, worth several hundred million rupees and covers hundreds of acres of land. When completed, it would vie with the best of parks in the world!

Within the Zoological gardens campus also lies the State museum which possesses, besides a noteworthy numismatics collection and picturesque nature galleries, a rare exhibit of about 3000-year old Egyptian mummy.

ARTS, HANDICRAFTS AND LITERATURE

Lucknow has earned a name for itself as the cradle of fine arts, handicrafts and Urdu and Hindi literature and its fame continues to spread far and wide in these fields. Lucknow is considered as the home of *Kathak,* one of the main half a dozen forms of Indian classical dance and the only one form North India. Right from the Binda Din-Kalaka Prasad Maharaj duo, a number of illustrious masters of *Kathak, viz.* Pandit Acchan Maharaj, Pandit Kishan Maharaj, Pandit Lachhu Maharaj and their descendants like Pandit Birju Maharaj have hailed form Lucknow. *Thumari, Daadra, Qawaali, Marsia* and *Soze-Khwaani* are some of the classical and popular forms of vocal music developed here. These arts received great intial impetus by the overzealous royal patronage during the rule of *nawab* Wajid Ali Shah who himself was no mean a dancer, actor, singer and composer.

Establishment of the School (later College) of Arts and Crafts in 1911 and the Bhatkhande College of Hindustani Music (Bhatkhande Sangeet Mahavidyalaya) in 1926 set in motion regular training and specialization in various forms of dance and music, painting, sculpture, printing, etc. Some of the world renowned musicians, dancers and painters have honed their skills in these institutions. The Bhatkhande Sangeet Mahavidyalaya has attained such an excellence in dance and music that it has recently been elevated to the status of a deemed university and its Principal has been redesignated as Vice-Chancellor, a rare distinction indeed, for an artiste!

Embroidery styles, such as *zardozi, chikankaari* and *batik* painting of textiles have also brought worldwide laurels to the artisans of the city. The manufacturers of *itrs* and scents of the city have caste a spell of their perfumes all over the eastern world, with *Shamamat-ul-itr* or *itr-e-shamama*

being a special favourite with the Middle Eastern countries where it is known as the king of perfumes! And whoever heard of an earthen scent. Well, the ingenious perfumers of Lucknow once used to prepare an *itr* even from earth and it was a prized perfume with the royals!

Along with the artistes and artisans, writers and poets of Lucknow have also created a niche for themselves in the fields of Hindi and Urdu literature. The Lucknow school of Urdu poetry is as much respected as the Delhi school.

CENTRE OF EDUCATION

Lucknow is among the oldest centers of education and higher learning in the country and has the distinction of having five universities- the Lucknow University, the B.R. Ambedkar University, the Indira Gandhi National Open University (IGNOU), the Bhatkhande University of Music, and the Chhatrapati Sahuji Maharaj Medical University (CSMMU), the first one having been set up as early as 1921. The CSMMU is about a hundred years old, having been set up and formally opened by King George V of England, in 1911.

Nadvat-ul-Ulema, popularly Known as Nadva, is also an old institution of higher education and learning in Islamic studies and is considered one of the leading institutions of its type in the world. The Indian Institute of Management, comparatively a younger institution, has rapidly acquired a national stature and has been casting the spell of management *mantra* over the country's youth.

A SCIENCE CITY

Setting up of the Birbal Sahni Institute of Palaeobotany (BSIP) at Lucknow during the late forties started a chain reaction in that the following two decades witnessed the establishment, one after another, of a host of national laboratories and institutes in various fields of R&D. Prominent among these institutions are: Central Drug Research Institute (CDRI), National Botanical Research Institute (NBRI), Central Institute of Medicinal and Aromatic Plants (CIMAP), Indian Institute of Toxicology Research (IITR), Indian Institute of Sugarcane Research (IISR), Central Institute of Subtropical

Horticulture (CISH), Railway's Research Design and Standards Organization (RDSO), Geological Survey of India (Northern Region), Sanjay Gandhi Post Graduate Institute of Medical Sciences (SGPGIMS) and National Research Laboratory for Conservation of Cultural Property (NRLC). And the chain reaction is still going on, with the establishment of the National Bureau of Fish Genetic Resource (NBFGR) and the Biotech Park. Besides, there are several other research institutions and Ayurvedic, Homoeopathic and Unani medical colleges belonging to the State Government. Many of these laboratories are multidisciplinay in character and command an international repute. Consequently, Lucknow has over the years, become a major Centre of scientific research, particularly, in the field of biological sciences. The Regional Science Centre, established during the mid-eighties, is doing a yeoman's service in inculcating an interest in science among school-going children and educating them about science around them in their daily life.

Of late, I.T. explosion in the country has added another dimension to the R&D character of the town. Almost all the leading I.T. companies have set up their own centres or have franchises for computer education. A Cyber park is already being developed here and soon Lucknow is also going to acquire the status of a cyber city as well.

National Botanical Research Institute

Marching Ahead to Develop Plants for the Future

History of Botanic Garden

Established in 1953 as National Botanic Gardens (NBG) under the umbrella of Council of Scientific & Industrial Research (CSIR), the institute was renamed as National Botanical Research Institute (NBRI) in 1978 to reflect its national impact and promote the R & D component. Botanic Garden at NBRI surrounds, within its limits, the historical Sikandar Bagh laid out around 1800 AD. Sikandar Bagh was a historical garden, initially built on only 150 square yards. CSIR/NBRI has developed it into a precious national repository of plant germplasm and a globally reputed centre of advanced researches in plant sciences.

New Introductions to Botanic Garden

The Botanic Garden at NBRI harbours more than 5,000 taxa of endemic, exotic and threatened plants. The Garden houses conservatories with a collection of Bougainvillea, Gladioli, Roses, Cacti, Succulents and house plants. The most recent addition is a conservatory of Orchids (a wondrous group of flowering plants known for their floral beauty, diversity and specific habitats) with a collection of 50 different species. Plant introduction is one of the most significant activities in NBRI Botanic Garden. Some of the recently introduced plants of economic and education value are : *Adansonia za* (a related species of Kalpavriksh [*Adansonia digitata*], introduced for the first time in India from Madagascar; *Clerodendrum speciosissimum* (from Java & Sri Lanka); *Jacaranda cuspidifolia* (from Brazil), and an indigenous species-*Butea superba* (climbing Dhak) from Sonbhadra forests. NBRI's Botanical Garden has a rich collection of the Cycads, a unique group of plants called "living fossil" and several unique ferns and ferns allies. These new additions to the Botanic Garden are now open to teachers and students from schools and institutes of higher learning to enhance their knowledge of plant life and take up challenging researches to unravel the mysteries of plant growth, development and utilization.

R& D Programme

NBRI is a front ranking plant based multi-disciplinary national centre of excellence for basic and applied research in advanced areas of plant sciences. NBRI is known for its national role in promoting both classical and cutting edge research in Systematic Botany, Conservation Biology, Plant Diversity Prospecting, Plant Improvement, Genomics and Plant Biotechnology, Primary and Secondary Metabolism, Botanical Informatics and Floriculture.

The Institute has developed a wide range of IPR covered technologies, products and processes. Some of these are: insect resistant transgenic plants, plant-based products for health and industry, nutraceuticals, cosmeceuticals, natural dyes, biopesticides and plant growth promoting microbes. Technology packages based on microbes cover about 1, 00,000 hectares of farms. Recently, NBRI developed the 'India Herbal Garden' at WHO (HQ), Geneva, showcasing some of the India's medicinal plant wealth.

NBRI has major programmes in molecular analysis of genetic diversity of plants, manipulation of metabolic pathways, protein engineering, genetic transformation of cotton, groundnut, pigeonpea and chickpea, molecular biology of fruit ripening and senescence, genetic enhancement of Bougainvillea, Gladiolus, Amaranthus, Opium Poppy, restoration ecology, environmental audit, usar soils, etc. The poppy varieties developed at NBRI are cultivated in about 6000 hectare. The floriculture group has released nearly 200 new cultivars of ornamental plants and imparts training in dry floral crafts across the country. NBRI steers a major biodiesel programme and maintains a large collection of petro crops (including 'Jatropha').

New Model in Public Private Partnership with Equity Sharing

NBRI has the distinction of designing the first ever novel: δ-endotoxin gene and synthesizing it chemically to develop transgenic Bt-cotton indigenously. The Institute is now launching a larger programme jointly with seed industry and six other institutes for developing transgenic lines of cotton with multiple genes effective against both leaf-eating (herbivores) and sucking pests. An agreement including 30% equity participation by seed industry and sharing of royalty was signed at CSIR on July 27th 2007 to take up this challenging task. NBRI will coordinate the multi-institutional project that includes four partners from seed biotech industry. The industry partners are JK Agri Genetics, Krishi Dhan Seeds, Swagat Biotech and Amareswara Agritech and the total overlay is about Rs. Six crores through the next three years.

Plant Genomic Facility for Designing Plants for Future

Yet, another area, where NBRI has launched a major project with JK Agri Genetics is for improving fibre quality and drought tolerance in cotton. A Joint research project for 5 years costing 10 crores as a major initiative based on a state-of-art genomics of cotton will be taken up. The Institute has procured a genomic expression analysis system, called Affymatrix Microarray, the first system now available in Lucknow. It will soon be completed with a state-of-art Whole Genome Sequencing platform that can execute 2,00,000 parallel sequencing reactions. Other advanced facilities, including high throughput genotyping systems and capillary sequencer are being procured. The Institute has taken a big leap forward by establishing the Plant Genomic Facility in Lucknow. The facility will open unfathomable gateway to the genome based knowledge to identify new genes. This will provide opportunities to break the barriers for enhancing the yield of crop plants. Several service providing biotechnology companies are in discussion with NBRI to develop partnerships, where they would run and manage the knowledge based-state-of art technology-driven genomic facility in a semi commercial mode in national interest.

Validation of NBRI's Herbal Formulations

The herbal formulations developed on the basis of leads taken from traditional knowledge including Ayurveda literature, have been validated by external sources for efficacy and safety studies on animal systems. In this direction, scientific validation of two prominent herbal formulations has been done for wound healing and ulcer. These are now being taken up for clinical studies, jointly with industry.

NBRI's Biofertilizers for Organic Cultivation

The plant growth enhancing biofertilizers developed at NBRI by isolating unique strains of bacteria from soils of various agroclimatic zones of India have been used this year on large scale in U.P. and Gujarat. The Department of Agriculture, U.P released the NBRI technology based on *Rhizobium* and phosphate solubilizing bacteria through 13 of its laboratories. The high quality biofertilizers were applied on an estimated 1,00,000 hectare farm area through more than 1000 officials and farmers trained by NBRI. Another biopesticides technology based on *Trichoderma* was scaled by Gujarat Agri Processing Company Ltd., Gujarat, to market about 10 metric tons of the formulation this year. Partnership with larger industry and NGOs are being sought to enable large scale production in U.P. for sustainable and environmentally cleaner agriculture.

(For details visit: www.nbri-lko.org)

Central Drug Research Institute, Lucknow

The Central Drug Research Institute (CDRI) in Lucknow, India with its broad-based research facilities, technical infrastructure and expertise in frontline research disciplines as well as expertise in regional health area, is amongst the internationally reputed laboratories in the field of drug research. CDRI was formally inaugurated on 17th February 1951 by the then Prime Minister of India, Pandit Jawahar Lal Nehru and now a new state-of-the art campus is under development.

CDRI has the distinction of having made significant contributions to drug research in India. Several products developed by the Institute have been commercialized and are currently in the market: Centchroman (contraceptive pill for females), two antimalarial drugs, one herbal remedy for memory improvement and one spermicidal cream. Besides, several process technologies developed at CDRI are in commercial production and new products are in pipeline. CDRI has a successful record of research partnership with industry since its establishment.

R & D Programme

The Institute's R & D programme has been organized keeping in view the national and international needs. CDRI aims at developing drugs, diagnostics and vaccines to cure and get rid of the ailments confronted by the mankind in general and Indians in particular. With an aim to carry out focused works on various diseases, the R & D activities of CDRI have been categorized in various research areas. Each research area focuses on the design and development of drugs, diagnostics/vaccines related to the concerned disease group right from the synthesis of compounds up to regulatory studies and clinical trials. The entire research is now directed towards knowledge generation in order to identify novel targets and leads for development of safer and cost effective drug molecules.

Under project *'Biological Screening'* efforts are directed at anti-TB screening, anticancer screening, HTS and development of new screening models; *'Cardiovascular, Central Nervous System & Other Disorders'* cover synthesis and development of new drugs for various diseases of Cardiovascular system (stroke, thrombosis and hypertension), CNS (dementia and stress) and other disorders are diabetes, lipid disorders, impaired wounds, inflammation, allergy including asthma and ulcers; *'Filariasis'* focus is on development of a macrofilaricides and/or female worm-sterilizing agent; *'Leishmaniasis'* aims at new challenges of drug resistance, treatment failures, occurrence of relapses and convergence of HIV related VL cases, new and better alternatives of chemotherapy; *'Malaria'* aims at mechanism of action and resistance to traditional drugs, the emergence of artemisinins as one of the most important antimalarial class of compounds, and determination of the genome sequence of Malaria parasite promises a more optimistic future for antimalarial drug development; *'Microbial Infections'* cover the development of vaccines for cholera and tuberculosis, development of tuberculosis infection, novel antigens and drug targets; *Natural Products'* aims at chemical and pharmacological investigation of Indian medicinal plants and marine flora/fauna for isolation of active constituents to obtain new therapeutic agents; *'Newer Approaches in Drug Design & Discovery'* focus on structural studies on small and macromolecules and identification of drug targets; *'Reproductive health'* is directed at design and synthesis of novel molecules/isolates from natural sources and bioevaluate them for generating new leads and to develop them as female or male contraceptives, spermicides with anti-STI properties, agents for the management to post-menopausal osteoporosis and other endocrine disorder.

Technical Infrastructure and Facilities

The Institute's capability in drug R & D is spread in various R & D and Infrastructure divisions. In recent times, drug discovery has been revolutionized due to rapid advances in molecular biology. There is a focus on target-based drug discovery using new high-throughput screening systems, combinatorial chemical synthesis for rapid generation of novel structures and lead molecules and X-ray crystallography techniques to determine the structure of small or large molecules. Therefore, in order to reach global standards, the CDRI has been constantly strengthening its facilities in molecular biology, structural biology, genomics, combinatorial chemistry, medium/high-throughput screening, and molecular modeling.

The R & D facilities are also being upgraded to develop GLP conforming facilities. These facilities are being complemented with adequate strengthening of expertise in these areas by inducting new staff and reorientation of the existing scientists.

