CLIMATE CHANGE AND GLOBAL WARMING ABSTRACTS

CONTENTS

Sl.No	CHAPTERS	PAGE NO
I.	**Biodiversity and Climate Change**	
II.	**Impact of Climatic Factors on Insect Abundance**	
III.	**Forestry and Climate Change**	
IV.	**Carbon Sequestration**	
V.	**Agriculture and Climate Change**	
VI.	**Coastal Environment and Climate Change**	
VII.	**Water resources and climate Change**	
VIII.	**Health and Climate Change**	
IX.	**Eco Technologies and Climate Change**	
X.	**Climate Change adaptation and mitigation measures**	
XI.	**Green House Gas and Climate Change**	
XII.	**Energy and Environment**	
XIII.	**Pollution & Climate Change**	
XIV.	**Global Warming and climate change with special reference to India**	
XV.	**Global Warming and climate change with reference to other countries**	

I. Biodiversity and Climate Change

1. Effects of Climate Change on Biodiversity[#1]

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"Biological Diversity" means the variability among living organisms from all sources including, inter alia, terrestrial marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between spec ics and of ecosystems. Conservation is defined as management of human use of the biosphere so that it may yield sustainable benefit to the present generation while maintaining its potential to meet the needs and aspirations of posterity. Thus as stated in the World Conservation Strategy (IUCN), 1980 conservation is positive, embracing, preservation, maintenance and sustainable utilization, restoration and enhancement of the natural environment. The concepts of preservation and sustainable use are intimately linked. The objectives of Biodiversity Conservation are achieving Food Security, Health Security, Ecological Security, Evolutionary Security and Environmental Stability Our common future, 1987 report produced by the World Commission on Environment and Development, commonly known as Brundtland Commission report defines sustainable development as that which "meets the needs of the present without compromising the ability of future generations to meet their own needs". Thus sustainable development is "development which does not compromise the future". It highlighted the need to integrate environmental and economic objectives to ensure sustainable development of Economical and Social systems.

As of today, the number of species identified is about 1.7 million species. The global estimates of the total number of species is anywhere between 2-10 million species. Byjust 1°C warming at least 1,70,000(10%) of land species could be facing extinction, according to one study. Coral reef bleaching will become much more frequent, with slow recovery, particularly in the southern Indian Ocean, Great Barrier Reef and the Caribbean. Tropical mountain habitats are very species rich and are likely to lose many species as suitable habitat disappears. By 2°C warming around 6,80,000 (40%) of land species could be facing extinction, with most major species groups affected, including 25—60% of mammals in South Africa and 15—25% of butterflies in Australia. Coral reefs are expected to bleach annually in many areas, causing irreversible damage, affecting tens of millions of people who depend on coral reefs for their livelihood or food supply.

By 3°C warming around 8,50,000(50%) of land species could be facing extinction. Thousands of species maybe lost in biodiversity hotspots around the world, e.g. over 40% of endemic species in some biodiversity hotspots such as African national parks and Queensland rain forest. Large areas of coastal wetlands will be permanently lost because of sea level rise. Strong drying over the Amazon, according to some climate models, would result in dieback of forest with the highest biodiversity on the planet. Temperatures could rise by more than 4 or 5°C if emissions continue unabated, but the full range of consequences at this level of warming have not been clearly articulated to date. Nevertheless, a basic understanding of ecological processes leads quickly to the conclusion that many of the ecosystem effects will become compounded with increased levels of warming, particularly since small shifts in the composition of ecosystems or the timing of biological events will have knock-on effects through the food chain such as loss of pollinators or food supply.

Key words: Biodiversity, Sustainable development, Climate change, Species extinction

2. Global Warming and Marine Biodiversity[#1]

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Biodiversity is the central tenet of nature, one of the key defining features. Evolution has produced an amazing variety of microorganisms, plants and animals and the ecosystems of which they are the part, all intricately linked. Man is also one among the millions of species. Biodiversity is also the basis for continuous evolution of species and ecosystems. The survival of human societies and culture is dependent on biological diversity. It provides the essential ecosystem services including hydrological and geochemical cycles and climate regulation that form the basis for human survival. It also meets the myriad survival and livelihood needs of fisher folk, farmers, forest-dwellers, pastoralists, craftsperson and others. This wonderful diversity and each of its components are worthy of high respect and conservation in their own right. Among the various threats to biodiversity, global warming appears to be the most serious one. Global warming is projected to cause massive changes in biodiversity which are on a scale unprecedented in the last 1,000 years. Global warming would affect the distribution and abundance of marine organisms. Many marine organisms have a narrow range of optimum temperature related both to the specie's basic metabolism and the availability of food organisms that have their own optimum temperature ranges. The temperature sensitiveness is just a few degrees higher than those they usually experience in nature. A rise in temperature as small as 1°C could have important and rapid effects on the mortality of some organisms and on their geographic distribution. The more mobile species should be able to adjust their ranges over time, but less mobile and sedentary species may not. Depending on the species area it occupies may expand, shrink or be relocated with changes in oceanic conditions. Such distributional changes would results in varying and novel mixes of or in a region leaving species to adjust to new predators, prey competition and parasites. There are about 1.8 million named species. Approximately 20-30 percent of the plant and animal species are likely to be at greater risk of extinction if increase in global average temperature exceeds 1.5 to 2.5 ° Celsius (2.7 to 4° Fahrenheit). Warming oceans are going to have terrible impact on marine biodiversity. There is a projection that combined with over-fishing, fish stocks will be effectively wiped out by 2048. The present paper explains the various marine organisms which are seriously threatened by global warming.

3. Impact of Increased Anthropogenic Activities on Marine Biota[#3]

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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 ^{0}C during the nest 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.

4. Predicting Impacts of Climate Change on the Himalayan Flora[#3]

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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 climate 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. Palaeoecological 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., ca4-5,000 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 refereed as 'climatic amelioration' in the Himalayan context. The Intergovernmental Panel on Climate Change (IPCC) has predicted that given the current rate of green house 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 included 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 phonological 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 MSL 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 steam 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

5. Global Climatic Change and its Impact on Fern Biodiversity: A Case Study on Ferns from Kolli Hills -Eastern Ghats, India[#1]

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Ferns and fern allies are the primitive vascular plants which successfully invaded the terrestrial habitats and ultimately leading to the evolution of higher plants, gymnosperms and angiosperms. Although they are the first group of vascular-land plants, still they depend on water for fertilization process and so they are usually growing in and around streams or river banks at high altitude mountains with high humidity, particularly inside evergreen forests. But due to various reasons, the forest cover decreases throughout the world and ultimately results in the decrease of biodiversity of ferns and their allies. Present study on biodiversity of ferns and fern allies in comparison, with previous studies before sixteen years, show whether there is any impact on its biodiversity due to climatic changes or not. Manickam and Irudayaraj have made extensive survey of Pteridophytes of the Western Ghats along with some Eastern Ghats including Kolli Hills. In the present study about 65 species of ferns and fern allies have been collected. The rare and endangered ferns such as *Lindsaea malabarica*, *Anemia wightiana* and *Trichomanes saxifragoides* have been collected from the same localities after sixteen years. Thus it is concluded that there is not much of disturbance on the biodiversity of ferns and fern allies on Kolli Hills due to climatic changes or anthropogenic disturbances. It indicates that there is not chance for the disturbances except agricultural practices.

6. Global Climatic Change and its Impact on the Survival of Ferns and Fern Allies[#1]

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Pteridophyta, which consists ferns and fern-allies have radiated into the same diverse environments as spermatophytes, and have done so with an independent gametophyte that is not protected by the parent plant. Due to several factors, particularly anthropogenic effects, this delicate group of plants is struggling a lot for their survival. The drastic global climate change has its own effects on this peculiar group of plant and due to the facts several species have already become extinct in the biosphere and several other species are struggling a lot for their survival. In Pteridophytes both the gametophytic and sporophytic generations are independent and they should to find their own way to survive in nature. In this paper the adaptive mechanisms of both the sporophyte and gametophyte generations are discussed based on the original research works and literatures. The sporophytic generation has several adaptive mechanisms to cope with the unfavourable biotic and abiotic stresses. Thus ferns in general have several defense mechanisms against herbivory and they are also highly tolerable to the high concentration of several heavy metals in the soil. Interestingly hymenophyllaceous and grammitidaceous ferns with chlorophyllous spores, which are with very short viability period, have their own adaptive mechanism by the survival of gametophytic generation in the soil for long time by the multiplication of gametophytes themselves.

7. Impact of Global Warming on Biodiversity and its Concerns[#1]

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Biodiversity is the variety in nature, which sustains the harmonious existence of life on earth. The components of this diversity are so independent that any change in the system may lead to a major imbalance in the normal ecological cycle. Tolerance capacity to the external disturbances is observed from the individual organism up to ecosystem level. But, beyond a limit, the disturbance will lead to considerable damage to the individual organisms, including human beings. Due to overpopulation, human activities

are the major threat to biodiversity like construction of dams, commercial agriculture and monoculture practice, large scale deforestation, mining; industrialization filling up of wet lands is destruction of coastal areas resulting in global warming lead to loss of flora and fauna. Hence conservation of the precious wealth of nature is the need of the day. The first step to solve the problem is to control the factors responsible for global warming through green house effect. It is to be done at global level. Some developed countries blame the developing countries like India, for the green house effect by saying that the emission of methane from the paddy fields is the major source of green house gases. But it has been disproved by the Indian scientists. Now it is clear that the developed countries are more responsible for the emission of green house gases due to modern life styles.

8. Influence of Climatic Changes on Genetic Diversity of *Vitex negundo* L.

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This research article reveals that the climatic changes may be responsible for the genetic diversity (RAPD markers) in *Vitex negundo* L., an anti-cancer drug, collected from five different locations of Kanyakumari District of Tamil Nadu. RAPD fingerprints were applied by Polymerase Chain Reaction of the genomic DNA using random primers. These primers produced multiple band profiles with a number of amplified DNA fragments varying from 5 to 10. A total of 35 polymorphic bands were observed. The genetic distance between the population ranged from 0.1881 to 0.3773 and the genetic identity ranged from 0.6857 to 0.8284. The overall observed and effective number of alleles is about 1.4571 and 1.2798 respectively. The percentage of polymorphic loci is 45.71. Nei over all genetic diversity is 0.1691. Correlating with the environmental (Climatic) changes, it is clear that there is distinct genetic variability in *Vitex negundo* L.

9. Global Climate Change and Biodiversity[#1]

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The United Nations Conference on Environment and Development held in Rio de Janerio in 1992 and World Summit on Sustainable Development at Johannesburg in 2002 drew the attention of people around the globe to the deteriorating condition of our environment. It is clear that no citizen of the earth can afford to be ignorant of environmental issues.The impacts of climate change on biodiversity in terms of changes in species' ranges and ecosystem boundaries, shifts in reproductive cycles and growing seasons, and changes to the complex ways in which species interact (predation, pollination, competition and disease) will be studied. The extent of these effects varies between regions, and between species and ecosystems, some of which are more vulnerable than others. Suitable strategies will need to be adopted to mitigate or adapt to climate change. In addition to that, land use changes (such as cutting down forests or draining peat lands) and subsequent changes to biodiversity can also alter levels of greenhouse gas emissions thus affecting the global climate. Many linkages between climate and biodiversity will be integrated for more integrated policy responses, at international, regional and national levels. The linkages between climate change (mitigation and adaptation) to livelihoods, poverty and achieving the Millennium Development Goals will be investigated. This research will adopt strategies for actions needed at global, national and local levels in order to support local solutions.Habitat change, overexploitation, invasive alien species, pollution and climate change are identified by the Millennium Ecosystem Assessment as the most important drivers presently of ecosystem change and biodiversity loss. By the end of the 21st century, it is possible that climate change may become the dominant driver (MEA, 2005). Vulnerability is also determined by human caused pressures on ecosystems in addition to climate change that may weaken their resilience, by human made obstacles that can impede species migration, and by human efforts to relieve pressures and make obstacles more porous.

10. Biodiversity and climate change

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The term 'Biodiversity' is the short form of Biological diversity, used to convey the total number, variety and variability of living organisms in a given area, whether be it on land, in rivers and fresh water bodies, and the seas or the whole surface of the earth. Biodiversity embraces the whole of life, and includes all the micro-organisms, plants and animals, on earth. Biodiversity also refers to and includes the genes of organisms, the ecosystems they live in and the services they provide to keep the planet healthy. The term 'biological resources' denotes those components of biodiversity which maintain the current or potential human uses. Biodiversity and related issues are now a serious global concern. An awareness of the issues involved is not really new, though the urgency for action was driven home in stages a) UN Conference at Stockholm in June 1972 and the Declaration on the Human Environment; b) United Nations' Environment Programme (UNEP) of 1991, setting i) priorities for action for conservation and sustainable use of biodiversity and agenda for scientific and technological research; b) evaluation of economic implications of conservation of biodiversity and its sustainable use, and evaluation of biological and genetic resources; c) technology transfer and financial issues; and d) modalities of a protocol for transfer and handling of any living modified organisms through biotechnology; c) The Earth Summit (or UN Conference on Environment and Development) at Rio de Janeiro, June 1992, where the document 'Agenda 21', that defined the programme for biodiversity estimation, conservation, sustainable use, involvement of local populations and their interests, etc., was adopted by 178 Governments of the world nations. This document is organised under 27 Principles and covers all issues concerning biodiversity. Although the Governments have been a party to the document, action in the respective countries can be taken only when legislative measures, through different Acts of Government, are available. Progress in this regard has been patchy, though Government of India has taken initiatives through making Biodiversity Act enacted in 2003.Climate change and biodiversity are closely linked and interrelated. According to the Millennium Ecosystem Assessment, a comprehensive assessment of the links between ecosystem health and human well-being, climate change is likely to become the dominant direct driver of biodiversity loss by the end of the century. Projected change in climate, combined with land use change and the spread of exotic or alien species, are likely to limit the capability of some species to migrate and therefore will accelerate species loss. The impact of climate change on biodiversity is major concern in the CBD. The convention also recognizes that there are significant opportunities for mitigating climate change and adapting to it, while enhancing the conservation of biodiversity. The lecture links the climate change and global warming to the loss of biodiversity and especially the increase in carbon dioxide accumulation as a result of deforestation and measures to mitigate the ill effects of climate change through conservation of plant diversity and afforestation programmes.

11. Effects of Climate Change on Avian Fauna[#1]

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Climate change includes phenomenon such as the unpredictable alterations in temperature, precipitation, extreme weather and climates such as too much rainfall or drought. As a result, there is variation in biological productivity with concomitant effects in the food chains in ecosystems such as alterations in the life cycles like, abundance of insect species at unusual seasons. Such variations in biodiversity cannot be easily quantified. However, studying the behaviour, life cycles and migration patterns of birds can easily indicate a change in the habitat due to climate change. This is because birds feed on plants and insects. Studies indicate a direct impact of climate change on the breeding and nesting patterns of seabirds, shorebirds and waterfowls because of the fluctuations in the biological productivity in the water bodies such as oceans, ponds etc. As the foraging habitats are altered in a given region, migratory birds either alter their route or never migrate. Many migratory birds do not find enough insects at the place of migration or have to lay their eggs much in advance of their normal period which results in loss of eggs or greater adult mortality. Hence, migratory birds face larger threat due to climate change than resident birds, the latter are able to adapt themselves to the alterations in the local habitat. In the Indian scenario, migrations of wetland birds have attracted more attention than other types of birds, such as rosy pastor, swallows etc. For example, environmentalists voice their concern due to non-arrival or late arrival of Siberian Crane at Bharatpur, due to the vagaries of monsoon, reduction in the number of flamingoes to various places, such as Mumbai, due to loss of biological productivity. However, the quantification of this information is lacking in India as compared to the more systematic studies abroad.

12. Modeling Plant Response to Climate Change: Opportunities and Research[#3] Needs

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Developing general predictions about plant responses to climate change is a challenging task because of individualistic nature of species responses. Nevertheless, predicting future vegetation change is necessary to quantify biotic feedbacks to climate change and rising greenhouse gas concentrations. Approaches to assessing ecosystem responses to climate change include equilibrium models and Dynamic Global Vegetation Models (DGVMs). Biome-BGC is a mechanistic equilibrium eco-system model that simulates the storage and fluxes of water, C, and N within the vegetation, litter, and soil components of the terrestrial ecosystems. This model uses daily time step, driven by daily values for maximum and minimum temperatures, precipitation, solar radiation, and air humidity and requires definitions of vegetation, climate and site characteristics. To run model faithfully, parameter calibration is necessary. However, it is a challenging task as values are difficult to locate and standardize. For ex, in India, data are limited or absent for most of the ecophysiological parameters in most of the models are mostly temperate-measured which make it unreliable for Indian biomes. Future research directions for India include ecophysiological characterization of important plant functional traits, optimization of selected models such as Biome-BGC for Indian Ecosystems, and interface it with IPCC scenarios to develop predictive capabilities in face of climate change. This can be achieved by establishment of long term ecosystem research site where micrometeorological and open top chamber experiments may be established to generate data required for model calibration. Only when reliable parameters are available, model calibration may be done with direct field measurement data by non-linear inversion method.

Key words: Climate change, equilibrium models, DGVMs, Biome-BGC, Plant responses

13. Climate Change and its Impact on Biodiversity: An Indian Perspective[#3]

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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 observation for the past thousand years provide evidence that global warming is due to anthropogenic increase in greenhouse gases (i.e. CO_2, CH_4, NO_x, 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 of Indian biodiversity.

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

14. Climatic influence on radial growth of *Pinus wallichiana* in Ziro Valley, Northeast Himalaya

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An attempt has been made here to study the climatic influence on variation of tree-ring width (radial growth) of Blue Pine (*Pinus wallichiana* A.B. Jackson) growing in five different sites in and around Ziro Valley, Arunachal Pradesh, Northeast Himalaya. The site chronologies have been evaluated to assess inter-site differences through several statistical analyses, viz. correlation matrices, principal component and hierarchical cluster analysis. Analysis of tree growth–climate relationship suggests that the pre-monsoon precipitation (December– April) is a significant factor influencing the growth of Blue Pine in all these sites.

Keywords: Blue Pine, climatic influence, radial growth, tree ring.

15. Impacts of Global Warming on Biodiversity[#1]

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Global warming is an increase in the average temperature of the earth's atmosphere. The progressive gradual size of the earth's surface temperature thought to be caused by the green house effect and responsible for changes in global climate patterns. A diversity of species (flora & fauna) is involved in maintaining the ecosystem. A loss of species could reduce this ability, especially if environmental conditions change periodically. The effects of global warming are more frequent high temperature and less frequent low temperature, increase in variability of climate, decrease in snow cover, alterations to the distribution of certain infectious diseases, and rising sea levels. Certain species are becoming endangered, global warming being the major cause and also certain new species are introducing into environment. Biotechnology strategies should be utilized to conserve these types of species for future use.

II. IMPACT OF CLIMATE FACTORS ON INSECT ABUNDANCE

1. Effect of Climatic Change on the Functional Dynamics of Honey Bees[#6]

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Climatic changes have affected the physiology, life cycle, migratory patterns of many living forms. In this paper the effect of chemicals, pesticides, radiation, electro-magnetic effects and poisonous gases on the life of honey bees have been discussed. The various climatic factors that contribute to "colony collapse disorder" have also been indicated.

Key Words: Honey bee, colony collapse disorder, radiation

2. Monitoring and Forecasting Rice Tungro Virus Disease and its Vector in a Changing Environment[#6]

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Rice tungro virus occurs in epidemic form in many parts of India and the world. The outbreak mechanisms have not been filly understood as it involves the marriage of many disciplines and an understanding of three organisms i.e. host plant, disease and vector. Climatic factors have an impact on all three levels. Modeling is the option available to understand the impact of climatic factors on the disease outbreak. This paper discusses the present status in the modeling of Rice tungro disease outbreak and the future prospects to empower the farmers by developing a good decision support system for disease prediction and management.

3. Seasonal Abundance of Certain Predators of the Tubuliferanthrips *Cercothrips tibialis* (Bagnall) (Thripidae: Thysanoptera) Infesting *Ficus glomerata*[#6]

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Three predatory bugs viz., a mirid *Fingulus porrecta* (Begroth), an anthocorid *Montandoniola moraguesi* (Puton) and a lygaeid *Geocoris ochropterus* Fabr., have been

recorded as predators of *Cercothrips tibialis* (Bagnall) infesting the leaves of *Ficus glomerata*. Among the three species of predators, the anthocorid and lygaeid bugs are reported for the first time from South Gujarat, (Western India). Their seasonal abundance and climatic situation in relation to the host thrips are discussed.

Key words: *Fingulus porrecta, Monlandoniola moraguesi, Geocoris ochropterus. Cercothrips tibialis, Ficus glomerala*, tubuliferen thrips, mirid bugs, anthocorid bugs, Iygaeid bugs

4. Incidence of *Amrasca devastans* (Distant) in Cotton in Relation to Weather Factors[#6]

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Studies conducted at the Agricultural College and Research Institute, Killikulam on the impact of weather factors on the incidence of Amrasca devastans (Distant) in cotton leafhopper population on cotton plants under different levels of protection revealed negative influence of maximum temperature and positive influence of relative humidity on the nymphal population (R^2 = 0.4674; F=6.143 **) on plants that were treated during vegetative phase alone; while on untreated plants maximum temperature and relative humidity had the positive influence (R^2 =0.3934; F=4.539 *)• However, on plants protected during reproductive phase and on plants under complete protection weather parameters had no influence on the nymphal population of *A.devastans.*

Key Words: Weather parameters, Amrasca devastans, cotton

5. Role of Weather Factors and Time of Sowing on the Population Fluctuation of *Amrasca devastans* in Cotton[#6]

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Impact of the weather parameters viz., maximum temperature, minimum temperature, relative humidity, sunshine hours, wind velocity and rainfall on the incidence of the leafhopper, Amrasca devastans in cotton crop was studied under four levels of plant protection and three levels of time of sowing. Under different levels of plant protection multiple regression analysis of weather factors and incidence of

leafhopper, in cotton revealed that decrease in minimum temperature favoured leafhopper population on crop protected during vegetative phase; and that on crop unprotected throughout the crop period.. In the crop protected during reproductive phase, increase in minimum temperature favoured the leafhopper population. The weather parameters had no contribution to the incidence of leafhoppers on the crop protected throughout the crop period. Under three levels of sowing dates, 75, 79 and 85 per cent of the variation in leafhopper incidence was contributed by the weather parameters in early- (relative humidity, sun shines hours and wind velocity), normal-(minimum temperature, wind velocity and rainfall) and delayed sown crops (maximum temperature, minimum temperature, sunshine hours and rainfall) respectively.