Opportunities and Services

CDRI focuses on developing New Diagnostics and Vaccines and state-of-the-art technologies for clients in India and abroad and associated fundamental research. The Institute has close commercial relationship with Pharmaceutical Industry and other R & D Organizations involved in the area of biomedical research. Our collaborative relations will go a long way in developing a strong drug research base in the country and in making India a

stronghold in biomedical research opportunities. We offer collaborative as well as contract commercial opportunities in following areas :

Advisory Consultancy Services: Trouble shooting problems identified by industries.

Contract Research: CDRI undertakes Research work as per the requirement of contracting party. Terms & Conditions negotiable.

Collaborative Project: CDRI collaborates with industry / R & D organizations. Sharing of benefits as per agreement.

Product/ Technology Licensing: Drugs/ Diagnostics/ Vaccines developed by CDRI and technology for industrial production of known drug.

Modern Drug Discovery Facilities: Combinatorial chemistry, proteomics, high-throughput screening, laboratory animals, structural biology, medicinal chemistry facilities can be availed on payment basis.

Analytical Services: Sophisticated instruments facility can be availed at nominal charges.

Biological Screening: *in vitro & vivo* tests of compounds against various disease models at nominal charges.

Information Services: Current information, current awareness/ document delivery/technical query services on drugs & pharmaceuticals.

Human Resource Development

Scientists training programme : CSIR launched a scheme of providing training to the laboratory scientists in business development activities. Under this scheme scientists from CDRI have undergone training programme.

Hands on training courses: Under this programme the Institute conducts training to short duration in various disciplines against payment. The courses comprise both lectures and practical with emphasis on practical R & D aspects in a particular discipline. Employees of industries/ institutions/ academics can avail training of short duration comprising theory/practical on advanced techniques.

Career in R & D: JRF/SRF/RA/SRA/ Post docs can pursue proficiency in various disciplines of biomedical research at molecular level.

Students training programme : CDRI offers a bright and fruitfully productive career to the students of science interested in pursuing career in the area of Biomedical Research. The Institute prepares the youth of today to take up newer and boundless challenges that the biomedical research faces to combat the large number of ailments that mankind has to face. CDRI conducts short term (Minimum of two months) courses for the postgraduate students in various areas of Biomedical Research Students from academic institutions can carry out project works in biomedical research at nominal charges.

CSIR Programme on Youth for Leadership in Science (CPYLS): With the vision to develop interest in science in younger generation, CSIR has launched this programme. Under this programme several meritorious students from Uttar Pradesh were exposed to latest

techniques being employed in drug research by way of exposure to experiments, laboratory visits, use of various instruments and holding lectures followed by discussions with our scientists.

Achievements

CDRI has been successful in meeting the expectations of her stakeholders. Over the years, achievements made by its scientists and infrastructure capabilities built up have been widely appreciated. The country witnessed the momentous occasion of the fruitful achievements of CDRI, when in 1987 the then Prime Minister of India, Mr. Rajeev Gandhi released four drugs developed by this Institute. More than twelve new drugs have been developed by the Institute, besides sensitive diagnostics for early detection of diseases like tuberculosis. Many cheaper and more convenient technologies for known drugs have been developed at pilot plant level, which have been transferred to drug industry where they have been successfully commercialized. The Institute has published more than 8200 research papers and filed 775 Indian and international patents. So far CDRI has produced more than 1200 Ph. D. scholars and students from different academic institutions / universities have undergone student training programme in biomedical science.

Central Institute of Medicinal and Aromatic Plants

Central Institute of Medicinal and Aromatic Plants, popularly known as CIMAP, is the known frontier plant research laboratory of CSIR. Established as CIMPO in 1959, CIMAP (reorganized R&D laboratory in 1978) is **steering research on medicinal and aromatic plants (MAPs) with its nucleus at Lucknow and extending its wings as four Resource Centres, (Bangalore, Hyderabad, Pantnagar & Purara)**, representing different agro-climatic zones of the country for multilocation field trials and research. Now with two strategic Resource Points added, one each at NIEST, Jorhat in Assam and IIAR, Ahmedabad in Gujarat for dissemination of MAPs technologies, CIMAP, as true national institute, is marching ahead on its well defined mission of "Green Path to Better Health and Life". While conserving the plant genetic resources systematically, CIMAP is equipping the nation with high-tech agriculture linked to industrial processing of MAPs while also providing quality seeds and propagules to the growers and entrepreneurs. CIMAP is equipped with state of art laboratories, ultra modern instrumentation and expertise in Agriculture, Biotechnology and Chemical Sciences ('ABC' of CIMAP).

CIMAP is known for its green discoveries, products and technologies. The business opportunity portfolio of CIMAP is presented here:

Molecules

1. Bioenhancers

i. Bioenhancer molecules enhance the killing action of antibiotics by increasing the availability.

ii. Improves the availability of vitamins.

iii. Increase the efficacy of anticancerous drugs.

A. Lysergol

B. Glycyrrhizin

C. Niaziridin

2. Antibacterials & Antifungals

i. Novel antibacterial compounds Oenostacin and Stilbenestcin active against vancomycin resistant *Staphylococcus epidermidis*

ii. Thymol isolated from *Trychyspermum ammi* (Ajwain) to control multi-drug resistant (mdr) and complex resistant microbial pathogens.

iii. Combination for prevention of drug resistant against fluoroquinolones like Ciprofloxacin

iv. Synergistic combinations of plant essential oil components and commercial antifungals to control candiasis. New antifungals: Everniarwin & Everniallin from lichen and Glabridin from licorice

In-vitro technologies

- High throughput micropropagation of high value plants: *Rauvolfia serpentina, Glycyrrhiza glabra, Picrorrhiza kurroa*
- Hairy root technologies for *in-vitro* production of secondary metabolites

Processes

1. An improved process for isolation of artemisinin from antimalarial drug plant *Artemisia annua* (40 kg per batch)

2. An improved process for isolation of antihepatotoxic agent silymarin from the plant *Silybum marianum*.

3. A bench scale technology for isolation of Camptothecin with a yield of 0.15% from the stem of *Mappia foetida*.

4. A bench scale process for the isolation of antihepatotoxic CLIV-92 (A combination of three

coumarino lignoids) at a scale of 20 kg has been developed with a yield of 0.2%.

5. A bench scale (1 kg) technology for the isolation of andrographolide from *Andrographis paniculata*.

6. A bench scale process (4 kg) for the isolation of lysergol from the seeds of *Ipomea muricata* (0.2% yield).

7. Isolation of calliterpinone from the *Callicarpa macrophylla* (10 kg scale)

Herbal based formulations

- Formulation for scented mosquito repellent spray "Mospray".
- Balm for headache and sprain "Pain Chhoo.....".
- "Swabee" a super strong surface disinfectant
- The coolest way to hand disinfection "Hankool"
- Broad spectrum antifungal cream "Skinpro"
- Herbal based broad-spectrum antifungal cream "Myconil".
- "Herbal tooth powder" a formulation effective against plaque formation and gingivitis.
- Aloe based face and hand wash-"Kleenzie"
- "Mosnobite", a mosquito repellent vaporising formulation
- "Mosaway", mosquito repellent cream
- Geranium Active, Herbal based anti-dandruff Shampoo
- CIM-Phal-se nutraceutical granules
- CIM Paushak a scientific awaleh
- Herbi Soft Shampoo
- HAloe Skin, multi purpose cream

Agrotechnologies of MAPs

Mentha arvensis (Menthol mint); *Mentha piperita* (Peppermint); *Mentha citrata* (bergamot mint); *Mentha spicata* (Spearmint); *Mentha cardiaca* (Scotch spearmint); *Cymbopogon winterianus* (Citronella); *Cymbopogon martinii* (Palmarosa); *Cymbopogon flexuosus* (Lemongrass); *Pelargonium graveolens* (Geranium); *Rosa damascena* (Rose) ; *Matricaria chamomilla* (chamomile); *Vertiveria zizanioides* (vetiver) ; *Chrysanthemum cineriaefolium* (Pyrethrum) ;*Catharanthus roseus* (Periwinkle); *Withania somnifera* (Ashwagandha); *Phyllanthus amarus* (Bhuin amlaki); *Ocimum sanctum* (Krishna Tulsi); *Plantago ovata* (Isabgol); *Cassia angustifolia* (Senna), *Artemisia annua* etc.

Agro-product and process packages

- Bio-control agents for fungal and bacterial diseases
- Bio-insecticides (microbial and plant based)
- PGPRs for crops as bioinoculants
- Biofertilizers and value added vermi composts
- Organic cultivation packages
  - Organic planting material (nucleus)
  - Organic aromatic oils (Eco Cert)
  - Consultancy (cultivation to processing)
- Slow release and value added fertilizers
- Antimalarial molecules from *Artemisia*: production package
- Herbal fumigants for stored grain pests
- Antisprouting agents for potato tuber storage

Contact: Director, Central Institute of Medicinal and Aromatic Plants (CIMAP)(CSIR), Lucknow - 226015;
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Indian Institute of Toxicology Research

(Formerly: Industrial Toxicology Research Centre)

Indian Institute of Toxicology Research (IITR), a constituent laboratory of Council of Scientific & Industrial Research (CSIR) was established on November 4, 1965 at Lucknow. Its establishment symbolizes the commitment of our people for sustainable industrialization and agricultural development. The objectives of the 'Centre' are:

- To identify occupational health hazards due to exposure to chemicals in industries, mines, agricultural fields and general environment by undertaking health and environmental surveys.
- To determine the mode of action of toxic chemicals/pollutants.
- To conduct safety evaluation of chemicals used in industry, agriculture and everyday life.
- To suggest remedial/preventive measures to safeguard health and environment from pollutants.
- To collect, store and disseminate information on toxic chemicals.
- To develop human resource for dealing with industrial and environmental problems.

Mission of IITR is to provide research based solution to the problems of environment and health, and recommend safe limits of chemicals to regulatory agencies for help in formulating or amending and implementing National guidelines. Ever since its inception it has been in

service of the society through generating data on the toxicogenic potential of the chemicals of interest to the country like pesticides, heavy metals, dyes and food colours; developing test systems for evaluating the safety of chemicals. The centre assists regulatory agencies in monitoring, establishing and prescribing safe limits of the pollutants in finished products including the food material.

The Institute during its journey has expanded its activities in diverse areas of toxicology and has undertaken studies as diverse as problems of miners inhaling the dusts and fibres to toxicity of dyes, pesticides, heavy metals, plastics, polymers, solvents, food additives, adulterants and contaminants. Simultaneously issues related to diagnostic, preventive and interventional toxicology were addressed by researchers. It has also participated in multicentric programme for development of pharmacopial standards of drugs used in Indian system-of-medicine. State-of-art tools like Comet assay, FISH, ELISA, image analysis for neuronal injury, gene expression and quantification of the histopathological lesions have been introduced for toxicity assessment. The centre has made significant progress to establish facilities and to develop assays for rapid assessment of toxicity of chemicals using *in-vitro/ex vivo* models and small invertebrate animal and plant models, there by reducing use of animals in toxicology.

IITR also participated in a major CSIR coordinated programme for identification, development and commercialization of bioactive molecules from natural sources. Currently, the research at IITR focuses on understanding the molecular mechanisms of toxicity using proteomics, genomics and bioinformatics approaches towards development of biomarkers for risk assessment of human exposure to chemicals. IITR has an active research programme on genetic polymorphism in Indian population for differential response to toxicants and susceptibility to different diseases.

The laboratory remained at the forefront in addressing the human health and environmental problems of the country and participated actively in National Mission and societal programmes such as National Drinking Water Mission, Technology Mission on Oilseeds, Pulses and Maize (TMOP&M), and monitoring of the Ganga and Gomti Rivers. Based on its mandate and expertise, it delivered the best in the time of the national crises like unfortunate Bhopal Gas Tragedy due to leakage of Methyl Isocyanide, 'Epidemic dropsy at Delhi', floods in Gorakhpur and Deoria districts of Uttar Pradesh, super cyclone in the state of Orissa and earthquake in Gujarat.

Technologies like Water Analysis Kit, Mobile Laboratory Van for analysis of drinking water and On-line Water Disinfection Unit developed by the centre are simple yet sensitive and above all are cost effective. These were used to provide safe drinking water during the devastating super cyclone that severely affected parts of Orissa in October 1999. A colour detection strip for the detection of butter yellow and Argemone detection kit are being used in the country. The Argemone detection kit proved to be an invaluable tool during the unfortunate incidence of "epidemic dropsy".

IITR has received accreditation from NABL as biological and chemical testing laboratory for air quality, environmental impact, chemical and bacteriological quality of

water and effluents, chemical and biological safety of plastics, residue analysis for pesticides and metals and toxicity/safety evaluation of a vast variety of chemicals/products.

The research and outreach activities that are related to the environmental pollution, health risks and mitigation of such problems, are regularly made available to the scientific community and public. IITR holds exhibitions displaying its technologies, public awareneess programmes and medical camps in cities as well as in rural areas. The Institute's expertise is reflected in the MOUs with several state and central universities and institutes of repute to provide post-graduate, doctoral and post doctoral and post doctoral training to students. Based on the expertise of the laboratory, IITR has been recognized by the agencies: like U.P. Pollution Control Board, Lucknow, Central Pollution Control Board, New Delhi, and Bureau of Indian Standards (BIS) New Delhi. IITR provides services to industry, academia and public and private sectors, agencies, company to national and international guidelines (OECD, USEPA, BIS ISO). More than 2500 research papers have been published, so far, along with regular publications: *viz*: (a) Annual Report (b) Brochures (c) Industrial Toxicology Bulletin (d) ENVIS Newsletter

The R & D at IITR is aligned with needs of the Nation. The laboratory has expanded its capabilities in the new areas of concern to the country such as safety evaluation of biotechnological products, nanomaterials, analysis of food and water contaminants and rendered its services and expertise to industry and government agencies. The four decades of expertise, manpower and knowledge base in toxicology research empowers the centre to conduct research in the contemporary areas of:

- Systems Toxicolgy
- Toxicogenomics & Predictive Toxicology
- Food, Drug & Chemical Toxicology
- Environmental Toxicology
- Ground Water Mapping
- In Silico Toxicology

The endeavour of IITR scientists and technical staff is to become a unique, valuable and internationally competitive scientific resource in toxicology research and testing, and is strategically positioning itself to meet the global challenges.

(For details visit: www.itrcindia.org)

ABSTRACTS

KEYNOTE ADDRESS

Impact of Climate Change on Biodiversity in Forest and Natural Ecosystems in India

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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 hoods of people who depend on forest resources.