Key Words: Time of sowing, cotton, weather factors, Amrasca devastans

6. Impact of Climatic Factors on Insect Abundance: Changing Scenario and Future Research Thrusts[#6]

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Agriculture would need to undergo dramatic adjustment and increase in the incidence and pest load could be anticipated with climate change since insects are poikilothermic. Temperature and precipitation can strongly influence the life history and fitness of ectotherms, such as insects. Ectotherms rely on external heat sources and sinks to regulate their body temperature, and small changes effects on the rates of biochemical reactions. As their body temperature varies with the surrounding temperature they are strongly influenced by climate and weather. It has been estimated that with a 2°C temperature increase, insects might experience one to five additional life cycles per season. The outbreak of citrus blackfly during dry weather and humid conditions (due to sprinkler irrigation) in Maharashtra, red spider mites in summer, mealy bugs in dry weather, rice thrips in rainfed rice, heavier incidence of cotton leafroller in shady edges, *Spodoptera* with the advent of rain fall after long dry spell, raidhairy caterpillar after rains are some of the examples that reminds the influence of climate/weather on pests. Temperature influences consumption, developmental rates, distribution and migration, larval survival, larval emergence, the number of generations a year. As temperature increases insects can respond in several ways—adapt, migrate or become extinct. The absence of *Helicoverpa* problem on cotton in Egypt indicates the impact of temperature on soil pupating pests. Lower winter mortality of insects due to warmer winter temperatures could be important in increasing insect populations. The washing down of aphids, mites and thrips by heavy precipitation is the other extreme. Change in climate will influence increased overwintering, change in population, growth rate, increase in number of generations, extension meat season, change in population, growth rate, increase in number of generations, extension of development season, change in crop-pest synchrony changes in i e risk of invasion by migrant pests like mealy bugs. Farmers would incur increased cost as a result of increased frequency of insecticide treatment/ pest control measures. Need to taking in account of the impact of climate change on pest status and pest management components are emphasized. Farmers and researchers should keep in mind that climate change is likely to be a gradual process that will give them some opportunity to adapt and develop required pest management strategies.

7. Effect of Climate Changes on the Swarming Pattern of Termites *Odontotermes obesus* (Rambur) (Termitidae: Isoptera) at Madurai[#6]

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The effect of climate changes on the swarming pattern of *Odontotermes obesus* was studied at the Agricultural College and Research Institute, Madurai during 1992, 1993 and 2006. The changes in the climate (increase in maximum temperature, decrease in rainfall etc) favoured the population build up of termites which was evinced by the increase in number of swarms. There were eight swarms during 1992; seven during 2993 and eleven during 2006. A total of 24,400 alates emerged in 1992 and 41,400 in 2006. There was a proportional increase In maximum temperature, minimum temperature, relative humidity and soil temperature during the study period. A negative correlation was observed between swarming and following weather factors: maximum and minimum temperature and soil temperature. Rainfall arid relative humidity had positive correlation.

Key Words: Termites, Swarming, Weather parameters

8. Contribution of Weather Factors to the Light Trap Catches of Rice Green Leafhopper, *Nephotettix virescens* (Distant) in Thamiraparani Tract[#6]

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Correlations were made on the light trap catches as well as field population of Nephotettix virescens. On rice at two locations viz., Killikulam and Ambasamudram in Thamiraparani Tract. Multiple regression analysis was made to study the impact of weather factors. Under diverse crop situation encountered at Killikulam the weather parameters of the corresponding week besides the previous third week influenced the population caught in the light traps; whereas, under continuous monocropping system prevailed in Ambasamudram, the weather parameters of the corresponding week alone influenced the population of GLH. Positive influence of rainfall and relative humidity and negative influence of minimum- and maximum temperatures on the light trap catches was observed at Killikulam as well as Ambasamudram. At Rice Research Station, Ambasamudram the variability in light trap caches of N.virescens due to the weather parameters of the corresponding week was 16 (R = 0.1613) percent; However, the individual parameters had no significant influence on the light trap catches. Existence of significant positive association between light trap catches and field population was also brought out.

Key Words: Weather Factors, Light Trap, Rice GLH, Nephotettix virescens

9. Effect of Climatic Change on Mosquito Population in India and the Role of Gis (Geographic Information System) in its Mapping[#6]

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Mosquitoes, popularly known as ‘the tiny terminators’, are vectors of ravaging diseases like malaria, dengue, yellow fever and chikungunya. WHO reports state that the surface temperature of the earth has increased by about 0.8 degrees Celsius over the past century. Climatic change is either due natural or anthropogenic causes and plays a vital role in the proliferation 0 mosquito population and the diseases they transmit. WHO has aptly declared the theme for World Health Day 2008 as “protecting health from climate change.” WHO reports indicate that due to climatic change, mosquito-borne diseases like malaria have not only resurged after 40 years but have also become exacerbated and invaded new niches. This has indeed drastically increased the incidence of mosquito-borne epidemics and diseases in the national as well as in the global setting. In this paper we will be discussing about the predominant mosquito-borne diseases prevalent in India, climatic change - its effects on mosquito population and the role of Geographic Information System (GIS) in organizing and presenting spatial data on mosquito mapping, in disease control and its other advantages galore.

Key Words: Global warming, climatic change, anthropogenic causes Geographic Information System (GIS), resurgence, vector- borne diseases, mosquitoes, disease transmission, causative organism, clinical symptoms, spatial data, mapping.

10. Short Term Forecasting Through Evaluation of Microclimatic Influence on the Population of Bollworm Complex on Summer Irrigated Cotton Crop in Tamil Nadu[#6]

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The study focuses on the influence of microclimatic factors on population buildup of bollworm and predator complex on summer-irrigated cotton crop in three locations at Villupuram district (l2 and 79’52’E), Tamil Nadu, India. Weather parameters viz., temperature and relative humidity showed greater influence on the pest incidence, Results on correlation analysis fo4 three years together indicate significant negative influence of temperature on the population buildup of Pectinophora gossypiella and *Spodoptera litura* ($y = -0.42x + 20.85$ and $y = -1.51x + 78.45$ respectively), Relative humidity facilitated the build-up of P gossypiella and *S.litura* population. But influence of temperature was positively correlated with population of *Earias vittella* ($y= 0.38x + 25.77$) and vice versa for relative humidity ($y = -0.87x + 82.68$). No significant influence of weather parameters was observed on the predator complex in all the sites except at Raghavan Nagar where a significant negative influence of temperature on predator population was recorded. The correlation equations computed would come in handy for forecasting the buildup of the pest complex at the given environmental parameters of temperature and relative humidity,

Key Words: Cotton, bollworm complex, predator population, weather parameters, correlation

III. Forestry and Climate Change

1. Late Holocene Vegetation and Environment of Meenachil River Baisn, Kottayam District, Kerala, India[#3]

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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 carbonized 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. Calaophyllum 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 carbonized woods have provided evidence about the prevailing environmental conditions and sea level fluctuations in the area.

2. NABARD's Initiatives in Promoting Forestry Projects for Mitigating Climate Change[#4]

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NABARD is a developmental bank with a mandate to promote sustainable agriculture. Besides, it funds forestry projects through Forest Development Corporations and wood based industries. India possesses nearly 60 million hectare degraded lands suitable for forestry plantations, which can be a potent tool for mitigating climate change. In spite of this, hardly any projects are forthcoming due to strict land eligibility criteria, forest definition, additionality, leakage, long term nature, high risks, low cost of CER (Carbon Emission Reduction) and complex methodologies involved for claiming carbon credits under Kyoto Protocol. For the first time in India, an agro forestry project is being implemented by J.K.Paper Mills.The World Bank has agreed to purchase the VCER (Verified CER) @US $ 4.05. The area is 3500 hectare degraded lands of small farmers and the tree is Eucalyptus camaldulensis clones. NABARD had visited the project sites twice in Orissa and observed that the farmers needed credit for raising and maintaining the plantations properly. Hence it is trying to provide subsidized credit under its Umbrella Project for Natural Resource Management (UPNRM). ITC had also submitted a forestry project to United Nations, which is likely to be registered. Earlier NABARD sanctioned two forestry projects of Rs.70 crores to Andhra Pradesh Forest Department for raising *Pongamia pinnata* plantations on 31, 6000 ha degraded forest lands for biodiesel production. Efforts are being made to bring the project under Clean Development Mechanism of Kyoto Protocol for obtaining carbon credits. Our studies indicated that huge opportunities exist in promoting forestry projects for mitigating climate change, but there is an urgent need to evolve simple systems for claiming forestry carbon credits.

3. Role of Forests in Climate Change Mitigation in India[#4]

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The issue of climate change has gained tremendous importance in the recent years. Many mechanisms like emissions trading; joint implementation and clean development mechanism have been put in place to arrest or halt climate change through Kyoto Protocol. Forests play an important role in regulating climate as they store large quantities of carbon in vegetation and soil, exchange carbon with the atmosphere through photosynthesis and respiration and act as sources of atmospheric carbon if they are disturbed by some human activities or natural causes. However, they become atmospheric carbon sinks during land abandonment, regrowth after disturbance and due to afforestation and forest conservation. The net flux of carbon between the forest sector and the atmosphere determines whether the 'carbon footprint' is positive or negative. Though forests play an important role in climate change, forestry projects have not qualified under the emission reduction projects of the clean development mechanism until recently. Recently, reducing emissions from deforestation and forest degradation (REDD) has been recognized as playing a key role in climate change mitigation in the coming years. Not only does this benefit climate, but can offer tremendous opportunity for conserving biodiversity, poverty alleviation and promoting sustainable development in many developing countries. However, it all depends on how well the projects are designed. The main objective of this paper is to quantify the current role of forests in carbon sequestration in India using a comprehensive accounting framework and discusses some of the positive as well as negative consequences of REDD.

4. Forestry and Climate change

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Forests cover nearly 4 billion hectares or 30% of land area in the world, and form a major land use. They are also repositories of rich biodiversity. "Forestry" includes the management of the natural forests, afforestation/ reforestation of degraded land, management of forest plantations, agroforestry and farm forestry, forest produce and wood based industries, etc. The linkage between forestry and climate change is threefold: firstly, forestry contributes to climate change, especially, conversion of forests to non-forestry uses and logging; secondly, forests and forestry are also adversely affected by climate change and thirdly, forestry helps in reducing the adverse effects of climate change. Contribution of forestry to Climate Change: Forestry is an important sector in the human enterprise. Nearly 1.6 billion people the world over are directly dependent on forests for the livelihood. A still larger number is dependent for various products and employment. The human dependence on land and forests is leading to a net loss of 7.3 million hectares of forests every year. The loss of forest cover is mainly due to conversion of forests into commercial plantations, agriculture, submergence under irrigation and hydel projects, encroachments, slash and burn cultivation and urbanization. Unsustainable harvest practices also lead to loss of density and degradation of the forest, if not fully cleared. This deforestation adds about 20% of GHGs present in the atmosphere, by release of locked carbon in the forest soils, burning of the wood and slash after timber extraction and the subsequent use of extracted timber as fuel. It has been projected that the harvest of timber from natural forests will go down in future and the contribution from plantations will increase from 20% of the total harvest in 2000 to more than 40% in 2030. Estimates of the Food and Agriculture Organization of the United Nations (FAO) state that the proportion of harvest from plantations which was 34% in 2001 will increase to 44% in 2020 and 75% in 2050. The intensively managed plantations comprised only 4% of the forest area in 2005, but the area is increasing at the rate of 2.5 million hectares annually. A shift in industrial wood supply from the Northern hemisphere to the Southern hemisphere is also predicted.

5. Forest Productivity under Elevated Carbon Dioxide in the Atmosphere[#4]

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It has been predicted that forest productivity will increase as atmospheric CO_2 concentrations continue to rise. Giving a spurt of CO_2 to normally growing plants in controlled conditions showed that there could be a 40 per cent increase in photosynthesis. This gave rise to the idea that CO_2 could be acting as a “fertilizer” for increasing productivity. However, as science progressed, and our understanding on photosynthesis increased, it was noted that continuous exposure to elevated CO_2 could sometimes lead to a neutral effect, or even down regulation of photosynthesis in some species. Even then, there is a universal agreement on stimulation of photosynthesis at elevated CO_2 Does it mean that forest trees will sequester all the excess CO_2 in the atmosphere and give us a much higher productivity?

The stimulation of photosynthesis due to elevated CO_2 gives variable growth responses and it still remains a big puzzle. Photosynthesis is not saturated at current CO_2 (approx. 380 ppm) in the atmosphere, that is, plants are able to assimilate far higher CO_2 concentrations. This means that more carbon enters the plant when exposed to elevated CO_2 atmosphere. This should mean a higher productivity. However, it should be realised that structural growth is controlled by a morphogenetic plan, by developmental stage and by availability of resources other than carbon, namely, light, water and soil nutrients. Physiological studies have exposed a wide mismatch between photosynthetic capacity of leaves and crop biomass production. The most modern method developed to study the elevated CO_2 effects on trees is the Free-Air- CO_2 (FACE) technology. Almost all the studies done in temperate countries have shown 27 to 30 per cent increase in forest productivity on long-term exposure to elevated CO_2 The increase was mainly in young trees where canopy closure had not occurred. In not a single case was steady state Leaf Area Index (LAI) increased under elevated CO_2 In all cases, the nutrient cycle sets the ultimate limit to long-term stimulation of plant production. All the available data warns against overstating beneficial effects of a CO_2 world for plant growth. It should be also cautioned that any growth stimulation would enhance forest dynamics and would translate into greater abundance of fast-growing taxa, with likely negative effects on overall carbon storage. It is concluded from all the studies that a global upper limit of net ecosystem carbon fixation resulting from elevated CO_2 was considered to be 10 per cent of the projected anthropogenic CO_2 release by 2050. It may be also pointed out that hardly any tropical species has been studied for its response to elevated CO_2 on a long-term basis.

6. Climate Change and CDM Regime: Sundarbans Mangroves[#3]

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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 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 mangroves-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 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, rainwater 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 is also highlighted as discrete developmental objectives rather than as a development agenda with an ecosystem approach.

Past and ongoing developmental effort has 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. Consistence with sustainable development agenda any development related investment need to ensure how natural capital along with manmade and human capital re 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.

Key word: Sunderbans, mangroves, CDM, green accounting

7. Forest Management strategies for carbon management functions in context of climate change. [#4]

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It has been almost established that it is the accumulation of Green House Gases (GHGs), which constitute predominantly carbon dioxide, is the prime cause of the global climate change through the phenomenon of global warming. In spite of the uncertainties about the extent, impact and outcome of global warming, it is unequivocally accepted that reduction of Green House Gases is the direction in which concerted efforts from the global community should be focused. Forests, as the carbon sinks, play a major role in removal of the GHGs from the atmosphere. Forest management has thus attained an exclusive additional dimension and responsibility in context of atmospheric carbon management.Forests have been recognized as simple but effective means of carbon sequestration where ultra modern technological advances are not required. However, several factors determine the feasibility of role of forests as carbon sinks and enhancing their utility in carbon sequestration. As wood is the most important carbon storage system of the forest biomass, the strategy for carbon management must include wood management as an important component. Consequently forest productivity and wood management become most important factors of carbon management.

This paper attempts to analyse the costs and concerns involved, the opportunities and the issues needed to be addressed while accounting the role of forests as carbon sinks, among the different roles and functions the forests play in the ecological and socio economic paradigms of human life, in the Country. The present notion of conservation trades off required in optimizing the carbon sink efficiency of forests and need of a new perspective in the forest management have been presented. Some of the management imperatives and options that would be required to be internalized in forest management planning and administration in this context have been discussed.

8. Sundarban and Global warming — the real threat[#4]

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The Sundarban Region in India is located between 21° 32' and 22°40N latitude and 88° and 89°00 E longitudes. It is bounded by the river Hoogh!y on the west, Ichamati-Kalindi-Raimangal on the east, Dampier-Hodges line on the north and the Bay of Bengal on the south. The total area of Indian Sundarban region is about 9630 sq. km., out of which the Reserve Forest occupies nearly 4260 sq. km. At present, out of 108 islands of the Sundarban region, 54 are inhabitated with a population of about 3.2 million (1991 census), spread over 1093 mouzas. The area contains a rich inter tidal mangrove forest which provides appropriate habitat and sanctuary to many rare and endangered animals including about 500 to 600 Royal Bengal Tigers.The effect of High tide causes the water level in the tidal rivers rise as high as 12 ft — 15 ft every six hours and large parts of the islands containing mangrove forest get inundated. Species like Avicenna and Ceriops, which tolerates prolonged water logging and high degree of salinity, comes up naturally in such inter-tidal mud flats.Of late, there is a global concern regarding the threat posed to Sundarban, due to the global warming and projected sea level rise. It is beyond any controversy that the projected climate change will bring in its effect globally, and different regions of the world will be affected in different ways. However, it must be kept in mind that the threat of sea level rise near Sundarban and elsewhere will originate most possibly due to global warming caused through uncontrolled industrial pollution elsewhere, far away from Sundarban, and no amount of ameliorative measures in the deltaic region can stop the projected danger. If we are concerned about the conservation of Sundarban, we should look at the root of the possible dangers and stop diverting attention from the real issues by undertaking localised measures. The mangrove forests in 4200 sq km of reserved area are well protected and the natural vegetation dynamics will take care of the changing soil- water-climatic conditions in this region.

The real threat and a thought for future

- Arrest the present trend of reduced fresh water flow in Indian Sundarban
- Allow the process of formation of islands in this young estuary
- No more increased human pressure on the over-populated islands
- Review the conventional development process Island embankment — breach — rebuild — rise of river bed — increase of embankment height — more flooding — more money to repair breaches — less fund for socio-economic development
- Reduce dependence of forest fringe population on mangrove forest, by providing sustainable, alternate livelihood in the villages
- Leave the estuarine forest to itself— nature will take care of mangrove species and its wildlife

9. Climate Change and Forests[#4]

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Forests provide several goods and services that are crucial to human survival. They are one of the world's major carbon stores, containing about 80% of aboveground terrestrial biospheric carbon and 40% of terrestrial belowground carbon. The forestry sector is unique, in that it contributes significantly to global CO emissions (about 20% of global CO emissions) and also provides significant opportunities to not only reduce the current or projected emissions, but also to remove CO accumulated from past emissions in the atmosphere, and sequester it in soil, vegetation and wood products. Finally, forest sector is highly vulnerable to climate change, adversely affecting the species composition, species dominance, biodiversity and ultimately to extinction. Further, forestry sector is closely linked to socio-economic systems, particularly the forest dwellers and rural communities and thus making them vulnerable to projected impacts of climate change.

In 1990, the Land Use Change and Forestry (LUCF) sector accounted for 20% of the global CO emissions of 7.1 GtC. GHG emissions and removals were estimated, by Indian Institute of Science, for India using the IPCC (Intergovernmental Panel on Climate Change) Revised 1996 Guidelines for the National Communications submitted to the IJNFCCC (United Nations Framework Convention on Climate Change). A net marginal emission of 14.29 million tonnes of CO was estimated for the forest sector for 1994. In India, CO emissions from forest conversion or loss are largely offset by afforestation.

IPCC Reports have concluded that even moderate warming and climate change will impact forest ecosystems and biodiversity adversely. A detailed assessment of impacts of climate change on forests at national level for India by Ravindranath et al, 2006 made using BIOME4 model, SRES scenarios A2 and B2 and Regional Climate Model of the Hadley Centre (HadRM3) outputs shows that in India 68 to 77% of the currently forested grids are likely to undergo change in forest type, adversely affecting biodiversity in the transient phase. The model outputs further show that the projected climate is likely to be not optimal for existing vegetation. The study also shows that Net Primary Productivity is likely to increase by 70-100 % due to CO fertilization, assuming no nutrient limitation. Recent dynamic Global Vegetation Modeling Studies have also confirmed that majority of the currently forested grids are highly vulnerable to climate change even by 2050s.

A comprehensive assessment of the CO sequestration or mitigation potential of forest sector in India has been made and published in several papers. Contrary to the belief that forest sector in India has limited carbon mitigation potential, due to high human and livestock population density, mitigation studies carried out by the Indian Institute of Science at national, regional, district and project level shows the following. At the national level, economic mitigation assessment is carried out for the first time using AEZ (Agro-ecological Zone) classification of land. Economic mitigation potential assessment is carried out under baseline and mitigation scenarios, including the carbon price incentive using GCOMAP model. The incremental mitigation potential, over the baseline scenario afforestation, is estimated to be in the range of 129 to 435 million tonnes of Carbon during the period 2005 to 2035 (Ravindranath et al, 2007). The regional mitigation study focused on developing regional baseline and comparing with the project baseline, for the first time. The study adopted three-step approach namely; identification of likely baseline options for land-use, estimation of baseline rates of land-use change. and quantification of baseline carbon profile over time. The analysis showed that carbon stock estimates made for wastelands and fallow lands for project-specific as well as regional baseline are comparable. The study for the first time showed that conducting field studies for estimating carbon stock changes in biomass and soil, using regional baseline approach is about a quarter developing a project baseline. The study demonstrated the reliability, feasibility and cost-effectiveness of adopting regional baseline for forest sector mitigation projects. A study at district level demonstrated the approach and methods to be adopted for estimating carbon mitigation potential of forestry projects.