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 CO_2 concentrations, there are projected major changes in ecosystem structure and function, species ecological interactions, and shifts in species' geographical ranges, with predominantly negative consequences for biodiversity and ecosystem goods and services, e.g. water and food supply.

India is a mega-biodiversity country where forests account for about 20% (64 million ha) of the geographical area. With nearly 200,000 villages classified as forest villages, there is obviously large dependence of communities on forest resources. Thus it is important to

assess the likely impacts of projected climate change on forests and develop and implement adaptation strategies for both biodiversity conservation and the livelihoods of forest-dependent people.

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

Current and Future Climate Patterns

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

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

Changes in Climate Over Forested Areas

The high-resolution data from FSI (Forest Survey of India) can be used to map the location of various types of forests across India. The major forest types in India (those occupying 0.5% or more of the forested area) and their areas are given in Table 1. Forests in India are extremely diverse and heterogeneous in nature, and it is difficult to classify them into a small number of categories. As a result, the pan-Indian 'Miscellaneous forest' category (with no dominant species) shows the highest (63%) proportion. The miscellaneous forest area occurs under all the forest types. The other two most dominant forest types are *Shorea*

robusta or sal (12%) in the eastern part of Central India and *Tectona grandis* or teak (9.5%), spread across Central India and the Western Ghats in Southern India. The climate impact analysis is carried out for the FSI forest categories as well as the BIOME model vegetation types.

Changes in climate in the forest areas are presented in Table 1 using the B2 scenario projections and FSI categories of forests. The temperature and rainfall means are obtained by considering all the grids of each forest type, occurring in different parts of India. In general, under the B2 scenario projections, the mean rainfall (and mean temperature) in areas under forest cover is somewhat higher than that in the non-forested areas. The increase expected in rainfall under the changed climate is also relatively larger for the forested areas, about 376 mm compared to the overall average of about 235 mm. The mean change in temperature, however, is not different from that in the non-forested regions. As expected, the changes in climate are not uniform 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	1523.8	476.9	16.4	2.7
Teak	3364	9.56	1314.6	553.0	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	22339	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[12].

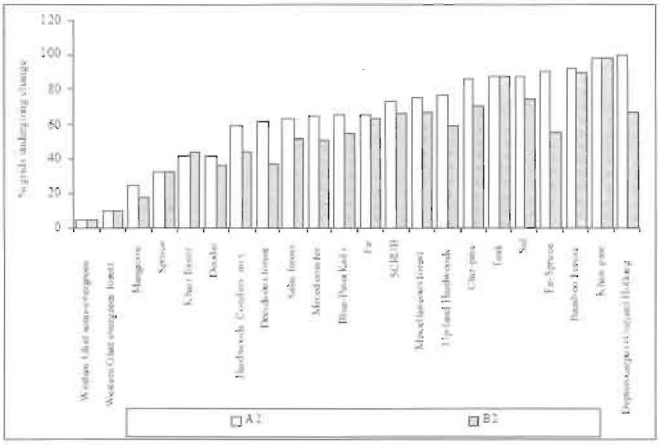

Figure 1: Percentage of grids under different forest types undergoing change in A2 and B2 GHG Scenario.

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

Impact of Climate Change on Forest Types and Distribution

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

Forest Biodiversity

A review of studies by IPCC and Gitay *et al.* has shown that forest biodiversity or the species assemblage is projected to undergo changes due to the projected climate change. Biodiversity is likely to be impacted under the projected climate scenarios due to 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 are 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 impact 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 northeastern 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 northwestern 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.

SESSION - 1

Climate Change – Scenario in Different Countries

(Presentation by delegates from
Afghanistan, Bangladesh, Bhutan, India, Maldives,
Nepal, Pakistan & Sri Lanka)

SESSION - 2

Climate Change and Biodiversity

Abstract No. 2.1

Predicting Impacts of Climate Change on the Himalayan Flora

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The Himalayan region represents a complex chain of mountains ranging over 7000 m in altitude, 8 degrees in latitude, 28 degrees in longitude and encompassing a climatic regime of tropical rain forest to alpine-arid and sub-nival zones. At 45 million years, the Himalaya is regarded as young and growing, in the process regularly giving rise to new habitats and corridors for evolution and migration of species. Palaeo-ecological evidences suggest that most drastic changes in the Himalaya took place during the Pliocene when the forests of *Dipterocarpus* and *Anisoptera* totally disappeared from the Western Himalaya and the wet forests were transformed into moist or dry types. More recently i.e., ca 4-5,000 years before preset (YBP) the forests of North-Western Himalaya experienced rapid decline of oaks, laurels, figs and gradual preponderance of *Pinus, Cendrus, Spruce* and graminoids. Thus the current floral and faunal assemblages in the region are results of continuous interaction with the climate. It is believed that changes in the climate during mid Holocene (ca. 18,000 YBP.) led to rapid colonization of higher altitudes by modern flora accompanied by increase in human populations. In fact, the phenomenon of global warming after the last Ice age has been referred as 'climatic amelioration' in the Himalayan context.

The Intergovernmental Panel on Climate Change (IPCC) has predicted that given the current rate of greenhouse gas emission, the earth's temperature would increase by 1.4 to 5.8 °C by the year 2100. Rapid change in climate due to global warming coupled with increased intensity of human use would certainly affect the Himalayan flora in various ways. However, patterns of changes in flora and vegetation due to change in climate are too complex to explain and predict. The most predictable impact includes upward migration of several taxa leading to changes in species composition and competition at higher altitudes. Many alpine species, in the process of edging uphill, may over run rarer species near the mountain summits. Other species would be unable to migrate because of topographic constraints and may decline or even die out. Empirical evidences suggest that several species have begun to exhibit phenological acceleration which may affect the pollinators and dispersal agents. It has been established that increase in atmospheric temperature by 1 °C would cause 100 – 150 km shift in latitude and as much as 500 km shift in isotherms. Since Himalayan mountains exhibit a great compression of climatic zones owing to sharp altitudinal gradient, one would expect a shift of 250 – 300 m in the distribution of species with increase in 1 °C. If global average of 3 °C increase in temperature is applied in case of Himalaya, most of the herbaceous communities at the lower alpine zone i.e, below 4200 m asl would be replaced by woody

communities. The Ericaceous krummholz formations would spread further in the eastern Himalaya. The range of several moisture dependent taxa, especially cryptogams, may shrink further. The impacts are likely to be quite different in the trans-Himalaya which may experience shifts in aridity and resultant changes in the distribution of plant and animal communities. Increased temperature would have direct bearing on snowfall, snowmelt and rainfall regimes affecting soil moisture and habitat conditions which would affect species regeneration and establishment. Hence the predictive models for species distribution under changed climatic conditions in the Himalayan region should include soil moisture (e.g., alpine stream corridors), shifts in snow banks, dispersal patterns and invasive ability of low altitude native and alien species as variables. We also need to model landscape level vegetation dynamics as an outcome of species' physiological and life-history characteristics, inter-specific competition, landscape heterogeneity, natural disturbance and response of key species for detecting future changes due to global warming.

This presentation deals with current patterns of diversity and distribution among vascular plants in the Himalayan region vis-à-vis predicted impacts of climate change. A few strategies for long term monitoring of sensitive taxa and threatened habitats are discussed.

Keywords : Himalayan region, climatic amelioration, Himalayan flora

Abstract No. 2.2

Impact of Increased Anthropogenic Activities on Marine Biota

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It is evident now that the planet is warming, from north to south poles, and everywhere in between apparent effects of increasing temperatures is already happening. Global and regional climate models predict that air and sea temperatures will rise by approximately 3°C during the next 70--100 years. Thus, floods and droughts will become more common due to the increased precipitation (rain and snowfall) which will result in sea level rise. Even though, marine biota have capability to absorb the consequences of increased human activities, marine living resources such as marine capture fishery and coral reefs are showing the obvious negative impact of increased human activities. Using the complex numerical models, scientists are able to estimate the resulting impact of cloud formation by identifying the role of marine flora. Thus, the increased global temperature may even change some of the ecosystems as some species will move farther north or become more successful; others won't be able to moves could become extinct. Consequently, anything that can change global clouds can dramatically alter the impact of greenhouse gases on our changing climate. Other effects could happen later this century, if warming continues like sea level rise, hurricanes and other storms. Floods and droughts will become more common, species that depend on one another may become less common or even disappear. Some results of case studies on the effects of global warming on marine flora and fauna are discussed.

Keywords : Marine fishery, coral reef, global warming

Abstract No. 2.3

Climate Change and its Impact on Biodiversity : An Indian Perspective

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Global climate change has emerged as a serious challenge for sustainability. Observed changes in temperature, precipitation, snow cover, sea level and extreme weather conditions confirm that the global warming is a reality. Scientific models and observations for the past thousand years provide evidence that global warming is due to anthropogenic increase in greenhouse gases (i.e. CO_2, CH_4, NOx, etc.). Projected impacts from climate change also include disruption of ecosystems and species extinctions, which leads to the tremendous loss of biodiversity. As average temperature increases, optimum habitat of many species will move to higher elevations. Where changes are taking place too quickly for ecosystems and species to adjust, local extinctions will certainly occur. Rapid temperature changes affect the seasons including shorter winters and variations in season length. This can lead to changes in physiology (e.g. flowering and leaf-break time in plants and breeding time in animals) and phenology as well. Increasing invasion by opportunistic, weedy and/or competitively mobile species, and progressive decoupling of species interactions (e.g. plants and pollinators), owing to mismatched phenology, also provide global evidence of climate change.

The scientific understanding of climate change is now sufficiently clear to justify nations taking prompt action. It is vital that all nations identify cost effective steps that they can take now, to contribute to substantial and long term reduction in net global greenhouse gas emissions and reducing rate of climate change. In the present study, we have underlined the impact of climate change on Indian biodiversity.

Keywords : Biodiversity, climate change, global warming, greenhouse gases, phenology

Abstract No. 2.4

Occurrence of a Conifer Wood in the Desert of Rajasthan and its Climatic Significance

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Western Rajasthan forms part of the Thar Desert. In the present communication, a gymnospermous wood collected from east of the Habur village, situated about 45 km north of Jaisalmer, is reported for the first time from the Lower/ Early Cretaceous sediments of Pariwar Formation.

Only a few plant megafossils have been reported from these sediments, which belong to Filicales, Cycadales, Bennettitales and Coniferales. The conifers are represented by *Pagiophyllum* (Family Araucariaceae) and *Elatocladus* (Family Podocarpaceae). All the known megafossils are represented by their impressions. A petrified wood is being reported for the first time from these sediments. The fossil is 25 cm in length and 10 cm in diameter, dark in colour and ferruginous in nature.

Important anatomical characters of the fossil are: - *Growth rings* distinct, *Early wood* zone is fairly wide and consists of tracheidal cells of wide lumen. *Late wood* zone is narrow, consists of 3-4 thick walled cells. *Parenchyma* cells present but infrequent. *Xylem rays* fine, predominantly uniseriate, rarely biseriate, homocellular. *Tracheidal pits* on radial and tangential wall. *Cross field pits* could not be observed due to poor preservation.

The above characters indicate that the wood belongs to gymnosperms and it may belong to family Araucariaceae or Podocarpaceae, the leaf remains of which have already been reported from this locality. However, without the preservation of tracheidal pits it is difficult to assign the fossil to either of the Conifer family at present. Consequently, the wood has not been assigned to any known taxa like *Dadoxylon*, *Araucarioxylon* or *Podocarpoxylon*. Such conifer woods have been reported from various Lower Cretaceous horizons of the Peninsular India like Kachchh, Andhra Pradesh and Tamil Nadu, besides Rajamahal. The occurrence of growth rings, early wide wood and narrow late wood indicates some sasonality and prevalence of conducive climatic conditions for good growth of plants in contrast to the present xeric and desertic conditions prevailing in the area.

Keywords : Cretaceous sediments, Pariwar Formation, coniferales, *Dedoxylon, Araucaroxylon, Podocarpoxylon*

Abstract No. 2.5

Late Holocene Vegetation and Environment of Meenachil River Basin, Kottayam District, Kerala, India

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A few carbonized wood samples were collected from Late Holocene sediments of Mosco and Ponpally area of Meenachil river basin situated about 15 km inland from the coast in Kottayam District of Kerala. The area is traversed by Meenachil River in the north and its tributary Meenadom in the south. The anatomical study of the woods has revealed the occurrence of eight type of woods. The assemblage consists of six genera, viz., *Artocarpus* (Family Moraceae), *Calophyllum* 2 spp. (Family Clusiaceae), *Canarium* (Family Burseraceae), *Holigarna* (Family Anacardiaceae), *Sonneratia* (Family Sonneratiaceae) and *Spondias* (Family Anacardiaceae), comprising seven species representing five families. In addition, one wood sample, which could not be assigned to any genus, due to poor preservation, is being reported simply as a dicotyledonous wood. No carbonised wood has been reported so far from the Kottayam District and the paper deals with the identification and significance of these woods.

Among the above genera, *Calophyllum, Spondias* and *Sonneratia* are inhabitant of coastal area and indicate near shore conditions. *Sonneratia* is a mangrove tree that occurs in the tidal creeks and littoral forests. *Calophyllum inophyllum*, a comparable species is found all along the coast above high water mark and in the evergreen forests of Western Ghats along the river banks. Likewise, *Artocarpus* (the jack fruit tree), *Holigarna* and *Canarium* are found in the evergreen forests of Western Ghats including Kerala. The assemblage indicates that the area was covered by dense forest and witnessed high rainfall and the prevailing conditions must had been warm and humid at the time of deposition of these woods. Further the occurrence of *Sonneratia,* specially indicate the proximity of sea in the area at the time of deposition of these woods. Obviously, the sea level was much higher at the time than at present. Evidently, the sea had receded since then. Thus the carbonised woods have provided evidence about the prevailing environmental conditions and sea level fluctuations in the area.