A recent study by Indian Institute of Science, made an assessment of the implications of past and current forest conservation and regeneration policies and programs on forest carbon sink in India. The study concluded that if the current rate of afforestation continues the carbon stock in Indian forest is projected to increase from 8.79 GtC in 2006 to 9.75 GtC by 2030. Mitigation and adaptation are the two strategies to address climate change. Currently the two strategies are separately addressed. A preliminary attempt was made to conceptualize and explore the opportunity for synergy between mitigation and adaptation. Firstly, there is a need to ensure that mitigation projects and programmes do not increase the vulnerability of forest ecosystems and plantations. Secondly, several adaptation practices could be incorporated into mitigation projects to reduce vulnerability. The study has listed several adaptation activities which contribute to mitigation. The paper concluded that there is limited information about the synergy between mitigation and adaptation and highlighted the need for research and demonstration of synergy through field projects.

10. Impact of Climate Change on Forests in India[#2]

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Global assessments have shown that future climate change is likely to significantly impact forest ecosystems. The present study makes an assessment of the impact of projected climate change on forest ecosystems in India. This assessment is based on climate projections of Regional Climate Model of the Hadley Centre (HadRM3) using the A2 (740 ppm CO_2) and B2 (575 ppm CO_2) scenarios of Special Report on Emissions Scenarios and the BIOME4 vegetation response model. The main conclusion is that under the climate projection for the year 2085, 77% and 68% of the forested grids in India are likely to experience shift in forest types under A2 and B2 scenario, respectively. Indications are a shift towards wetter forest types in the northeastern region and drier forest types in the northwestern region in the absence of human influence. Increasing atmospheric CO_2 concentration and climate warming could also result in a doubling of net primary productivity under the A2 scenario and nearly 70% increase under the B2 scenario. The trends of impacts could be considered as robust but the magnitudes should be viewed with caution, due to the uncertainty in climate projections. Given the projected trends of likely impacts of climate change on forest ecosystems, it is important to incorporate climate change consideration in forest sector long-term planning process.

11. Forest Conservation, Afforestation and Reforestation in India: Implications for Forest Carbon Stocks

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This article presents an assessment of the implications of past and current forest conservation and regeneration policies and programmes for forest carbon sink in India. The area under forests, including part of the area afforested, is increasing and currently 67.83 mha of area is under forest cover. Assuming that the current trend continues, the area under forest cover is projected to reach 72 mha by 2030. Estimates of carbon stock in Indian forests in both soil and vegetation range from 8.58 to 9.57 GtC. The carbon

stocks in existing forests are projected to be nearly stable over the next 25 year period at 8.79 GtC. However, if the current rate of afforestation and reforestation is assumed to continue, the carbon stock could increase from 8.79 GtC in 2006 to 9.75 GtC by 2030 – an increase of 11%. The estimates made in this study assume that the current trend will continue and do not include forest degradation and loss of carbon stocks due to biomass extraction, fire, grazing and other disturbances.

12. Rewarding Forest Conservation in Forest and Climate Change Regime L: India Perspective[#3]

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The role of forests in GHG 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 COP 13/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.

13. Forestry — "A Magic Answer" on Global Warming? #4

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Although climate is naturally dynamic and has been altered by natural causes; in the recent past, the magnitude and rate of current climatic changes is unprecedented. Computer models are long proven to be inherently incapable of providing projections of the future state of the climate that are sound enough for policymaking. Even if the models could ever become reliable, there are studies that demonstrate that it is not at all likely that the world will warm as much as the IPCC imagines. Global warming, many scientists and social workers argue, is more a political drama than the real issue. The extra materialistic comforts and the decorative non-eco-friendly living that people have in cities are the real problem. This creates a psychological intolerance. And the cities are warming. Temperature measurements are records in the cities for the past few years (for the earth of hundreds of crores of years, this is a small sample) with concrete structures and local pollution around. Thus the so-called Global Warming is only the projection of the Local City Warming. Even if mitigation might do more good than harm, adaptation as (and if) necessary would be far more cost-effective and less likely to be harmful. Forests are centres of biodiversity, play a key role in water distribution, and are essential for carbon storage - key aspects of effort to address climate change. To investigate forest management as a method for controlling global warming, researchers are continuing study of carbon exchange between the atmosphere and forest. Climate change threatens forests. The forest may not cool climate and the present booming discussion. We can't solve the climate problem by just saving forests. However, it helps in aggressively protecting and restoring wild lands, wildlife, and water as an enduring legacy. It is nice to see that the forest is protected as permanently road-less areas and old-growth forest ecosystems. More studies understanding forest carbon flows and forest management is essential. The Indian heritage knowledge and the modem research must work in tandem towards better forest management.

14. Recent developments in the Bamboo Sector in India[#4]

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India, with the potential of 8.9 million ha of bamboo, professional expertise and major support from the Government, has initiated a rejuvenation of the bamboo sector. Some of the key initiatives include the launching of an integrated bamboo project by the Prime Minister in 1999, followed by the detailed documentation by the Planning Commission on bamboo sector in India. A network project initiated by UNDP and Development Commissioner (Handicrafts) on resource development and utilization of bamboo species suitable for handicrafts launched in 2000, brought together all the Institutes involved in R&D, extension and utilization in the same platform. In 2003, National Mission on Bamboo Application (NMBA) was formed under Ministry of Science and Technology. NMBA focused on resource enhancement and value added utilization of bamboo along with marketing. Support for establishment of bamboo industries, development of bamboo processing machineries and experimental plantations of species suitable for industries were some of the significant achievements of NMBA. In 2004, the seventh international workshop on bamboo was organized in Delhi and many key issues in the development of the bamboo sector were discussed. Formation of National Bamboo Mission under Ministry of Agriculture and Cooperation in 2006 is a major step in the Government initiatives for development of bamboo sector in each state. Bamboo has several advantages over other species in sustainability and carbon fixing capacity. The available data indicates that bamboo biomass and carbon production may be 7-30% higher when compared to fast growing wood species. Data is available on the carbon fixing ability of some of the Indian bamboo species such as *Bambusa bambos, Dendrocalamus strictus.* Although the potential is high, there is not much bamboo CDM projects implemented or planned. NBM has set up a high target of establishing 176000 ha of new bamboo plantation in India by the end of eleventh five year plan. Bamboo plantations can be promoted to become part of a global carbon credit mechanism to benefit the country and attract investments.

15. Climatological Effects on Flowering in Trees: A Review

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Seasonal duration of leafing, flowering and fruiting mainly determine phenological behaviour in tropical trees. These phenological events are not mutually independent in woody species, and flowering may be partly or wholly dependent on leafing activity. Nevertheless, tree species with similar leaf phenology often differ in the timing of their flowering and fruiting. Many deciduous tree species show flowering and fruiting during the leafless period, exhibiting wide separation between leafing and flowering phenophases. In many evergreen and in some deciduous species leaf flush and flowering occur close in time on the same new shoot. An analysis of the proximate controls of flowering in tropical deciduous forest species indicates that the timing of vegetative phenology strongly determines the flowering periods, and thus flowering at least depends indirectly on environmental periodicity. Variation in flowering time relative to vegetative phenology, induced by a variety of factors (significant rain in winter/summer, decreasing or increasing photoperiod, or drought-induced leaf fall), results in a number of flowering patterns in tropical trees. The current study aims to provide new insights into the phenological cycles and their relations to abiotic factors for a little-known ecosystem. It is of particular importance for Ecuador, the country which is at the present time suffering the highest annual rate (4%) of deforestation in the whole of South America (Miller 1998). Reforestation of abandoned agricultural areas with indigenous trees could help to rehabilitate biodiversity. A comparison of time series and power spectrum analysis suggests a synchronisation of flowering with the incidence of wetter and less wet periods, with an oscillation of 8–12 months.

To summarise, it can be concluded that phenological activity of the investigated trees generally follows an annual oscillation connected with relatively less and more humid periods. However, the extent to which most of the investigated species produce flowers and fruits is clearly modified by apparently irregular events, which most likely result from underlying oscillations of lower frequency (as e.g. ENSO) or trends. Hence, longer time series are required to examine the influence of these events in future studies.

16. Impact of Climate Change on Forests[#1]

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Natural ecosystem is vulnerable to climate change and cause irresistible dam age due to the limited adaptive capacity. Climate change is due to temperature gradients, soil, land and forest degradation, air pollution etc. This causes disturbance in ecosystem which leads to tremendous loss of biodiversity. The climate change due to high CO_2 concentration in the atmosphere and temperature alters the growth of seasonal crops, early flowering by trees, host pathogen relationships, yield of forest produce etc. these alterations will lead to change in composition of flora in the forests which includes soil flora. The climate change would also lead to detrimental for the vegetation of forests. Assessment of impacts of projected climate change including the socio-economic valuation of forests through scientific modeling and field studies helps to develop strategic to enhance the preparedness for global climate change by adapting technologies and measures. It is better to resist the influence of climate change which includes the reduction of anthropogenic emissions near the vulnerability region, high priority to endangered species, removal of invasive populations, resistant plants, to prevent insect and disease outbreaks and expanding genetic diversity.

17. Strategies for Increasing Tree Cover in the State of Kerala[#4]

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To achieve the ideal target of 1/3 of land under forest & tree cover, the only alternative for the State is to increase its tree cover outside the forest areas. With this objective, the

Social Forestry wing of the Kerala Forest Dept has embarked upon massive afforestation programmes outside the forest areas with maximum participation and involvement of the people. Such massive afforestation programmes have been launched by Social Forestry wing of the Forest Dept. since the year 2006.

The **Ente Maram Padhathi** (My Tree Programme) is a tree planting programme with the involvement and participation of school children from Standard V to IX. Around 29.40 lakhs seedlings have been planted by school children during the year 2007- 08 and 2008-09 under this scheme. The success of survival is above 80%. This scheme is to be continued. The **Nammude Maram Padhathi** (Our Tree Programme) is for afforestation by the Plus Two and college students in the College/School campuses. During the year 2008-09 a total of 555613 numbers of seedlings have been supplied to the 2323 educational institutions under this scheme. This scheme is to be continued. Under **the Vazhiyora Thanal Padhathi (Programme for Shade on Roadsides),** the avenue tree planting is being done with the participation of head load workers belonging to various trade unions. About 90000 seedlings were planted during the year 2007-08 and 14000 bigger size seedlings have been planted during 2008-09. The trees planted during the year 2008-09 have shown very high success. Under **Haritha Theeram Padhathi (Greening the Coast),** afforestation of coastal areas are done with the view to establish a bio-shield for the protection of State's coastal line from natural calamities like Tsunami, sea erosion etc. A total extent of 152.15 ha in 132 coastal wards of all nine coastal districts has been afforested through 132 TSVS. A total number of 22.4 lakhs seedling have been planted in 132 coastal wards for creation of bio-shield in the coastal areas under this scheme during the year 2007-08 and 2008-09. The **Haritha Keralam Padhathi (Greening Kerala Scheme)** is a for afforestation of non forest areas through Panchayaths. This schemes aims at creating woodlots in each and every Panchayaths wherever suitable non forest lands for afforestation are available. The unutilized lands in the villages, community lands, institutional lands, roadsides, railway sides, river banks, areas surrounding ponds and lakes and other unutilized lands are proposed to be brought under the tree cover. The scheme is proposed to be launched during June 2009. The Forest Department has to play a major role in the implementation of this scheme. The Social Forestry wing has already taken up steps for raising around 22 lakhs seedlings to be planted by the Panchayaths during the month of June 2009. The bamboo seedlings required by the Panchayaths is proposed to be provided by the State Bamboo Mission.

IV. Carbon Sequestration

1. Carbon Sequestration: Estimation of Carbon Stock in Teak (*Tectona grandis* Linn. f.) Ecosystem

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In the wake of global efforts to address climate change, considerable interest has been generated about carbon sequestration potential of trees and forestry programs such as afforestation and reforestation has received a great deal of attention. Sedjo (1989) estimated that to sequester 1.89 Pg of atmospheric carbon annually in forest biomass would be equivalent to planting over 400 million ha of fast growing plantations. Although forests do not sequester carbon permanently on account of harvest or natural death (Harmon *et al*., 1990) more recently, Kraenzel *et al*. (2003) have advocated that plantation is being considered as a mitigation option to reduce the increase in atmospheric CO_2 and climate change. Soil organic carbon, being the largest terrestrial carbon pool plays a very significant role in global terrestrial ecosystem carbon balance. Inter-governmental panel on climate change (2000) estimated the total soil carbon pool in top 1 m as 2011 Pg carbon. Eswaran *et al*. (2000) estimated the global forest soil organic carbon stock to about 580 Pg. Today teak (*Tectona grandis*) is widely planted in south-east Asia and as exotic species in Africa, South and Central America (Ball *et al*., 1999). This teak based global sink would certainly increase because during the past 20 years most supplies of teak wood from natural forests have dwindled and increased interest has developed in the establishment of teak forest plantations (Pandey and Brown, 2000).The basic premise of this potential is relatively simple. It revolves around the fundamental biological / ecological processes of photosynthesis, respiration and decomposition. There is a need to measure and understand rate-controlling factors for carbon fluxes between different ecosystem compartments and the atmosphere in order to understand the role of forest ecosystem in determining the global carbon cycle.

2. Bamboo Processing machineries and new generation products with Bamboo[#4]

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Through the technical and financial support of NMBA Kerala state Bamboo Corporation have successfully propagated ranges of efficient, sturdy and low cost tooling and process machinery, suited to Kerala conditions and species, to reduce drudgery, improve productivity and minimize wastage. These process technologies are being validated and converted to techno economic packages through KSBC community bamboo mat weaving centers and feeder units. Reed slivering machines, bamboo flattening machines, bamboo cross cutting, bamboo strips making machines are few examples. This hollow —stemmed grass isn't just for flimsy tropical huts any more - it's getting outsized attention in the world of serious architecture. From Hawaii to Vietnam, it's used to build everything from luxury homes and holiday resorts to churches and bridges. Boosters call it "vegetal steel ", with clear environmental appeal. Lighter than steel but stronger than concrete, bamboo is native to every continent except Europe and Antarctica. And unlike, slow to harvest timber, bamboos woody stalks can shoot up several feet a day, absorbing four times as much world warming carbon dioxide. In the interior of buildings, strips of bamboo laminated together into solid material have been used for cabinetry, paneling, counter tops and furniture. In fact, bamboo advocates claim the plant can replace the use of wood for nearly every application. This is related to the composition of bamboo, which consists of about 50-70 percent cellulose, 30 percent pentosans (polymer sugars) and 20-25 percent lignin. Although individual producers vary in their methods for the harvest, treatment and delivery of bamboo, the advantage of bamboo are being recognized by the consumers. For example National Mission on Bamboo applications estimated its bamboo market to reach USD 5.5 billion by 2015. This could mean that market pressure would force largely unorganized suppliers to respond quickly to systematic improvement in production standards and promote sustainability in the near future.

3. Carbon Sequestration by Higher Plants and Algae to Combat Global warming [#3]

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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 270ppm; 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 terrestraial 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 photo respiratory 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 sequestrations. 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 (popular 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.

4. Effect of Lignite Humic Acid (Potassium Humate) on Carbon Sequestration in Turmeric Cropping System in alfisol

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Soils are the largest carbon reservoir of the terrestrial carbon cycle. It contains about three times more carbon than vegetation and twice as that which is present in the atmosphere (Batjes and Sombrock, 1997). Carbon storage in soils is the balance between the input of dead plant material and loss from decomposition and mineralization processes. Under aerobic condition most of the carbon entering the soil is labile and therefore respired back to the atmosphere throughout the process known as soil respiration or soil CO_2 efflux. The process of soil carbon sequestration or flux of carbon into the soil forms part of the global carbon balance. Many of the factors affecting the flow of carbon into and out of soils are affected by land management practices. Therefore management practices should focus on increasing the inputs and reducing the outputs of carbon in soils. The present investigation was carried out with potassium humate, a source of readily available humic acid from Neyveli lignite contained 31.8 % humic acid (HA) with high organic carbon (OC) content (38.5 %) and CEC (140 cmol.(p+)/kg). The soil for the present investigation was selected based on the low organic carbon status by delineating the turmeric growing soils of western zone for organic carbon content. The study revealed that nearly 70 % of the soils tested low in OC content revealing the need for external application of organics to sustain the soil fertility.

5. Soil Carbon storage capacity as a tool to prioritize areas for carbon sequestration

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Carbon dioxide (CO_2), one of the major components of greenhouse gases, is of major concern in terms of the global warming phenomenon. To mitigate the effect of atmospheric CO2 carbon capture and storage (CCS) has been found to be an important tool. The present study aims at explaining the role of soils as one of the most important natural resources in enhancing CCS. Soils capture and store both organic and inorganic forms of carbon and thus act both as source and sink for atmospheric CO_2. The datasets developed on CCS of soils permit us to generate thematic maps on soil carbon stocks, which may serve as ready reckoners for planners in prioritizing Carbon sequestration programmes.

6. The effect of Increased atmospheric CO_2 Concentration on the Growth and Nitrogen Allocation of Eucalyptus

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The direct and indirect effects of atmospheric CO_2 increase on the plant growth and the functioning of the soils as net source or sink of CO_2 arise two fundamental questions: Is the carbon and especially the nitrogen, allocation in the plants modified in response to CO_2 increased. To what extent will the modification of the quantity of the plant material affect the decomposition rates of the soil organic matter and the nitrogen availability. The CO_2 enrichment for one year (complete growing season) changed markedly the net production and the carbon distribution in the plants. Carbon of the whole plant production expressed in C plant^{-1} (net production) was increased by 20%. Leaf production was increased by 20%. Fine roots (<1mm) were increased by 60%. Tap root and the coarse roots increased by 60%. Tap root and the coarse roots increased by 25%. The production of the stem and branch material was significantly increased by 29%. Doubling of the CO_2 concentration resulted in an increase of net production especially fine roots and leaves. The most important modification was a lowering of N concentration in all the organs of the plant except the leaves, expressed as N% dry material or as C:N ratio. The highest dimination of the N concentration occurred in the storage organs (tap root, the coarse roots the stem and the branches). The N concentration was maintained at relatively high levels in the active organs (the leaves and the fine roots). Doubling the CO_2 concentration does not increase the nitrogen uptake. The lowering of the N concentration was due to the increase of carbon without increasing nitrogen. The elevated CO_2 concentration condition (750 $\pm$ 30 ppm) net photosynthetic rate was highest (14.80 μ mole m^{-2} s^{-2}) with an increase of 27% over control. Followed by ET3 14.65 (μ mol m^{-2} s^{-1}) with an increase of net photosynthetic rate 29% over control. This increase in net photosynthetic rate increases the total plant carbon in leaves stems, branches and roots etc appreciably. Variations in stomatal conductance among clonal lines or provenances or seed sources were also reported in Eucalyptus camaldulensis Farnell *et al* 1966. The storage organs tended to act as source of N and the leaves and fine roots as sink.

7. Soil Carbon Sequestration – A Promising Option for Climate Change Mitigation

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"To stabilize and ultimately reduce concentrations of this greenhouse gas (CO_2)*,*
it will be necessary to employ carbon sequestration -
carbon capture, separation and storage or reuse."

The annual global net release of carbon from agricultural activities is estimated as 800 MMTC yr^{-1} (Lal, 2001). Among the green house gases, CO_2 is the dominant gas, compared to methane and nitrous oxide. The CO_2 accounts for about 50 % of the total global warming effect of all climate impact gases. Concentration of green house gases in the atmosphere has increased by about 30 % over the last two centuries. The global average temperature has risen by 0.2 ± 0.6º C during 20th century and world sea levels by about 15-20 cm. If no action is taken to reduce the green house gases emission, an increase in global warming of 1.4 to 5.8º C over 1990 levels would be projected to occur by 2100 and sea level rise by 9-88 cm (IPCC, 2001). It is clear that the problem of atmospheric CO_2 accumulation will not simply go away. Fossil fuel usage is not likely to cease any time soon, either in industrialized or less-developed countries. Therefore, a variety of strategies are needed to reduce CO_2 emissions and remove carbon from the atmosphere in order to mitigate the potential effect of climate change. One possible mechanism for climate change mitigation is carbon sequestration, the facilitated redistribution of carbon from the air to soils, terrestrial biomass, geologic formations, and the oceans. For semi-arid and sub-humid regions of the world, carbon sequestration in soils represents the most promising option for climate change mitigation. It has been estimated that 20 % (or) more of targeted CO_2 emission reductions could be met by agricultural soil carbon sequestration.

Soil carbon sequestration is the process of transferring carbon dioxide from the atmosphere into the soil through crop residues and other organic solids, and in a form that is not immediately reemitted. This transfer or "sequestering" of carbon helps off-set emissions from fossil fuel combustion and other carbon-emitting activities while enhancing soil quality and long-term agronomic productivity. Soil carbon sequestration can be accomplished by management systems that add high amounts of biomass to the soil, cause minimal soil disturbance, conserve soil and water, improve soil structure, and enhance soil fauna activity. Continuous no-till crop production is a prime example.

Soils are the largest carbon reservoir of the terrestrial carbon cycle. Soils contain much more C (1 500 Pg of C to 1 m depth and 2 500 Pg of C to 2 m; 1 Pg = 1 giga tonnes) than is contained in vegetation (650 Pg of C) and twice as much C as the atmosphere (750 Pg of C). It has been estimated that 20 % (or) more of targeted CO_2 emission reductions could be met by agricultural soil carbon sequestration. It is expected that in the next 50 years, Best Management Practices (BMPs) like organic manure addition, conservation tillage, cover cropping, crop rotation, vegetative barrier, grass lands, agro forestry and afforestation in agriculture could restore 5000 MMT of carbon to the soil (Lal, 2001). However, organic matter can be restored to about 60 to 70% of natural levels with best farming practices.

Effects from land management practices or land use on carbon sequestration potential

Technological options	Sequestration potential (tonnes C/ha/year)
Conservation tillage	0.10 - 0.20
Mulch farming (4 - 6 Mg/ha/year)	0.05 - 0.10
Compost (20 Mg/ha/year)	0.10 - 0.20
Elimination of bare fallow	0.05 - 0.10
Integrated nutrient management	0.10 - 0.20
Restoration of eroded soils	0.10 - 0.20
Restoration of salt-effected soils	0.05 - 0.10
Agricultural intensification	0.10 - 0.20
Water conservation and management	0.10 - 0.30
Afforestation	0.05 - 0.10
Grassland and pastures	0.05 - 0.10

(Lal *et al.*, 1998)

The concentration of carbon dioxide and other green house gases in the atmosphere are predicted continue to rise and may double or triple by the end of the century causing further global warming unless enhanced carbon sequestration processes are implemented. Carbon sequestration in soils provides an important means of decreasing green house gasses in the atmosphere to mitigate predicted climate changes.