Keywords : Holocene, Meenachil River Basin, carbonized wood, *Artocarpus, Calophyllum, Canarium, Holigarna, Sonneratia, Spondias*

SESSION - 3

Climate Change and Forestry Sector

Abstract No. 3.1

Rewarding Forest Conservation in Forest and Climate Change Regime : Indian Perspective

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The role of forests in CHG reduction and thus mitigation of climate change is globally recognized and accepted. The international community is increasingly devising appropriate mitigation and adaptation strategies under Land Use, Land Use Change and Forestry (LULUCF) sector. One such policy approach presented in COP 11 of UNFCCC in Montreal, was 'Avoided Deforestation" or Compensated Reduction, later known as Reducing Emission from Deforestation and Degradation in Developing Countries (REDD) in the further international negotiations. Initially, the issue of the forest conservation and stabilization of forest cover was not recognized under this policy approach as it mainly focused to compensate the countries for reducing their rate of deforestation. Therefore, India proposed the concept of Compensated Conservation, for compensating the countries for maintaining and increasing their forest as carbon pool as a result of conservation and increase/improvement in forest cover as an additional policy approach in the last COP 12/MOP at Nairobi in 2006. In the UN workshop at Cairns, Australia in March 2007, SBSTA (Subsidiary Body for Scientific and Technical Advice) meeting at Bonn, Germany in June 2007, and recently concluded COP13 /MOP at Bali, the Indian approach was successfully put forth. The international community at Bali duly recognized the role of conservation and accepted enhancement of forest carbon stocks due to sustainable management of forests, as one of the policy approach for providing incentives. Further, the Bali Action Plan (BAP), a comprehensive process for sustained implementation of UNFCCC through long term action as on now and beyond 2012, adopted in Bali COP/MOP, also acknowledged the role of conservation in enhancement of forest cover. It is hoped that India's sustained efforts in the field of forest conservation, would benefit immensely from acceptance of this policy approach.

Keywords : Forests, climate change, compensated conservation, REDD, avoided deforestation

Abstract No. 3.2

Afforestation and Reforestation Projects for Climate Change Mitigation : Current Status and Need for Policy Reforms

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The Climate Change is one of the biggest concerns recent for the global community. The Clean Development Mechanism (CDM) of Kyoto Protocol is one of the flexible mechanism for emission reduction activities in developing countries. India is the leading CDM country in the world with 35 % of the total share of global CDM projects. The Land use, Land use Change and Forestry (LULUCF) sector can provide relatively low cost opportunities to combat Climate Change. Although the CDM framework has been very active in India, The development of Forestry Projects under CDM has not been a great success so far. The CDM project submission process to CDM EB is very cumbersome. The approval rate of methodologies is very low. So far a total of 35 methodologies have been submitted and only ten have been approved by CDM-EB. Poor understanding of CDM A/R Modalities and Procedures has been one of the primary reasons for high rate of rejection of these projects. There is a potential of 59.6 million ha of land for afforestation and reforestation activities within the country. A sizable amount of this potential can be undertaken for CDM A/R projects. So far only 6 CDM A/R Projects have been developed in India and only two of them could make up to CDM EB.

In the present paper analysis of CDM A/R projects at national and International level have been made. Suggestions have been made to create an enabling environment for development of CDM A/R projects. Some of the recommendation suggested are: (i) Delineation of Potential CDM A/R area (ii) Inclusion of CDM Component in Forest Working Plans (iii) Opening of a CDM Cells in research and extension wings of State Forest Departments (iv) Incorporation of CDM component in JFM Programs (iv) Promoting Forestry based CDM Projects other than CDM A/R, such as biomass based renewable energy projects and fuel switching from *Jatropha* oil etc. (v) Making the finance available for CDM Projects (vi) Institutional Strengthening and capacity building and finally creating market for CDM A/R Projects.

If India has to maintain its lead in CDM it must offers a well tailored CDM infrastructure for afforestation and reforestation projects and then only the transaction costs can be lowered down and an enabling environment for CDM A/R project will be created. Success of CDM A/R projects in country will help forest dependent communities in poverty alleviation at local level as well as climate change mitigation for global benefits.

Keywords : Climate change, CDM modalities and procedures, Kyoto Proto, LULUCF, afforestation and reforestation

Abstract No. 3.3

Climate Change on Forest Health (Susceptibility to Pests and Disease)

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The subject of climate change continues to be a topic of hot debate at global conventions, world summit and internationals conferences and symposia. Global climate change is a reality, a continuous process that needs to be taken seriously, even though there are large uncertainties in its spatial and temporal distribution. Many evidences have been gathered to depict that climate change is taking place. An increase in insect and diseases caused losses in forests could become one of the first observed effects on climate change. Evidence of this can be found in the pest epidemics, which are the result of stress brought on by periodic drought or excess rainfall. The potential effect on climate change on pest and diseases in agriculture provide a framework from which to identify potential forests sector effects. They include both positive and negative responses. Some anticipated negative effects on forests health are include higher temperature could result in more generation of insect pests per year, thus increasing their destructive potential also the ratios of pest species to their natural environments could change in favour of the pest and widening C/N ratios in trees due to elevated level of CO_2 could increase foliage consumption by insects. A higher incidence of insects and diseases out break due to stress on trees associated with climate change will result in higher level of combustible fuels in forests increasing the risk of wildfires. Some anticipated positive effects includes, due to warmer temperature and elevated CO_2 level might allow forests to sustain higher level of insect and disease damage without reduction in growth and yield, increase vigour of trees and forest growing in elevated CO_2 level could be more resistant to attack by insect and elevated CO_2 may benefit plant health and productivity by altering the morphology and physiology of plants to the detriment of disease causing organism.

The hazard of destructive insect and disease outbreak in tropical forests is believed to be minimal when compared to temperate and boreal forests because of their inherent diversity. This review clearly indicates that in tropical managed forests; there are an ample number of insect and disease pests, which could respond to change in climate.

Keywords : Climate change, pests, diseases, tropical forests, vigour

SESSION - 4

Climate Change and Agriculture Sector

Abstract No. 4.1

Rise in Atmospheric CO_2 and its Impact on Crop Productivity: Research and Technology: South Asian Studies

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Global climate changes are unique challenges to agro ecosystems. Human activities have altered the global atmosphere effecting the land environment. The doubling of human population in next five years will intensify such pressures. These anthropogenic changes in atmospheric composition and climate will significantly influence the performance of crops. The exponential rise in the atmospheric CO_2 is an important global climate change, which effectively influences the productivity of the crop plants. Innovative approaches, for conducting long-term experiments to study the responses of crop plants to the elevated CO_2, have been developed.

Open top chamber CO_2 enrichment technology was designed and developed for south Asian conditions to study the effect of elevated CO_2 on crop plants. CO_2 enrichment research network of India, Bangladesh, Nepal, Pakistan and Sri Lanka for multi country, multi disciplinary experiments is being coordinated by the National Fellow Program of the Indian Agricultural Research Institute, New Delhi (Uprety *et al.*, 2000). A PC based system of Free Air CO_2 enrichment (FACE) technology was established with the help of National Physical Laboratory, New Delhi, to generate realistic biological data on the crop responses to the higher CO_2 concentrations.

Addition of these facilities has brought India on the GCTE CO_2 research network which is active in tackling vulnerable issues and adaptation strategies for meeting the rise in global food demand in the face of global environmental changes.

Field experiments, for studying the responses of crop plants to the elevated CO_2 using OTC and FACE facilities, were conducted at IARI under a global change national programme. Following conclusions were drawn :

1. Elevated CO_2 was highly significant in mitigating the adverse moisture stress effect on plant processes in *Brassica* species.
2. There is a possibility of transferring CO_2 responsive characters from one parent *Brassica campestris* to the hybrid *Brassica oxycamp*.
3. Studies on rice and wheat cultivars demonstrated significant increase in their growth and productivity. These responses have been physiologically and bio- chemically characterized.

This information is an important component for decision support system for strategic choice of crop cultivars to be promoted in agricultural area vulnerable to global environmental change to sustain the livelihood amongst the poor farmers.

Keywords : OTC, FACE, *CO_2*, *Brassica campestris*, *Brassica oxycamp*, rice cultivar, wheat cultivar

Abstract No. 4.2

Climate Change and Extreme Weather Events : Impact on Agriculture

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Despite uncertainties, global warming is now a reality. The global average air temperature near the Earth's surface rose by 0.74°C during the 100 years ending in 2005. The fact that eleven of the last twelve years were among the 12 warmest years since 1850, provides enough evidence for prevailing trend of global warming. There are other evidences too. For example, during the last 50 years, cold days, cold nights and frost have become less frequent, while hot days, hot nights, and heat waves have become more frequent. Warming has caused rise in global average sea level at an average rate of 1.8 mm per year over past 50 years. While most land areas have witnessed increase in frequency of heavy precipitation events, regions like Sahel and Mediterranean have recorded long term decreasing trend in the total precipitation.

India is no exception to these trends, though not as dramatic as in other regions. There has been a warming of 0.4C during past 100 years with a significant warming trend along the west coast, central India, and interior Peninsula and over northeast India. Interestingly, a cooling trend has been observed in northwest and some parts of southern India. The all India monsoon rainfall does not show any trend but there are some regional patterns. Areas of increasing trend in monsoon rainfall are found along the west coast, north Andhra Pradesh and north-west India, and those of decreasing trend over east Madhya Pradesh and adjoining areas, north-east India and parts of Gujarat and Kerala. There are ample evidences that glaciers in Himalayas are receding at a rapid pace.

One of the anticipated effects of climate change is the possible increase in both frequency and intensity of extreme weather events, such as cyclones, floods, and droughts. The warming of the earth may fuel interactions between the ocean and atmosphere that will amplify the frequency and intensity of extreme weather events. The question now being asked is – are extreme weather events becoming more frequent, and is this linked to climate change? As per a recent report by the World Meteorological Organization (WMO), the number of global hydro-meteorological disasters has doubled over the last decade. During this period more than 90 per cent of people killed by natural hazards lost their lives as a consequence of severe meteorological and hydrological events. Asia was the continent, most frequently hit by disasters registering nearly 43% of the total number of events, and 80 % of the people killed.

The case of India is quite interesting. For a country that has more than 70% of its population relying on agriculture directly or indirectly, the impact of extreme weather events is critical. In the last decade, India has repeatedly been battered by successive monsoon flooding and droughts. For example, for the last 100 years in the state of Orissa, 49 years have experienced floods, 30 have had droughts, and 11 faced cyclones. These extreme weather

events are not mutually exclusive. It is not unusual for a year to have a combination of droughts, floods and cyclones. Instrumental records over the past 130 years, however, do not show any significant long-term trend in the frequencies of large-scale droughts or floods in the summer- monsoon season.

There are no definite evidences of impact of climate change on Indian agriculture because of very slow change in climatic parameters. However, there are some trends that can be noticed -

- There is preliminary evidence to indicate that decrease in rice yields, in recent past, in Indo-Gangetic plains was associated with a slight rise in minimum temperatures.
- Wheat yields and hence production is showing losses of 4-6 million tons in recent years due to increased heat in February-March.
- Increasing temperatures in Himachal Pradesh have resulted in a decrease in apple productivity and the apple belt is gradually shifting upwards (higher elevation).

The Fourth Assessment Report of the Inter-governmental Panel on Climate Change (IPCC) indicates that the projected temperature increase by the end of this century is likely to be in the range 2 to 4.5°C with a best estimate of about 3°C, and is very unlikely to be less than 1.5°C. Values substantially higher than 4.5°C cannot be excluded. This warming trend is likely to be much higher than the observed changes during the 20th century and is expected to be without precedence during at least the last 10,000 years.

Precipitation is projected to intensify during the 21st century. At low latitudes, there would be decreases in some regions and increases in others. It is also likely that there would be greater Asian monsoon precipitation variability, more intense future tropical cyclones and depletion of snow cover. It is very likely that hot extremes, heat waves, and heavy precipitation events will continue to become more frequent. The projected sea level rise by the end of this century is likely to be 0.18 to 0.59 metres.

Increase in temperatures, and increased variability of rainfall would considerably impact food production. Recent IPCC report indicates considerable probability of loss in crop production with increases in temperature in tropical regions. Indian studies do confirm this trend, although there is considerable disagreement among the studies on the magnitude of loss. Among cereal crops, important for food security, wheat is most sensitive to even small increase in temperature. Relatively, rice has greater tolerance to increase in temperature. It is, however, possible for farmers to adapt to a limited extent and reduce the losses. Increasing glacier melt could affect availability of irrigation especially in the Indo-Gangetic plains, which, in turn, would have consequences on food production. Global warming in short-term is likely to favour agricultural production in temperate regions (largely Europe, north America) and negatively impact tropical crop production (South Asia, Africa). This is likely to have consequences on international food prices, trade, and could lead to a problem of food security.

Keywords : Global warming, agricultural productivity, IPCC

Abstract No. 4.3

Influence of Agricultural Resource Conservation Technologies on Environment

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The Indo Gangetic plains (IGP) occupy one-sixth of south Asia's geographical area, hold nearly 42 per cent of its population and produce more than 45 per cent of its food. Rice-wheat is grown on more than 12 million ha and provides livelihood for millions in the IGP. An increase of temperature by 1° C in the IGP would be equivalent to a 150 km Northward shift of isotherms (lines joining places with similar temperature) or about 150 m lower altitude. There is a 5 per cent decrease in rice yield of every °C rise above 32° C. During the 1990s the atmospheric abundance of almost all greenhouse gases (GHG) reached their highest value in recorded history. According to recent estimates by IPCC, by 2100 A.D., the average global surface temperature is projected to increase by 1.4 to 3° C above 1990 levels for low emission scenario of GHG and between 2.5 to 5.8°C for higher emissions.

To assess how environmentally efficient the various production systems are with respect to GHG emission and how much food is actually placed on the table, a Carbon to Productivity Ratio (CPR) is an ideal measure. CPR the value obtained by dividing the total annual on-site GHG emissions stated as Carbon Equivalents (CE) by the total annual food production in that area. Yield data of a long-term experiment at Pantnagar (India) with NPK fertilizers at 50, 100 and 150 per cent of the recommended dose when analyzed after constructing annual GHG budgets individually for CO_2, CH_4 and N_2O indicated that CPR values of 0.45 to 0.48 were possible with zero tillage and retention of crop residues at all three levels of N fertilizer use as against 0.54 for control, (without fertilizer). However, with conventional tillage practices and burning of crop residue the CPR values were 0.57 to 0.73 showing a higher level of ineffectiveness in the production system. The lower the CPR, the more efficient the system is at producing food with respect to the health of the global environment.