"Soil carbon is a priceless key to the planet's
health and our environmental quality"

8. Bamboo Plantations: An Approach to Carbon Sequestration[#4]

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Carbon sequestration is one of the approaches in climate change mitigation policy that had received significant attention over the past several years. Being one of the most productive and fastest growing plants on the planet with its decay resistant litter, bamboo potentially acts as a valuable sink for carbon storage. On an average, one hectare of bamboo stand absorbs about 17 tonnes of carbon per year. Bamboo stands occupy an area of 36 million hectares worldwide which is equivalent to 3.2 percent of the total forest area in the world. In Asia, India is the major bamboo producing country (almost 11 .4 million hectares) which accounts for roughly half the total area of bamboo reported for Asia. The dry matter accumulation by Chzisquea culeou (Chile) is in the tune of 156-162 t ha , while that of Phyllostachys pubescence (Japan), and Gigantochloa alter (Indonesia) is 138 ton ha' and 45 t ha^{-1}, respectively. The lowest dry matter accumulation (0.35 ton ha^{-1}) has been reported by Bashania fangiana (China). In our common thorny bamboo, Bambusa bamboos the dry matter accumulation at the age of 4, 6 and 8 has been reported to be 122, 225 and 286 t ha^{-1}, respectively and it is on par with the 10 year old fast growing *Causarina equisetjfolia* (292.68 ton ha^{-1}) or Eucalyptus tereticornis plantation (254.97 ton ha'). The biomass production and thereby the carbon sequestration potential of many of the Indian bamboos are yet to be unravelled. If scientifically and intelligently managed, bamboo which owes an inherent fast growth and thereby producing high biomass on a sustained basis can potentially act as the carbon sink and contribute to the global climate change mitigation initiatives.

9. Climate Change and Himalayas with Special Reference to Carbon Sequestration[#3]

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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 8000m) represent one of the largest anthropogenic system on the planet. Through the Gangetic river connections, the Himalayan forests have been serving the Gangetic pains 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 150m rise in snowline. The alpine belt would be most vulnerable to climate change, as species like *Quercus semecarpifolia (brown oak), Betula utilis (brich) and Abies pindrow (silver fir)* occur in islands. Animals like pikas and musk deer are excepted 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 crop fields, 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 6.5 million tonnes of carbon each year. One of the major consequences of global warming could be the increased rate of soil carbon depletion.

Several adaptation 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.

10. Carbon Sequestration Potential Studies in Forest and Agro-Ecosystem in Central Himalayan Region of India[#3]

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Out of the six most important elements necessary for life, carbon accounts for about 49% of organism[1]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-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 agroecosystems in central Himalayan region with a view for better carbon management with respect to increased carbon sequestration potential in mountains.

V. Agriculture and Climate Change

1. Modeling of Changes in Soil Organic Carbon through Soil Temperature, Rainfall and Evaporation Parameters under Permanent Manurial Experiment in Dry Land Vertisols of Tamil Nadu

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Soils are a major carbon pool and are estimated to contain 1220 to1550 Pg C in organic form and almost half in inorganic form. Amongst different soil orders Histosols contain maximum and Vertisols contain minimum carbon. In general, Inorganic C in soils is generally very stable but SOC is very reactive and a large quantity can be lost through changes in land use especially from ploughing and erosion. Most of the good lands in tropics are already under intensive cultivation leading to depletion of soil organic carbon (Datta *et al*. 2001). The present investigation is to know the modeling of changes in soil organic carbon through soil temperature, rainfall and evaporation under dryland vertisol tract of Tamil Nadu.

2. Assessment of Climate Change and Development of Isohyetal Zoning Technique for Crop Planning in the NCR of Delhi[#7]

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In order to ensure sustained agricultural production it is vital to ensure that the water lost by evapo-transpiration, from reservoirs, ground water and soil profile, is fully replenished by the water received through the rains, on a regular basis. The availability of rainwater and its proper management, indeed, holds the key to sustained productivity and production. A precise estimation of the quantum of water that would be available from rains is, therefore, essential for appropriate crop planning and adoption of water conservation measures. Farmers are often handicapped in making the right choices of crops and management practices because the long-term rainfall data is generally not available easily. A precise estimation is also not easy because of the wide spatial and temporal variability in rainfall. An attempt has been made in this paper to use the geostatistical approaches to generate the spatial variability map of average rainfall depths over the National Capital Region (NCR) of Delhi, using the IMD's point rainfall data collected from the raingauge stations spread over the NCR of Delhi. The variability map assists in delineation of different isoheytal zones pertaining to a given range of rainfall depths. The generated spatial variability map of rainfall depths provides a more precise estimation of the rainfall depth, than it has been possible thus far. The study, based on the long term (1974 to 2006) monthly rainfall values over the NCR [1], reveals that as compared to 1974-83 decadal annual average rainfall of 880 mm the rainfall during 1984-93 and 1996-2005 has declined by 14% and 20%, respectively. The overall average annual rainfall depth from 1974-1983 to 1996-2005 has declined by about 19%. These results clearly indicate that there is a need to generate an appropriate spatial variability model to predict the rainfall amounts for the locations that are not gauged. Geostatistical concepts starting from Exploratory Data Analysis (EDA), development of semivariogram models and kriged map with delineated isohyetal zones were generated using the ArcGIS and GS+ softwares. The spherical model with ordinary kriging technique was used to generate the isohyets ranging from 400 mm to 1100 mm depths. Further, the isohytal map was use to delineate the Zones under different rainfall depths and the area under different zones was estimated by using the polygon feature of GIS. Thus, the delineated land parcel units (LPUs) under a given rainfall depth range can be used to accomplish the agricultural water management activities in a scientific manner. This is possible by taking up the monthly, seasonal and annual rainfall depths and generating more accurate variability maps to delineate the isohyetal zones. Further, the detailed water budgeting approaches within the delineated isohyetal zones could assist the planners to suggest crop sequences to the farmers that are most suited to the availability of water from the rainfall and other sources, in that particular region. The developed geostatistical protocol of rainfall depth variability can also be used to predict the surface water availability under different rainfall scenarios due to climate change, by coupling a surface runoff model. Efforts are now being made to generate the surface runoff yield potential of the NCR of Delhi under different climate change scenarios leading to the optimal land use planning.

3. Climate Change and its Impact on Agriculture[#7]

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Changes in Earth's climate have been projected by the end of this century because some atmospheric "greenhouse" gases, among them carbon dioxide (CO_2), are increasing (IPCC, 2001). It is expected that atmospheric CO_2 concentration will double sometime during this century if fossil fuels burning continues and air temperature is predicted to rise 1.5 to 5°C with more than 90% likelihood by 2100 (Mahlman, 1997). If the increase in atmospheric CO_2 concentration will be accompanied by an increase in air temperature, crops may shorten their growing cycle, which may offset the advantages of an increasing CO_2 concentration. Therefore, the interacting effect of CO_2 concentration and temperature on plant growth is complicated. How climate change will affect crop yield will be critical for agriculture as an enterprise and food supply activity worldwide.

4. Phenological Calendar of Basmati Rice Varieties in the Southern Agro Climatic Region of Kerala

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Traditional *basmati rice* varieties possess excellent aroma and quality but their level of productivity is quite low. With the release of semi dwarf scented rice varieties, the optimum planting time had to be determined to exploit their grain yield potential while still maintaining grain quality (Singh et al., 1995). The maximum productivity has been reported to be achieved by planting the crop at the optimum time at any specific location which may vary from variety to variety (Babu, 1987). Though the photoperiod insensitive varieties can be grown throughout the year irrespective of the season, their growth and yield largely depend upon various weather factors like rainfall, temperature, solar radiation and relative humidity that prevail during the growing season. Maximum yield is possible only when the crop experiences a suitable combination of these factors in optimum range. Hence the time of planting and prevailing weather conditions play a major role in the final yield of rice. At present in Kerala there is no such information available on the integrated influence of weather components in the growth and yield of basmati rice. Hence a field experiment was conducted in the wetlands of Instructional Farm, College of Agriculture, Vellayani during Rabi season of 2001 for assessing the performance of basmati rice (*Oryza sativa* L.) varieties under different dates of planting.

The treatment consisted of combinations of four basmati rice varieties with four dates of planting. The varieties tried were Pusa basmati-1, Haryana basmati, Kasturi and Basmati- 370.

The duration of various pheno phases with respect to varieties and planting dates showed wide variation. The number of days taken for attainment of different phenological stages were largely in order $d_1 > d_4 > d_3 > d_2$. The early transplanting of seedlings took longest time (119,123,116 and 116 days respectively) for attainment of maturity in Pusa basmati-1, Haryana basmati, Kasturi and Basmati-370 respectively. The results presented revealed that there was difference between varieties and between different dates of planting in the cumulative heat units required for the completion of different phenological phases.

The Degree-days required to attain different phenological stages revealed that sowing date had marked influence on degree days accumulated. For different planting dates degree-days from planting to maturity ranged between 1487 to 1709 ^{o}Cd, 1488 to 1605^{o}Cd, 1317 to 1620^{o}Cd and 1316 to 1620^{o}Cd for Pusa basmati-1, Haryana basmati, Kasturi and Basmati-370 respectively.

“Kasturi” required less cumulative heat units to complete the vegetative phase when compared to the other varieties. “Haryana basmati” required more cumulative heat units to complete the first phase while it was compensated in the reproductive and maturity phases of crop growth. However, Kasturi required the least cumulative heat units to reach maturity while “Pusa basmati” the most. “Kasturi” recorded the highest grain yield, possess the first ranking in quality attributes and matured within short period. Because of all these factors “Kasturi” can be recommended from among the varieties for cultivation in the Southern agro-climatic region of Kerala.

5. Influence of Weather Parameters on the Productivity of Coconut

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Coconut palm is not very fastidious or exacting in to climatic requirements. But, for ensuing the development of a profitable and prosperous coconut garden it is necessary that the likes and dislikes of the palm are given due consideration. Monthly rainfall data of Coconut Research Station, Veppankulam for the period 1961 to 2006 was taken to assess the mean annual and seasonal distribution of rainfall. The correlation between weather variables and nut yield of coconut palm as well as the size of nuts was assessed with 10 years mean annual data to study the impact of weather variables on the productivity of palms. The mean annual rainfall is 1120 mm and the mean seasonal distribution of rainfall is 59.9, 129.6, 302 and 628.5 mm during winter, summer, south west and north east monsoon respectively. Though the influence of annual rainfall on the coconut productivity is not significant, the influence of north east monsoon seasonal rainfall on the productivity and barren nut production is highly significant. Among the other variables, the maximum temperature had significant influence on productivity as well as barren nuts production.