Resource conservation technologies (RCTs) of agriculture, which include Reduced/ Zero tillage/surface seeding practices and crop residue retention, can reduce GHG emission and curb global warming. Water and agriculture sectors are likely to be the most sensitive to climate change in South Asia. Increasing demand for waters by competing sectors may limit the viability of irrigation as a sustainable adoption to climate change. Positive changes in agronomic practices like tillage, manuring and irrigation can help reduce greatly the release of greenhouse gases into the atmosphere. Adoption of zero tillage and controlled irrigation can

drastically reduce the evolution of CO_2 and N_2O. Reduction in burning of crop residues reduces the generation of CO_2, N_2O and CH_4 to a significant extent. Saving on diesel by reduced tillage and judicious use of water pumps can have a major role to play, with each litre of diesel generating 2.6 kg CO_2. About 3.2 Mt CO_2/annum (about 0.8 MMTCE) can be reduced by zero-tillage in the 12 million ha under rice - wheat systems in the IGPs alone. Intermittent irrigation and drainage will further reduce CH_4 emission from rice fields by 28% - 30%. Use of calcium nitrate or urea, instead of ammonium sulphate and deep placement (5 cm) through zero till machines, instead of surface application of nitrogenous fertilizers can increase its efficiency and plant uptake thereby reducing N_2O emission.

Adoption of zero tillage (ZT) systems on one hectare of land would save up to 100 litres of diesel and approximately 1 million litres of irrigation water. Using a conversion factor of 2.6 kg of carbon dioxide per litre of diesel burned, this represents a quarter ton less emission per hectare of carbon dioxide, a principal contributor to global warming. Zero-tillage even on 5 million hectares of rice-wheat system area would save 5 billion cubic metres of water each year. About 0.5 billion litres of saving in diesel every year will help reduce carbon dioxide emissions by 1.3 million tons every year.

Judicious management of water is imperative in ZT to improve productivity of land and water. Adoption of resource conservation technologies (RCTs)/ZT has assumed greater acceleration in the IGPs. In Zero till direct seeded rice 12 – 15 cm water (30 litre diesel) is reduced for puddling. Due to no cracking of ZT field (which is common in puddled field), there is saving of 7-8 irrigations (210 litre diesel) per hactare in rice cultivation. Total saving of 240 litre diesel reduces CO_2 emission by 624 kg/ha. Further, reduction in ground water exploitation reduces the high concentrations of toxic arsenic in drinking water especially in West Bengal and Bihar.

In first irrigation under ZT wheat, there is saving of 5-6 hrs/ha (20-21 hrs in conventional and 14-15 hrs in ZT) under 5HP diesel motor pumping. This saves 14.3 kg CO_2 emission. In permanent bed planting of rice - wheat system the total requirement of water is reduced by 30 per cent (from 155 cm in conventional to 108 cm) which means saving of 47 cm depth of water (220 litre diesel = 572 kg CO_2). Better placement of N through ZT helps to increased N use efficiency and reduced NO_3 leaching to soil.

RCTs improve water use efficiency/ water productivity and overall input use efficiency. Reduction of water use in land preparation (ZT Direct Seeded Rice and wheat, ZT transplanted rice) and adoption of second generation RCTs (laser land levelling system, residue management, bed planting and crop diversification) are worth considering in this regard. These RCTs are cost effective to improve total factor productivity as well as to reduce air and soil pollution.

Keywords : Resource Conservation Technologies (RCTs), greenhouse gases (GHG), Carbon to Productivity Ratio (CPR), Zero Tillage and Carbon Equivalents (CE)

Abstract No. 4.4

Simulation of Rice Yield and Methods of Adaptation under Climate Change Scenarios

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Elevated atmospheric CO_2 concentration and temperature will affect rice yield under the changing climate scenarios. Using the models ORYZA1 and INFOCROP-rice, the impact of climate change on rice in eastern India was characterized. The crop and weather data from ten different sites viz., Bhubaneswar, Chinsurah, Cuttack, Faizabad, Jabalpur, Jorhat, Kalyani, Pusa, Raipur and Ranchi, which differed significantly in their geographical and climatological factors, were used in these two models. At the current level of CO_2 (380 ppm), the ORYZA1and INFOCROP-rice models predicted an average yield change of -7.20% and -6.66%, respectively, for every 1°C increase in temperature. Likewise, an increase in CO_2 concentration of up to 700 ppm resulted in an increase of about 30.73% and 56.37%, respectively, which are higher than the actual increase of about 10%, reported by the recent FACE experiments. When the increase in temperature was about + 4°C above the ambient level, the differences between the two models became remarkably small. The ORYZA model predicted the yield changes of -7.63, -9.38 and -15.86% for the GDFL, GISS and UKMO scenarios, respectively while the INFOCROP did at -9.02, -11.30 and -21.35%, for the corresponding scenarios. There were considerable differences in the yield predictions for the various sites, with more declines in Cuttack and Bhubaneswar, but with increases for Jorhat. These differences in yield predictions were mainly due to the rice spikelet sterility at high temperature. Our results suggest that the limitation on rice yield imposed by high CO_2 and temperature can be mitigated, at least in part, by altering the sowing time and selection of genotypes that possess a higher tolerance of spikelet fertility at high temperatures.

Keywords : Adaptation, climate change scenario, INFOCROP-Rice, ORYZA1, rice

Abstract No. 4.5

Climate Change and Agriculture

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The impact of climate change on crop production and hence food security is an extremely important issue. At the global level, the fourth Assessment Report (AR4) of the Intergovernmental Panel on Climate Change (IPCC) projected an increase in the potential of food production with increase in average local temperatures between 1-3°C, but above this range the food production is expected to decrease. The AR4 has also projected that crop yields could increase up to 20% in East and South-East Asia while they could decrease up to 30% in Central and South-Asia by the mid-21st century. The available scenarios in India for future climate change show a high regional variability both in temperature and precipitation patterns. But the general projections of climate change impacts on agriculture in India point towards the adverse impacts and thus efforts may be required to develop/enhance appropriate adaptation technologies and measures.

Keywords : Climate change, crop production, food security

SESSION - 5

Environmental Issues Related to Climate Change

Abstract No. 5.1

Climate Change and CDM Regime : Sundarbans Mangroves

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Sunderbans, the largest delta in the world, consists of 10,200 km^2 of Mangrove Forest, spread over India (about 4200 km^2 of Reserved Forest) and Bangladesh (about 6000 km^2 Reserved Forest). It is also the largest Mangrove Forest in the world. In predicted climate variability scenarios, frequencies and intensities of tropical cyclones in Bay of Bengal will increase particularly in post monsoon period and increased flooding in low lying coastal areas. Most pertinent question is how current developmental investment and local stakeholders are addressing these concerns, in decision making process. Given the nature of the ecosystem with "incomparable value", addressing human well-being through vulnerability reduction would mean conservation of the unique ecosystem that can make income less uncertain through maintenance of the natural capital stock, human capacity building and substituting natural capital by manmade capital following precautionary principles determined by safe minimum standard.

Most important development choice with relevance to sea level rise in Sundarbans is in the shoreline protection through embankments. Major engineering intervention, which started in 1770 through 3500 km long embankment construction, changed the demographic pattern and disregarded the natural ecosystem. Embankment was created by hiring laborers from neighboring districts and states, who later became settlers there and started agricultural activity. Besides, this development induced migration and human induced land use pattern change, creation of embankment itself led to major interference with the natural environment causing conversion of forest land for creating human settlement and embankment itself through reclamation. The current population pressure has a historical past and past development choice has led to irreversibility that throws up a major challenge of resettlement for increasing within island movements.

The mangrove-shrimp linkage in the Sundarbans is different from that of other locations. There is little encroachment of shrimp farms into mangrove forests. However, the location of shrimp farms in the Sundarbans on agricultural land shifts the burden away from mangroves. Conversion to aquaculture ponds has induced further embankments. The anticipated rapid growth of the shrimp aquaculture industry has generated debate within the sustainability paradigm: regarding its contribution to economic growth, distribution of its benefits and costs, the environmental and ecological impacts, and the extent of public participation. More recent development choices are also in no way different than traditional

development pathway which causes vulnerability and does not mainstream ecosystem resilience. Huge investments projects on infrastructure are still guided more by engineering design, civil works, ground water abstraction etc. rather than integrated approach of eco-friendly shoreline protection, rain water harvesting, innovating institutional arrangements, etc. Approximately 80% of the development funds are spent on road construction, bridges, civil works, etc. Very recently mangrove protection, eco-tourism etc are also highlighted as discrete developmental objectives rather than as a development agenda with an ecosystem approach.

Past and ongoing developmental efforts have depleted the productive base of the local economy. Tidal flats, agricultural land, mangrove forests declined over time, while abandoned aquaculture ponds, degraded mangrove, salt marshes have increased. Over a period of one decade mangrove area has declined in Sundarbans from 420 (1987) hectares to 212 (1997) hectares. No appropriate valuation has been done to assess the monetary damage due to these physical changes in natural capital due to development choices and natural erosion. Consistent with sustainable development agenda any development related investment need to ensure how natural capital along with manmade and human capital are maintained to get an estimate of genuine investment and evaluation criteria needs to be consistent with Green accounting.

Goal of mainstreaming climate variability would mean systems approach where shoreline protection, livelihood issue and social mobility all can be addressed. In this context single most important conservation agenda in Sundarbans can be investment in Mangrove if goals are to sustain flow of ecological, economic, social and cultural services and reduce social conflicts. Mangroves provide global sink capacity, maintain ecological functions to support biodiversity and sustain economic livelihood flowing from ecological service flow locally and regionally. Mangrove swamps are considered very suitable for shrimp farming.

Green accounting framework can show explicitly land loss, soil quality deterioration, forest depletion, habitat loss, water quality change. If market conditions are allowed to drive the land use pattern, then it is necessary to revise the market prices through correct valuation of land in the light of ecological values. Increasing demand on land for alternative uses and declining land stock is bound to lead to conflict between governments sponsored conservation efforts and local livelihood opportunities. Given all the uncertainties, based on precautionary principle, immediate action can be making necessary institutional changes and sharing of information about the regulations, land use management and adoption of green accounting framework to help in making genuine investment decisions. The importance of mangroves should be promoted through economic valuation of mangroves, leading to increased levels of reforestation and conservation.

Keywords : Sunderbans, mangroves, CDM , green accounting

Abstract No. 5.2

Observed Sea Level Rise along the Coasts of the North Indian Ocean

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Sea level rise is one of the good indicators of global warming. Estimates of sea level changes are usually made by analysing past records of tide-gauges, which are instruments installed in harbours to make continuous measurements of sea level variations. Studies on global sea level rise based on past tide gauge records have given estimates of about 1.7 mm/year for the 20th century (Bindoff et al., 2007). Even though a lot of studies have been made on global sea level rise, very few studies exist on regional sea level changes. Sea level rise estimates along the Indian coasts from past tide gauge data were made in some earlier studies (Emery and Aubrey, 1989; Douglas, 1991). However, in one of our recent studies (Unnikrishnan and Shankar, 2007), all the records having a duration of more than 20 years were analysed. It is shown that these records are consistent with each other, and can be used for estimating sea level rise.

Even though all records were analysed for inter-consistency checks, only some were chosen for sea level rise estimates. The estimates, which are statistically significant for the records having more than 40 years duration, were selected. These are based on the records at Aden, Karachi, Mumbai, Kochi, Visakhapatnam and Kolkata. The estimated trends at these stations, except that at Diamond Harbor (Kolkata), vary between 1 to 2 mm/year. The tide gauge at Diamond Harbour is located in the delta region, which is known to undergo subsidence (Goodbred and Kuel, 2000). The estimated trend at Diamond Harbour is found to be over 5 mm/year, which could be partly associated with the sinking of the delta. The sea level rise trends obtained in all the stations (except Diamond Harbour) along the north Indian Ocean coasts are found to be consistent with global estimates, with an average of about 1.30 mm/year.

Keywords : Sea level rise, tide gauge records

Abstract No. 5.3

Climate Change Impact on Trace Metals in Soil and Plants

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This presentation would deal with the impact of climate change phenomena on soil and plants with specific examples of a) ionic stress b) ionomics c) metallomics d) brackish or estuarine and wetland ecosystems and e) biogeochemistry of trace elements under climate change stress phenomena. Salinity and sodicity is a serious global 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 population explosion and rapid urbanization have forced farmers to utilize marginal lands with ground water irrigation leading to soil salinization. Salinity alters the mineral composition in plants and causes essential ionic imbalance or toxicity and is known to reduce the plant growth. Salinity also decreases photosynthesis. Severe salt stress disrupts homeostasis in water potential and ionic balance of crop plants. 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 phytoremediation and restoration. 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*. Sodicity in soils has a strong influence on the soil structure of the layer in which it is present. A high proportion of sodium within the soil can result in essential nutrient dispersion. Dispersion occurs when the clay particles swell strongly and separate from each other on wetting. On drying, the soil becomes dense, cloddy and without structure. This dense layer is often impermeable to water and plant roots. In addition, scaling can occur when the topsoil is eroded and sodic subsoil is exposed to the surface, reducing plant available water content and increasing erodibility. Nutritional security and quality of agricultural produce and also the problems of hazardous trace element availability will also be covered.

Keywords : Climate change, salinity, sodicity, trace metals

Abstract No. 5.4

Climate Change and its Environmental Impacts

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Climate change is defined as a "shift in the average weather" of a given region. This is measured in terms of perturbations in temperature, wind patterns, precipitation, and storms etc. Global climate change means change in the Earth's climate as a whole. The Earth's natural climate has been under continuous change. However, the present climate change differs significantly from the previous climatic changes both in terms of magnitude and rate of change. This can be attributed mainly to anthropogenic events and activities.

Human as well as ecosystems' health is always under risk due to the climatic perturbations, stratospheric ozone depletion, continuously degrading air quality, loss of biodiversity, changes in hydrological systems and consequent changes in wetlands, marine and river water quality, land degradation and associated food-contamination. There is plethora of evidence suggesting that climate variability can result in spread of diseases, morbidity and mortality (http://wwws.who.int/globalchange/climate/en/index.html). The kind of health impacts include common vector-borne diseases such as malaria and dengue; as well as other major killers such as malnutrition and diarrhoea.

In short, the impacts of climate change can be of any of the following kinds :

- Global warming, increased temperature-gradients and their impact on ecosystem and human health;
- Soil, land and forest degradation (i.e. the impact on the terrestrial ecosystem);
- Perturbations in water supply and demand;
- Perturbations in environmental water demands, rainfall and precipitation etc.;
- Aberrations in flooding patterns, desertification etc.;
- Impact of rising sea-levels on coastal lands;
- Impact on local, regional and global ecological and socio-economic patterns ;

These impacts are not going to be evenly distributed throughout the globe. Developing and developed countries will face different kinds of impacts. This calls for looking into the

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socio-economic routes and linkages with the health impacts. Then, different ecosystems will have different kinds of impacts on themselves as well as on their inhabitants. For instance, small island states, high mountain zones and densely populated coastal areas will have different levels of vulnerability and adaptability. Some issues and research areas which require closer look and analysis can be categorized as follows :

- Vulnerability and adaptability dynamics and innovative approaches towards disease management;
- Population dynamics, its household, socio-economic and age-structures and their relative sensitivity towards vulnerability and adaptability;
- Land-use changes, their implications in terms of climate change and the resultant impacts on ecosystem and human health;
- Trans-boundary air pollution, its interaction with climate change and impact on human and ecosystem health;
- Technological interventions and environmental management; and
- International interactions, negotiations and transnational health governance etc.

The presentation, *inter alia,* looks into past and present issues connected with climate change and its impact on human health, and analyses various on-going research activities which provide many useful insights into the land-air-water linkages of climatic changes with perturbations in carbon, hydrological and bio-geo-chemical cycles and their resultant impacts on human health.

Keywords : Climatic variability, global warming, population dynamics, wind patterns

Abstract No. 5.6

Quantifying the Minimum Possible Aerosol Load (RSPM and SPM) in Delhi

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A unique experiment was designed to estimate the minimum possible aerosol load in Delhi's ambient environment under conditions where all anthropogenic sources are in quiescent state; aerosol load is driven only by the regional and local meteorological factors. Sequential eight hourly aerosol samples in two size fractions (≤ 10 μm known as PM_{10} & ≥ 10 μm known as SPM) were collected and analyzed for the elemental signatures associated with the tracer and other sources. Principal Component Analysis (PCA) was used to resolve the sources; their respective mass contribution to PM_{10} and SPM load, in time sequence, was estimated using Absolute Principal Component Score (APCS) method. Discrete Fourier Analysis (DFT) of the resolved mass contributions arising from the source(s) was used to investigate the presence of any periodicity with respect to the (PM_{10} and SPM) ambient load associated with the identified sources and diurnal changes in the region's meteorological factors. The results suggest that Delhi will register 57.5 μg minimum background SPM load due to meteorological factor(s) driven re-suspension of local crustal material in the day hours during the onset of winter season.

Keywords : Aerosol load, PCA, APCS, Fourier analysis

Abstract No. 5.7

Undulation of Particulate (aerosol) Load in Ambient Environment, Driven by Early Winter Meteorology, Identification of New Anthropogenic Source, and Morphological Attributes of Carbonaceous Aerosols

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The presence of particles, also known as aerosols in atmosphere, is an ubiquitous natural trait. Morphologically, dimensionally, structurally, and chemically they manifest high degree of complexity and variation, which percolates into their functional attributes : both deleterious and beneficial to man. Perhaps, suspended particulate load in air represent an excellent example of functionally dynamic process linking Earth-Atmosphere system bestowed with dual character.

Threat to human health arises as we breathe in air containing particles, and depending on their chemical composition (benign to malignant) they can seriously stress respiratory, cardiovascular and visual acuity. On the other hand, they transport nutrient minerals, modulate atmospheric radiative balance and assists in the cloud formation. Given the widespread variability and complexity in their structural and functional attributes, ambient aerosols have come under intense scientific investigation in recent years : their role in enhancing global warming; identification of anthropogenic sources; and understanding their atmospheric load variability with reference to other atmospheric dynamic traits.

The presentation relates to the identification of new anthropogenic source of respirable particulate matter in Delhi's ambient environment accounting for ~25% of the ambient load. Identification of early morning city-wide practice of cleaning the surface deposits as a source was accomplished by designing a novel experimental design by appropriating a episodic event of Diwali as a tracer source. This novel experimental design has opened up possibilities to investigate the role of anthropogenic activities, so far, considered benign in amplifying the respirable particulate load in ambient environment in urban setting. The extent of carbonaceous aerosols emitted, their fractal structure, and their implication to global warming issue is also presented.

Keywords : Carbonaceous aerosols, respirable particulate matter, anthropogenic source

Abstract No. 5.8

Morphological Characterization of Carbonaceous Aerosols and its Role in Global Climate Change

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In this study, we have characterized soot on the basis of its fractal dimensions, morphology and functional groups attached to it. Soot aggregates of different fuels and carbonaceous aggregates found in freefall aerosols were compared. All were found to have fractal morphology with fractal dimension < 2. The result shows that cluster-cluster aggregation is the dominating process which leads to the formation of this chain/grape bunched like aggregates. Surface morphology of diesel soot shows that it has porous surface, which has potential to adsorb or absorb other atmospheric pollutants. The characteristic of soot aggregates and aerosol aggregates can be altered after emissions from the source and due to various meteorological processes, which can change its morphology and properties. Chemical nature of fuel and other factors such as fuel burning efficiency, engine type, etc. play an important role in defining the morphology of soot aggregates. In freefall aerosols it is difficult to apportion the source of carbonaceous aggregates but fractal analysis could prove beneficial for such kind of studies by the use of this dimension as a signature of particular soot type. This fractal dimension study was also linked to estimate radiative forcing caused by these carbonaceous aerosols.

Keywords : Carbonaceous aerosols, fractal dimension, climate change, morphology

Abstract No. 5.9

Emission Trends of Road Transport in Delhi, India in a Local and Global Perspective

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Delhi, the capital of India, is one of the most polluted regions of the world. In this regard, in excess of 70% pollutants emitted through the road transport sector stands out. Control measures implemented in the past (1999-2001) to alleviate the air quality have, up to some extent, helped in retarding the rate at which Delhi's air quality was vitiating. However, our research showed that the unprecedented increase in the number of vehicles; and likely further increase in near future (e.g. introduction of Tata-nano car), would severely compromise the air quality of the city. The approach used in this study was based upon material balance concept and we used two models [(MEET, 1999 and COPERT IV (2006)] to quantify the time sequence of emissions arising from the ever expanding transport sector in Delhi.

Keywords : Road transport, emission inventory, fossil fuels, CNG, urban air quality, Delhi, CO_2-emissions

Abstract No. 5.10

Correlation between Ground Level Ultra-Violet Radiation and Lower Atmospheric Aerosol Load in Delhi

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UV radiation is known to affect many biological and chemical processes, and is largely detrimental to individual organisms. Specific concerns include increases in the incidence of skin cancer, ocular damage, and other health effects in humans and animals; damage to terrestrial and oceanic vegetation; changes in the chemistry of lower atmosphere e.g. photochemical smog formation. Present study was undertaken to monitor lower atmospheric aerosol load with Respirable Dust Sampler and ultraviolet radiation with UV-radiometer in the ambient environment of Delhi. PM_{10} (≤ 10 μm) and SPM (≥ 10 μm) samples were collected for the period of the study (8 weeks, 2 samples per week, 16 samples). Hourly UV Fluxes (UV-B & UV-A) were measured from four hours ahead to four hours following the solar noon (LAT 12:00hrs) alongside aerosol sampling twice a week. Our study showed that lower atmospheric load of finer particles (PM_{10}) significantly cut-off both UV-A and UV-B fluxes reaching the earth surface. RSPM (PM_{10}) load showed a satisfactory negative correlation with UV-A and UV-B fluxes at ground level.

Keywords : UV, PM_{10}, SPM

SESSION - 6

Environment Issues, Carbon Sequestration & Clean Development Mechanism

Abstract No. 6.1

Climate Change and Himalyas with Special Reference to Carbon Sequestration

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Himalayas and adjacent Gangetic Plains together form one of the most important systems of the planet from geoecological and anthropological stand points. While the young and lofty Himalayas (the average altitude in the greater Himalayan region being 6100 m, with some peaks rising above 8000 m) represent one of the largest wilderness areas, the Gangetic Plains with about 500 million people is the largest anthropogenic system on the planet. Through the Gangetic river connections, the Himalayan forests have been serving the Gangetic Plains since time immemorial by providing soil and water and replenishing agricultural fertility. The climate change is predicted to affect the mountains and plains connection in several ways, the retreat of glaciers being the most critical of them. As the glaciers melt, the river flow would become exceedingly seasonal, with severe consequences on structure and functioning of river ecosystems and economic activities in the Gangetic watershed. A rise of one degree celsius temperature would cause about 150 m rise in snowline. The alpine belt would be most vulnerable to climate change, as species near the mountain tops would have no area to migrate. Already tree species like *Quercus semecarpifolia* (brown oak), *Betula utilis* (birch) and *Abies pindrow* (silver fir) occur in islands. Animals like pikas and musk deer are expected to be the first to disappear. The alpine meadows, where most of the medicinal and aromatic plants of importance occur, would be converted into woody vegetation with warming of temperature. Many plants requiring snow cover would be exposed to frosts with the advancement of snowmelt.

Since most of the natural vegetation of the lowland areas has been replaced by agricultural cropfields, they are left only with invasive weeds to migrate into the Himalayan region. The warming would send many of these species deep inside the mountains.

The adjacent marshy plains may prove to be the source of vector-borne diseases like malaria. It is predicted that malaria might reach beyond 1500 m altitude, where most hill stations are located.

A warmer condition may also disrupt altitudinal zonation of vegetation also in several other ways. For example, warming by hastening the seed maturation in *Shorea robusta* (sal) and in some more viviparous oaks, may disrupt the synchrony between seed maturation and commencement of monsoon rainfall. These ecologically dominant species may fail to maintain regeneration in such circumstances. The warmer temperatures may also cause increased evapo-transpiration during spring-time when most trees produce new leaves. How

species are going to respond to the water stress may substantially affect several processes at species and ecosystem levels.

The Himalayan forests, in a healthy condition, are effective carbon sequesters, accumulating carbon generally at the rates of 4 to 6 t ha $^{-1}$ yr $^{-1}$, which are on the higher side of the range of values observed at the global level for the forests. However, because of forest degradation values lower than these are common. At least in some community managed forests carbon sequestration rates between 2.2 and 4.4 t C ha $^{-1}$ yr $^{-1}$ have been observed, which are quite high seeing that villages also use them to meet their daily biomass needs. The entire Himalayan forests sequester about 65 million tonnes of carbon each year. One of the major consequences of global warming could be the increased rate of soil carbon depletion.

Several adaptational strategies would be required to address the problems that the climate change can trigger. The problem may pertain to change in precipitation pattern and hydrological cycle, glaciers retreat, retention of water in mountains, forest replacement, change in agricultural crops, spread of tropical diseases, depletion of alpine ecosystem in many areas, lack of corridors for the species migration, loss of habitats for several species of land for humans, and migration of people to suitable areas, if any.

Keywords : Himalayan forests, carbon sequestration, alpine vegetation

Abstract No. 6.2

Human Dimensions of Climate Change : Geospatial Perspective

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Climate change is a cumulative impact of the anthropogenically driven changes on the earth's surface. It has affected or is affecting almost all the aspects of the terrestrial ecosystems like primary productivity, biodiversity, agriculture, soil dynamics, etc. at macro as well as micro level. The major drivers of climate change are land use change, increase in green house gases, nutrient deposition and introduction of exotic and invasive species.

The amount of earth we use for maintaining the standard of our living (Ecological footprint) has a tremendous implication on the global climate change. Presently we are using resources, which will require 3.5 earths to sustain at the present rate of resource use. The ecological footprints of most of the regions of the earth have been estimated to increase as a result of climate change. The most important aspect of the ecological footprint i.e. water foot print will increase the most (~ 5.7%) as a result of climate change. Increasing population, depleting existing energy resources coupled with decrease in agricultural production as a result of the climate change will lead to an increase in the footprint of the energy and food. Food footprint will also increase due to loss of biodiversity hence gene pool, which is used by mankind for food and sustenance. The loss of forest cover as a result of deforestation (@ 13 million hectares per year) is systematically increasing the ecological foot print of the humanity as the ecological benefits of the deforested area has to be borne by the remaining vegetated areas.

In this context, remote sensing (RS) and Geographic Information System (GIS) can play an important role in providing spatially explicit information on the changing ecosystem structure and function. Various space-based platforms provide remotely sensed spatial data at various scales on land use and land cover and its temporal variations, landscape level biodiversity, cropping patterns and productivity, etc. These can be modelled in a GIS environment along with ancillary data from climate change models for predicting the probable change scenario. This database is also useful for identifying areas for conservation and prioritization, hotspot niches and predicting future land use change scenario using various geospatial models (SPLAM, GARP, GEOMOD). The extent and impact of damage to coral reefs, one of the major biodiversity rich regions of the world, due to rise in Sea Surface Temperature can be carried out using RS data. With the development of new technologies in LIDAR, hyper spectral, and microwave based sensors, spatial characterization of the various facets of the climate change and their impacts will become easier and will enable us to take appropriate steps in mitigation.

Key Words : Climate change, ecological footprints, change models, biodiversity

Abstract No. 6.3

Carbon Sequestration by Higher Plants and Algae to Combat Global Warming

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Atmospheric CO_2 concentration has risen at an accelerating pace since the start of the industrial revolution because of burning of fossil fuel and deforestation. Prior to the industrial revolution CO_2 was stable at about 270 ppm; today CO_2 is approximately 38% higher at 380 ppm, and by the middle of this century it is predicted to reach 550 ppm and by the end of the century the CO_2 concentration is likely to reach 700 ppm. Today's crop and natural vegetation are growing at an elevated CO_2 level that has not been experienced by terrestrial or aquatic vegetation for past thousands of years. Understanding how plants respond and might be adapted to a future increase in CO_2 will also help us understand how they are currently responding and how they may have adapted to the increase that has already occurred. Increase in carbon dioxide concentration should result in a stimulation in photosynthetic carbon fixation of between 30 and 50%, primarily due to a reduction in photorespiration as the ribulose 1·5-bisphosphate carboxylase/oxygenase (Rubisco) carboxylation reaction is favoured in these conditions. In field among natural vegetation and in aquatic ecosystem eg. ocean total carbon uptake is not simply a function of light-saturated photosynthesis, but also of light-limited photosynthesis, which may account for up to 50% of canopy carbon uptake. The initial slope of the response of carbon assimilation (A) to photon flux (Q) is the maximum quantum yield of CO_2 uptake (QY) and the phase of photosynthesis that is exclusively light limited. Light-limited photosynthesis is determined by the rate of regeneration of RuBP, and will increase as CO_2 increases because less ATP and NADPH is diverted into photorespiratory metabolism, and therefore more is available for CO_2 uptake. However, many plant species grown at elevated CO_2 do not have increased photosynthesis and growth to the level of 30-50%. It is substantially less than these figures. This is probably because plants at elevated CO_2 exhibit an acclimatory down-regulation, decreasing photosynthetic potential, particularly with long-term growth in elevated CO_2. This acclimatory response is often correlated with increased carbohydrate levels together with reductions in total nitrogen and Rubisco activity. Perennial plants are excellent examples of carbon sequestration. However, they are more prone to down-regulation of photosynthesis at elevated CO_2. It is essential to sequester carbon in fast growing perennial tree (poplar for example) for carbon sequestration. Although we some how know the effect of high CO_2 on annual crop plants its effect on

perennial plants are not well studied. More over the effect of high CO_2 accompanied by high temperature on C_3 photosynthesis and plant productivity needs to be studied in growth chamber as well as in field conditions. Increased CO_2 although may increase carbohydrate contents, the protein contents of plants especially in forest ecosystem will be severely downregulated as NO_3^- uptake from soil may not match with increased carbohydrate contents.

Besides long-term carbon sequestration by woody plants, it is essential to have short term carbon sequestration for production bio-ethanol. As the human population is increasing in the world especially in India, it will be prudent to use land plants for food and not for fuel. Therefore, we should look into sea or back waters for cultivation of carbohydrate-containing sea weeds, eg. red alga *Gracilaria vericosa* for production of bio-ethanol. Photosynthetic H_2 production from water by hydrogenase by marine phytoplanktons will be of great help in providing clean alternate energy to combat high CO_2 and global warming.

Keywords : Carbon sequestration, C_3 photosynthesis, higher plants, algae, global warming

Abstract No. 6.4

Carbon Sequestration Potential Studies in Forest and Agro-Ecosystem in Central Himalayan Region of India

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Out of the six most important elements necessary for life, carbon accounts for about 49% of organism's dry weight, carbon is only next to water in significance to the living world. The cycle involves movement of CO_2 from the atmospheric reservoir to plants, animals, decomposers and back to atmosphere. Land plants are estimated to contain about 250 times as much carbon as aquatic plants; most of it is in the form of forest growth. During the pre-industrial age, various pathways collectively formed self-regulating feed back mechanism resulting in a homeostatic system with adjustments of additions and deletions of CO_2 concentrations in the atmosphere. This balance has been disturbed with increase in CO_2 from 280 ppm in 1750 to about 371 ppm in 2001. Studies find that of the 6.3 GT carbon released annually into the atmosphere, about 84% is due to the fossil fuel combustion and cement production, and the remaining is due to tropical forest clearing. However, 46 % increase is expressed in atmospheric increase of CO_2. Some may be fixed by green plants in photosynthesis induced by increased atmospheric CO_2 level often termed as CO_2 fertilization. The forest and agroecosystem represent one of the important sinks for sequestration of CO_2; however the carbon stock and carbon sequestration potential may differ in different forest types, tree species and soil types. Variation in atmospheric carbon dioxide content due to change in climatic conditions and land use changes result in changes in the carbon sequestration potential in vegetation and soil. The study will highlight the importance of carbon stock studies in forest and agrocecosytems in central Himalayan region with a view for better carbon management with respect to increased carbon sequestration potential in mountains.

Keywords: Carbon sequesestration, forest ecosystems, agroecosystems, central himalaya

Abstract No. 6.5

Free Air CO_2 Enrichment Technology (FACE Technology)

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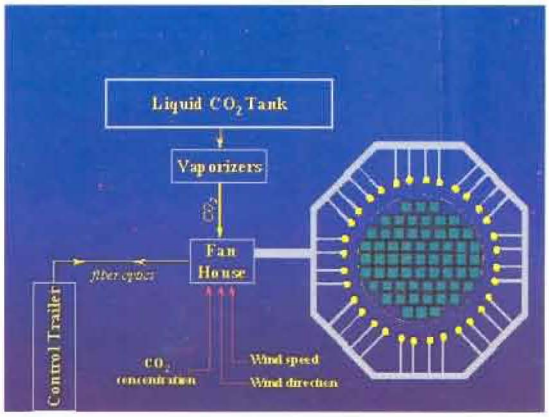
The atmospheric carbon dioxide concentration ($[CO_2]$) has risen by 35% since the start of the industrial revolution; it is higher now than at any time in the past 25 million years and is predicted to increase an additional 50% by 2050. Plants respond to rising $[CO_2]$ through increased photosynthesis and reduced transpiration. Photosynthesis removes CO_2 from the atmosphere and respiration by plants and heterotrophs add it back.

Therefore, the terrestrial biosphere is not just a passive respondent to rising $[CO_2]$ but can play a fundamental role in determining the rate of global change. Before FACE, much of what we knew about plant and ecosystem responses to rising $[CO_2]$ came from studies conducted in enclosures where the response of plants is modified by their growth conditions. FACE was developed as a mean to grow plants in the field at a controlled elevation of $[CO_2]$ under fully open-air conditions. Results from FACE experiments provide perhaps the best estimate of how plants and ecosystems will respond in a future high CO_2 world.

What is FACE?

A typical FACE plot is approximately circular and surrounded by a ring of pipes that release CO_2 or air enriched with CO_2, at vertical intervals from just above the ground to just above the top of the plant canopy. Wind direction, wind velocity, and $[CO_2]$ are measured at the centre of each plot and this information is used by a computer-controlled system to adjust CO_2 flow rate to maintain the target elevated $[CO_2]$.

Only pipes on the upwind side of the plots release CO_2, unless wind velocity is very low, at that time CO_2 is released alternately from adjacent release points. For vegetation of low stature, only one or two vertical release points are necessary, whereas for tall vegetation



several vertical release points are needed to enrich the whole canopy.

Fast feedback algorithms avoid large overshoots in response to fluctuations in [CO_2] and provide a stable elevation of [CO_2]. This basic design has been utilized with some variations and technical developments in over ten experiments in plots that are as large as 30m diameter that can accommodate vegetation as tall as 25 metres.

What are the advantages of FACE?

FACE studies are fully open air and have many benefits over controlled environment and open-top chamber (OTC) experiments. FACE allows the investigation of an undisturbed ecosystem and does not modify the vegetation's interaction with light, temperature, wind, precipitation, pathogens and insects.

This, in combination with the large size of FACE plots, allows the integrated measurement of many plant and ecosystem processes simultaneously in the same plot, avoids many of the problems associated with edge effects prevalent in OTCs, enables significantly more plant material to be harvested without compromising the experiment, and allows plants to be studied throughout their life cycle, including trees that have enough space to develop to canopy closure.

FACE is considered a consolidated technique to expose crops, forest plantations and natural vegetation to the conditions of elevated atmospheric CO_2 concentrations that are expected to occur in the near future. **FACE** technology has evolved considerably since the first experiments conducted by Harper and co-workers in the **70's** (Harper *et al.*, 1973) and by van Mooi and co-workers in the **80's** (Mooi, 1985). At present there are more than twenty operational FACE sites around the world in Northern and Central America, in Europe, Asia and Oceania. The size of the FACE plots varies from one metre diameter of the **MiniFACE** (Miglietta *et al.*, 1996; Miglietta *et al.*, 2001) to the **30 m** of the larger FACE systems that have been used to fumigate patches of forest plantations with CO_2 (Hendrey, 1999). FACE experiments are almost unanimously considered to provide the best opportunity to expose patches of managed or unmanaged vegetation to elevated CO_2 with minimal alteration of the natural environment where plants are growing. Nevertheless, FACE systems also suffer from some experimental limitations that have to do with the presence of substantial infrastructure, the unavoidable presence of CO_2 concentration gradients along the wind direction and short-term fluctuations in CO_2 concentration. The use of blowers has also some technical consequences on the FACE design that finally requires large pipes to allow the circulation of large quantities of air, higher power requirement and significant infrastructure. Moreover, the use of the blowers implies the construction of control rings where everything is operated in the same way than in the FACE, with the only exception of the injection of carbon dioxide. Recently different groups of scientists in the **USA** (Steve Roberts, personal communication), **Japan** (Okada *et al.*) have attempted to modify the design of their FACE systems to introduce the release of pure carbon dioxide instead of an air-CO_2 mixture. Such "pure-CO_2" FACE was thought to be a possible alternative solution to the more conventional systems, providing some potential advantages.Data developed by Ibimet clearly indicate that Free Air CO_2 Enrichment

can be satisfactorily obtained by releasing pure CO_2 instead of a pre-diluted air+CO_2 mixture. The use of CO_2 jets at sonic velocity greatly enhanced the air-CO_2 mixing that occurred at the releasing points and this translated into an adequate air-CO_2 mixing within the FACE area under both low and high-wind conditions. Power spectra analysis showed the relative merits of the pre-diluting effects of the sonic jets and plenums when compared to subsonic CO_2 release. As we hypothesized the effect of the pre-dilution was evidenced in the Kolmogorov scale fluctuation. The advantages of this type of FACE design are clear. The so called "blower effect" is completely suppressed, the infrastructure is much lighter and less disturbing than in any other FACE system, the capital cost of the infrastructure is greatly reduced and the construction of the "control rings" is no longer required. More research is instead needed to evaluate the quality of the control under atmospheric stability and in particular at night. This aspect was not specifically considered for the **POPFACE** system as the fumigation was stopped during night. In this respect, the direct comparison of fast-frequency CO_2 spectra for a pure-CO_2 and a pre-diluted CO_2 injection system, would be of importance to understand if pre-dilution operated by the blowers would improve the situation significantly, under those conditions (He *et al.*, 1996). The possibility to continue satisfactory CO_2 fumigation in a poplar plantation that is expected to grow very rapidly and to attain a significant height, is a big challenge ahead of us. Hopefully the POPFACE project will continue over the next seasons thus providing an opportunity to further test the quality of the CO_2 control with the same free air CO_2 enrichment system.

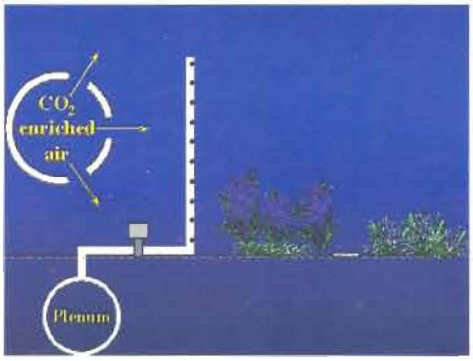
Unique Free Air CO_2 Enrichment (FACE) technology to elevate the atmospheric concentration of CO_2 in the experimental plots

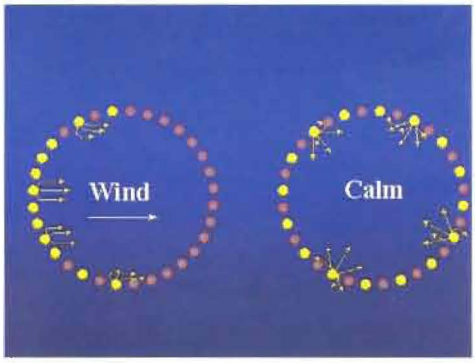
Much research using elevated CO_2 has been done in enclosed areas, such as growth chambers and greenhouses where it is relatively easy to control the levels of gases. However there are some limitations associated with these techniques. It is difficult to study plants under certain natural conditions, such as temperature, pollination, wind, humidity, and sunlight, within these enclosures. Size of the plant growth and experimental area is also constrained while using these technologies. It uses natural wind conditions to carry CO_2 enriched air across the vegetation. Because the plants are outside in a more natural environment, the chamber effects normally created by enclosures such as greenhouses are reduced or eliminated.

This is made up of six fumigation circles. Three of these circles are fumigated with CO_2 enriched air. The FACE system is designed to maintain the level of CO_2 above the experimental planting at 550 parts per million (ppm), using sensors set up in and near the

circles and a central control computer. The remaining 3 circles are 'fumigated' with ambient air (~360 ppm CO_2) with no experimental CO_2 addition in order to protect against erroneous results caused by the experimental equipment. Sensors at each circle continuously transmit information about wind speed and direction, as well as CO_2 concentrations above the plots via fibre optics to a control computer. The computer, located in a centralized control trailer, uses this information to calculate the amount of CO_2 to release, and which side of the circle to release it on. This information is sent to fan houses located at each circle that contain instruments, which adjust the CO_2 fumigation equipment.

A valve inside the fan house controls the amount of pure CO_2 added. The CO_2 then is





mixed with ambient air and a large fan blows this mixture into an underground pipe, called a plenum, which runs around the plot circle in the shape of an octagon. To conserve CO_2, the enriched air is only emitted on the upwind side of the circles. Every 4 seconds, the control computer relays control instructions to the fan where a system of electronic components open and close large pneumatic valves on vertical emitter pipes installed around the plots (upwind pipes are opened, downwind pipes are closed). After passing through these valves, the CO_2 enriched air travels up through the vertical pipes and is emitted through a series of small holes. Natural wind currents distribute the enriched air over and through the plots. When the wind speed is too low to carry the enriched air across the plots, alternating vertical pipes are opened so that small, shifting winds can still distribute the CO_2 enriched air.

Because airflow is important to the distribution of the CO_2, as much of the infrastructure at the site as possible is buried so as not to obstruct wind. This includes the plenums, CO_2 piping, and utilities serving each circle. Any aboveground structure in the field is located at a distance great enough from any fumigation area to prevent disturbance of the airflow patterns.

Keywords : High CO_2, FACE technology

Abstract No. 6.6

Need for a FACE System to Evaluate Interactive Effects of CO_2 and O_3 on Plants in India

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Atmospheric carbon dioxide (CO_2) concentrations have increased dramatically since pre-industrial times and are predicted to rise to over 700 ppm by 2100 (IPCC, 2007). Of late, much effort has been put into linking models of climate change and crop/plant yield/growth. It has been projected that increased temperature and decreased soil moisture, which would otherwise reduce crop yields, will be offset by the direct fertilization effect of rising CO_2. In C_3 plants, at 25°C, an increase in CO_2 from the present-day value of 380 ppm to that of 550 ppm, projected for the year 2050, would increase C_3 photosynthesis by 38%. C_4 crops, most probably, may not show a significant increase in photosynthesis. However, most of these prediction models have not included one very important factor that could negate CO_2 fertilization effect – tropospheric ozone (O_3).

Emissions of oxidized nitrogen (NOx) and volatile organic compounds (VOC) from fossil fuel combustion have increased background levels of tropospheric O_3 by 36–70% during last one century (IPCC, 2007). Ozone (O_3) is regarded as one of the most phytotoxic of the air pollutants, causing toxicity at concentrations as low as 30 ppb. In addition to their contribution to the 'greenhouse effect', CO_2 and O_3 have direct impacts on plant physiology and crop production. Initially these studies were done in growth chambers or open top chambers. But these chamber studies were found to be inadequate for predicting future crop yields owing to so called "chamber effects". These included decreased solar radiation and wind speed, increased air temperature and relative humidity, etc. To overcome these limitations, free-air concentration enrichment (FACE) was developed. The most important attribute of FACE is that it is chamberless. Only the desired gas (CO_2 or O_3) is released and its concentration is monitored along with wind direction, velocity, etc. This way the prediction becomes more realistic. All the FACE studies related to climate change and crops have been conducted either in North America or Europe (Karnosky *et* al., 2007). In India, all the precursors (ever increasing automobile population, narrow and poorly maintained roads and sun light) of O_3 are in plenty. In a recent study Mittal *et al.* (2007), using episodic chemical transport model christened HANK, found that many regions in India had high concentration of O_3. AOT40—a parameter that represents the accumulated dose of O_3 over a threshold of 40 ppb is computed for the region. The Indo-Gangetic plain in the Northeast region of India has been found to have very high AOT40. It is of significant concern for agricultural productivity. More than 40% of the population in this region depends on an economy related to agriculture.

Therefore, there is an urgent need to perform long-term FACE experiments to investigate interactive effects of simultaneous change in CO_2 and O_3 on plants. These studies will help in establishing a robust cause-and-effect chain, providing useful data for climate change prediction models.

Keywords : Climate change, FACE, CO_2, O_3, crops

Abstract No. 6.7

Yoga, a Measure to Conserve Climate in Retrospect of Reviving Flora

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Yoga is an extraordinary and unique Indian technique to dwell a deep awareness within. By virtue of vibration and pulsation with the body, mind and intellect levels one can master the internal and external forces. Yoga is a discipline, which provides perfection, purity and life's fulfillment. Womb to tomb, man is basically in search of happiness. The yoga way is a systematic process of calming down the mind. Nowadays man is tending towards materialism. Earth's climate is changing due to human activities like-

- Over exploitation of natural resources.
- Changes of land use.
- Increase in pollution and utilization of dangerous chemical compounds.
- Bombing and cyanide fishing, coral mining.
- Sedimentation.
- Tourism activities.

There is an urgent need to increase people's awareness of environmental protection and conservation. Practising Yoga can curb environmental degradation. Yoga is an ancient Indian art and science which enables a man to practice control over his body, mind and soul. It teaches self discipline and is able to change the mental disposition of human beings. Yoga is deeply associated with Ayurveda, which is entirely dependent on Flora.

"Yogena cittasya padena vaca malam sarirasya ca vaidyakena

Yopakarottam pravaram muninam Patanjalim pranjaliranatosmi"

Meaning- 'I offer my salutations with folded hands to Patanjali, the renowned amongst the sages, who removed the impurity of mind through Yoga, of the speech by Grammar and of the body by Ayurveda'. Practising Yoga directs a man towards self realization. It reminds him of his duty towards nature.The curtain of darkness of materialism is removed from mind. It is so miraculous that a man who wishes to grow the jungles of concrete and cement desires to seek peace in the lap of nature after absorbing into Yoga.

To conclude, it may be said that in today's fast growing world, high technology and competition in every field, Yoga is the need of the time. Yoga roots out the ethical problems. It believes in Ayurveda. Promotion of Yoga in the world can save climate and flora.

Key words : Climate change, yoga, environment, flora

शुभ कामनाओं सहित

राज्य संग्रहालय

प्राणि उद्यान परिसर, बनारसीबाग,
लखनऊ

राज्य संग्रहालय लखनऊ में विशेष रूप से दर्शनीय है:-

मुद्रा वीथिका, मूर्तिकला वीथिका, नवाबों के काल की कला वीथिका - जिसमें उनके द्वारा प्रयोग की गयी अनेक बेशकीमती वस्तुएं, चित्रकला वीथिका - जिसमें 15वीं शताब्दी से लेकर 19वीं शताब्दी के हस्तनिर्मित लघु चित्र। जैन कला वीथिका - जिसमें जैन धर्म से संबंधित पाण्डुलिपियां एवं तीर्थंकरों की मूर्तियाँ उल्लेखनीय हैं। - मिश्र देश की लगभग 5000 वर्ष पुरानी ममी, जो आजतक मूल रूप में प्रदर्शित है।

प्रदेश एवं देश की ऐतिहासिक एवं सांस्कृतिक धरोहर का संरक्षक। ज्ञान एवं मनोरंजन के लिए अवश्य पधारें।

निदेशक

सम्पर्क सूत्रः 0522-2206158

शुभ कामनाओं सहित

छोटे लाल ईंट उद्योग

सुराया, ब्लाक-एका, तहसील जसराना,
जनपद फिरोज़ाबाद

एटा से लगभग 18 किमी० दूर आगरा रोड पर अवागढ़ के पास हमारी उपरोक्त फर्म द्वारा संचालित भट्ठा प्रदूषण रहित तकनीक पर आधारित है, जिसमें मजबूत एवं उच्च कोटि के ईंटे निर्मित किये जा रहे हैं। उक्त ईंटों को रियायती दर पर बेचा जाता है। कृपया एक बार पधार कर सेवा का अवसर प्रदान करने की कृपा करें।

(अजय पाल सिंह)
भट्ठा संचालक
सम्पर्क सूत्रः 9410414474
9936868916

शुभ कामनाओं सहित

लखनऊ नगर निगम

प्रगति एवं विकास के पथ पर निरन्तर अग्रसर

मा. कांशीराम जी शहरी समग्र विकास योजना के अन्तर्गत संचालित योजनायें

1. इन्दिरा नगर वार्ड में रू0 973.92 लाख की लागत से पक्की सड़कों का निर्माण, जल निकासी हेतु नाली/नालों का निर्माण एवं जनसुविधाओं के दृष्टिगत मान्यवर कांशीराम जी सामुदायिक केन्द्र का निर्माण कार्य व प्रत्येक मार्ग पर स्ट्रीट लाईट लगवाने का कार्य प्रस्तावित है, जिन्हें शीघ्र ही प्रारम्भ किया जा रहा है।

2. राजा बिजली पासी वार्ड में रू0 1803.18 लाख की लागत से पक्की सड़कों का निर्माण, जल निकासी हेतु नाली/नालों का निर्माण एवं जनसुविधाओं के दृष्टिगत मान्यवर कांशीराम जी सामुदायिक केन्द्र का निर्माण कार्य व प्रत्येक मार्ग पर स्ट्रीट लाइट लगवाने का कार्य प्रस्तावित है, जिन्हें शीघ्र ही प्रारम्भ किया जा रहा है।

3. सआदतगंज वार्ड में रू0 1242.90 लाख की लागत से पक्की सड़कों का निर्माण, जल निकासी हेतु नाली/नालों का निर्माण एवं जनसुविधाओं के दृष्टिगत मान्यवर कांशीराम जी सामुदायिक केन्द्र का निर्माण कार्य प्रस्तावित है, जिसमें से जल निकासी, जनसुविधा एवं सामुदायिक केन्द्र का निर्माण व प्रत्येक मार्ग पर स्ट्रीट लाईट लगवाने का कार्य प्रस्तावित हैं, जिन्हें शीघ्र ही प्रारम्भ किया जा रहा है।

4. मल्लाही टोला वार्ड में रू0 746.89 लाख की लागत से गलियों/सड़कों के निर्माण कार्य, जल निकासी हेतु नाली/नालों का निर्माण एवं जनसुविधाओं के दृ टगत मान्यवर कांशी राम जी सामुदायिक केन्द्र का निर्माण कार्य प्रस्तावित है, जिनमें 16 नालों का निर्माण एवं. रू0 129.00 लाख की लागत से एक सामुदायिक केन्द्र का निर्माण व प्रत्येक मार्ग पर स्ट्रीट लाईट लगवाने का कार्य प्रस्तावित है, जिन्हें शीघ्र ही प्रारम्भ किया जा रहा है।

उपलब्धियां

- रू0 3720.24 लाख की धनराशि से 229.41 कि.मी. सड़क का निर्माण।
- 0.24 कि.मी. खड़ंजा का निर्माण। 75.25 कि.मी. नाली का निर्माण।
- 105 पार्कों का जीर्णोद्धार व मरम्मत।
- राष्ट्रीय फेरी नीति के अन्तर्गत फेरी नीति का निर्धारण।
- बीमारों हेतु एम्बुलेन्स, पशु हेतु पशु वाहन, लावारिस शवों हेतु शववाहन का लोकार्पण।
- कूड़ा निस्तारण हेतु 8 नयी ट्रकों का लोकार्पण।
- लखनऊ नगर में कूड़ा निस्तारण हेतु घर–घर कूड़ा संग्रहण कार्य का प्रस्ताव।

प्रस्तावित योजनाएं

- रू0 1619.20 लाख से 86.80 कि.मी. सड़क, 0.05 कि.मी. खड़ंजा एवं 27.25 कि.मी. नाली का निर्माण।
- गोमती तटबन्ध पर साँई उपवन, अवध गार्डेन, न्यू लक्ष्मण मेला पार्क, मनकामेश्वर वन भगवान झूलेलाल वाटिका, श्रद्धा उपवन, बाग–ए–अकीदत, बाबा मीर कासिम व मंहगू बाबा स्मृति वाटिका तथा कारगिल शहीद स्मृति वाटिका एवं शहीद भगत सिंह पार्क का निर्माण।
- 42 पार्कों का सौन्दर्यीकरण/मरम्मत कार्य तथा सभी 110 वार्डों में समान रूप से रू0 5–5 लाख का प्राविधान।
- महिला डिग्री कालेज निर्माण कार्य का शुभारम्भ।
- कान्हा उपवन के अन्तर्गत श्री कृष्ण गौशाला, हनुमान/वानर वाटिका, नन्दी शाला, भैरव चरण श्वानालय का निर्माण एवं राधासरोवर जीर्णोद्धार का कार्य।
- सिद्धार्थ पशु–पक्षी उपचार केन्द्र का निर्माण तथा नाका एवं ठाकुरगंज चिकित्सालयों का जीर्णोद्धार।

नागरिकों से अपील

- करों का समय से भुगतान करें।
- कूड़ा निर्धारित स्थानों पर डालें।
- नाले/नालियों, फुटपाथों एवं सड़कों पर अतिक्रमण न करें।

सुन्दर लखनऊ स्वच्छ लखनऊ

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शुभ कामनाओं सहित

जन जन का विश्वास
सभी को आवास

हर एक को आवास

- मान्यवर श्री कांशीराम जी नगर योजना के अन्तर्गत **10000** भवनों का निर्माण।
- गोमती नगर विस्तार, बसन्त कुंज एवं कानपुर रोड योजना में भवनों/भूखण्डों का विकास।
- विभिन्न योजनाओं में व्यावसायिक सम्पत्तियों का आवंटन।

विकास के आयाम

- **50** एकड़ का समस्त सुविधायुक्त रमाबाई अम्बेडकर मैदान।
- अति आधुनिक विश्वस्तरीय **200-1500** व्यक्तियों की क्षमता वाला मान्यवर श्री कांशीराम जी अन्तर्राष्ट्रीय कन्वेंशन सेन्टर।
- **500** शैय्या वाला मान्यवर श्री कांशीराम जी बहु-विशेषज्ञीय अस्पताल।
- मान्यवर श्री कांशीराम जी स्मारक स्थल।
- मान्यवर श्री कांशीराम जी स्मृति उपवन।

पर्यावरण संतुलन

- एक लाख वृक्षारोपण का लक्ष्य जिसमें 75 हजार पौधों का रोपण।

जनमानस को दी जाने वाली सुविधायें एवं पारदर्शिता

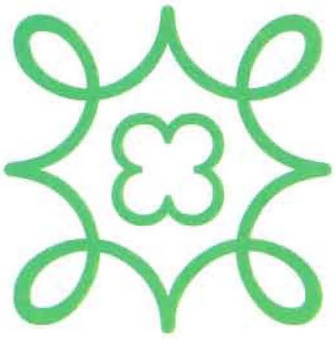
- एसएमएस के माध्यम से जनसामान्य को समस्त जानकारी उपलब्ध।
- बिना आवेदन पत्र के आवंटन के तुरन्त बाद रिफन्ड की सुविधा।
- कम्प्यूटर काउन्टर पर एकल विन्डो तत्काल सेवा के अन्तर्गत धन वापसी हेतु आवेदन पत्र की प्राप्ति।

एस.एस. मिश्र
सचिव

एन.एस. रवि
उपाध्यक्ष

लखनऊ विकास प्राधिकरण

शुभ कामनाओं सहित



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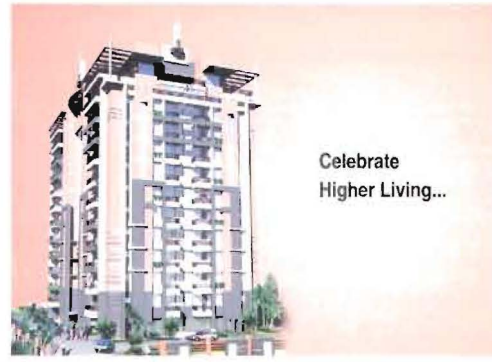

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- Indian Institute of Sugarcane Research (IISR)
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- Biotechnology Development Council (CST,UP)
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(आई.एस.ओ. 9001 - 2000 प्रमाणित संस्था)

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वार्षिक उपलब्धियाँ

वर्ष	वार्षिक टर्न–ओवर (करोड़ रू0 में)	लाभ (करोड़ रू0 में)
2004–05	516	10.08
2005–06	834	22.74
2006–07	1243	37.5660
2007–08	1500 (मार्च, 08 तक अनुमानित)	–

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3. मेडिकल कॉलेज (आजमगढ़, कन्नौज, जालौन, अम्बेडकर नगर, सहारनपुर, बाँदा)
4. पैरा मेडिकल कालेज (सैफई, झाँसी)
5. पी0जी0 आई0 लखनऊ
6. आई0आई0एम0 लखनऊ
7. अन्तर्राष्ट्रीय क्रिकेट स्टेडियम, सैफई
8. रिजर्व बैंक ऑफ इण्डिया के आवासीय भवन, मुम्बई
9. डा0 राम मनोहर लोहिया अस्पताल, लखनऊ
10. डा0 राम मनोहर लोहिया विधि संस्थान, लखनऊ
11. सवाई मानसिंह अस्पताल, जयपुर
12. इन्दिरा गाँधी प्रतिष्ठान, लखनऊ
13. यू0पी0 सदन, दिल्ली
14. उ0प्र0 राज्य अतिथि गृह, मुम्बई
15. न्यायिक प्रशिक्षण संस्थान, लखनऊ
16. स्पोर्ट्स कॉलेज, गोरखपुर

हमारा लक्ष्य : समयबद्धता, मितव्ययता एवं गुण्वत्ता

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