Key words: Rain fall, coconut productivity, barren nuts production

6. Assessment of the Impact of the Regional and Micro-Regional Climate Changes on Agriculture – A Case Study for Chhattisgarh State

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The climate of any place is assessed on macro-regional scale. However in a given micro-regional scale the general climate especially from agricultural point of view may vary due to factors like effective rainfall in undulated topography, soil variability and other biological factors. It is, therefore, necessary not only to study the regional climate changes in view of the global changes but also micro-regional changes that influence the agriculture in a given macro region like a district. With this above hypothesis, attempts have been made to study the regional climate studies in different districts of Chhattisgarh state and also micro-regional cliamte changes which directly affect the crop and influence the varietal selection as well as the cropping sequence in case water is available for irrigation purposes.

In the analysis it has been observed that at some pockets of the 16 districts of Chhattisgarh state the rainfall is significantly decreasing and as a result the climate is shifting from sub-humid type to semi-arid conditions. Looking into the impact of these regional climate changes the Government of Chhattisgarh had taken up ' crop diversification' programme in a large scale on priority basis. Also, in the Northern Hills agro climatic zone (ACZ) of Chhattisgarh state, it was observed that the day temperatures are significantly increasing during August and September while the same are in decreasing trend in winter seasons. This resulted in decreased crop duration during kharif (rainy) season and facilitated farmers to take two crops of potato after harvest of early duration rice. Such changes are favourable for agriculture but the impact due to unfavourable conditions are more in rainfed agriculture.

While analyzing the climate at micro-regional scale for agricultural purposes it was found that the micro-regional climate varied from semi-arid to humid even within a regional cliamte of sub-humid type. The reasons for such climate variations at micro-regional levels are very low effective rainfall due to the topography with slopes greater than 15 per cent and also due to very light and shallow depth of soils with very little water holding capacity. Such micro-regional climate variations also need to be analyzed for making fool-proof planning for sustainable agricultural development at micro-regional level in each district. In this paper attempts have been made to capture such significant changes of climate at regional as well as micro-regional levels and also to find out the significant crop zone shifts due to these changes. Such analyses are needed for proper planning of agricultural development in order to increase the agriculture GDP from existing level to 4 per cent level as emphasized by the government. For agricultural development it is always better to "think globally and act locally"

7. Impact of Climatic Change on Cotton Production

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The intergovernmental panel on climate change (IPCC, 2001) projects that global atmospheric concentration of CO_2 will increase from 368 µmol mol^{-1} in 2000 to 540 to 970 µ**mol mol^{-1}** in 2100. Over the same period IPCC estimates that rising concentration of green house gases will increase global air temperature 1.4 to 5.8 ^{0}C. Important regional variations will underlie these global trends. Many already dry regions may experience a decrease in precipitation, but other regions will get wetter. Extensive warming (by 4 ^{o}C) in India could cause significant reduction in crop yields (25-40%) in the absence of adaptation and C fertilization (Rosenziveig and Parry 1994). Adaptations would reduce the magnitude of losses. Even if warming was the same throughout India, some areas (western coastal districts) would lose heavily whereas some areas (districts of eastern states) would even benefit slightly (FAO 2000). Ramakrishna et al., (2006) indicated decreasing rainfall trends in south western and central parts of India and increasing rainfall trend in Punjab, Western Rajasthan, Gangetic West Bengal and Sub Himalayan West Bengal. These shifts can considerably affect crop performances.

8. Climatic Change and Apple Production in Himachal Himalayas

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The life has prospered on the earth for last 4000 million years and has witnessed many climatic fluctuations during this time. A variety of factors affect the global climatic pattern. The interaction between these factors is complex and has not been fully understood by the researchers so far. The climatic change experienced in the last century has been much more drastic and rapid in nature. This has given rise to global warming and its effects are being recognized all over the world (Brown, 1996). Awareness is increasing about Himalayas scientific, economic and tourist potential which remained ignored. Interaction between man and the mountains has brought haphazard development which had a perilous effect on its fragile environment and led to ecological degradation in terms of growing unplanned urbanization, increase in population, depleting forest cover and changes in landuse pattern. The exploitation of hydro-electric power potential of Himalayan Rivers has further deteriorated the ecosystem. Any change in the Himalayan climate and its subsequent effects likely to be felt for the socio-economic survival of crores of people inhabiting in the plains. The first and foremost effect of this climatic changes is likely to seen in agricultural production because, climate not only acts as the limits for a given crop but also determines to a great degree the consistency of annual cropping and the quality to be expected. Along with Kullu valley the Himachal Himalaya is showing a declining trend in per unit area of apple production where there is an increasing trend in temperature and decreasing in precipitation.

9. Studies on Historical Temperature Data and its Impact on Rice Production in Cauvery Delta Zone

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Historical maximum and minimum temperature date for 64 years from 1929 to 1992 were collected from Tamil Nadu Rice Research Institute Agromet, Aduthurai, India. The available data were collected and analysed using INSTAT package. The annual mean maximum temperature ranged from 32.1°C to 35.8°C during 1929-92 period. The mean annual minimum temperature ranged from 20.4°C to 24.4°C with a highest value of 33.3°C and the lowest value of 12.8°C. The mean annual temperature was almost constant during 1929-92. There were fluctuations in the highest and lowest values of both maximum and minimum temperatures once in four to six years. Variations are especially seen in the highest value of maximum temperature and the lowest value of minimum temperatures. However there is not any evidence for an increase in annual temperature scenario during 1929-92. The variation in temperature distribution during the different rice growing seasons were compared with rice production in Cauvery Delta Zone. The weather parameters prevailed from transplanting to harvest showed that the rice yield was positively correlated to solar radiation (r= 0.8526), maximum temperature (r= 0.8831) and minimum temperature (r= 0.9514) while negatively correlated with relative humidity (r= - 0.9514) and rainfall (r= - 0.7192) at Aduthurai during *kuruvai* season. The minimum temperature limits rice productivity in *samba, thaladi* seasons while the minimum temperature prevailed during vegetative growth period and the high temperature prevailed during flowering to maturity period in summer season. The weather parameters prevailed from transplanting to harvest showed that the rice yield was positively correlated to solar radiation (r= 0.9709), maximum temperature (r= 0.6381) and minimum temperature (r= 0.9466) while negatively correlated with relative humidity (r= - 0.7426) and rainfall (r= - 0.9100) at Aduthurai during *samba* / *thaladi* season.

10. Impact of Microclimate on Biochemical Changes on Growth and Yield of Tomato (*Lycopersicon esculentum* Mill.) Under Shade and Open Condition

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Tomato (*Lycopersicon esculentum* Mill.) is an important vegetable crop of the world and is widely grown throughout India. However, if the temperature goes beyond certain limit, it becomes detrimental to tomato production because of flower drop and low fruit set. Thus, cultural methods are needed to sustain flowering and fruit set even under adverse conditions and to supply tomato fruit to the existing market windows during off season. Studies were carried out at the University Orchard, Tamil Nadu Agricultural University, Coimbatore during 2004-05, two during summer (February- June, 2004 and 2005) and one during kharif (June- November, 2004). The investigation was carried out using tomato hybrid ‘Ruchi’ under controlled environment (shade net house) and open condition in split plot design with three replications. A spacing of 80 X 40 X 60 cm between pairs, rows and plants respectively. The treatment consists of two main plot (open and shade) and six sub plot treatments viz., 100, 75 and 50 per cent of water soluble fertilizer and same levels with straight fertilizers. The recommended dose of N: P: K at 250: 250: 250 kg per hectare was followed in the experiments. Twenty per cent of the recommended NPK was applied as basal and the remaining was applied through fertigation on alternate days starting from third week after planting as per sub -plot treatments. Five plants were selected at random in each replication for recording observations like carbohydrates content (Anthrone reagent and expressed as mg $100g^{-1}$.) IAA oxidase activity (Parthasarathi *et al*. (1970), nitrate reductase activity was Nicholas *et al.* (1976).

11. Climate Change and its Impact on Crop Yield in Jammu Region

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Analysis of last twenty years weather data revealed that rainfall during rabi season decreased by 2.96 mm per year; whereas the rainfall during kharif season increased by 1.69 mm per year. However, in case of annual rainfall a declined trend by 1.62 mm per year was observed. During the last two decades, its was observed that maximum and minimum seasonal temperature during the rabi season of the region increased at a rate of 0.023 and 0.038 °C per year, which resulted in an average increase of 0.30 °C per year. Due to the seasonal variation in temperature at different growth stages of the crop affected the produce. It was observed that wheat and rice grain yield varies –0.50 and 0.27 q ha^{-1}, respectively with every 1°C rise in seasonal temperature.

Key words: Climate change, rainfall, weather parameters, maximum and minimum temperature and crop production.

12. Effect of Climate Change on Productivity of Rice and Wheat in Tarai and Bhabar Agro-Climatic Zone of Uttarakhand

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The rice-wheat cropping system is a very important and popular cropping system being followed in the *tarai* area of Uttarakhand. The area, characterized by shallow water table and moist soil regime, lies within a narrow east-west strip of 8 to 25 km wide, on an outwash plain, gently slopping (<1%) southwards below the Bhabar tract along the foot hills of the Himalayas. The entire area is dissected by a number of small streams originating as springs from the junctions of Bhabar and *tarai* belts. In India, about 10.0 million hectare area is under rice-wheat cropping system and of this a large portion (4.8 m ha) falls in the *tarai* area of Uttarakhand. The sowing of wheat after rice is being

followed since about more than five decades after bringing the area under crop cultivation since its deforestation in 1950. In rice-wheat cropping system a complete recommended set of agronomic practices is followed including timely control of pests and diseases, proper integrated nutrient management, application of balanced fertilizers and crop residue management, recommended tillage practices after harvesting of rice and control of weed flora over a time period under different conditions and crop stages. In-spites of these the yield of wheat after rice in the area has declined by about 20-30% after the green revolution. It was thought that this decline in tend may follow the change in climatic conditions specially the air temperature and the rainfall in the area.

13. Impact of climate change on Indian Agriculture: A review

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During the recent decade, with the growing recognition of the possibility of climate change and clear evidence of observed changes in climate during 20th century, an increasing emphasis on food security and its regional impacts has come to forefront of the scientific community. In recent times, the crop simulation models have been used extensively to study the impact of climate change on agricultural production and food security. The output provided by the simulation models can be used to make appropriate crop management decisions and to provide farmers and others with alternative options for their farming system. It is expected that in the coming decades with the increased use of computers, the use of simulation models by farmers and professionals as well as policy and decision makers will increase. In India, substantial work has been done in last decade aimed at understanding the nature and magnitude of change in yield of different crops due to projected climate change. This paper presents an overview of the state of the knowledge of possible effect of the climate variability and change on food grain production in India.

14. Interaction of weather parameters on Sunflower yield under Irrigated upland condition

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The sunflower crop is a thermo- insensitive oilseed crop and it could be sown throughout the year and can find a place in any cropping system. Though thermo insensitive, sunflower cultivars differed in their response to the varying daily weather parameters even in a given season under different agro climatic sub zones. [Gaikwad *et.al.,* (1996)]. Hence, it is felt necessary to find out the role of weather parameters on the yield of sunflower in a particular agro climatic zone, so as to fix the optimum time of sowing to attain maximum yield. The field experiment was conducted during 2000-2002 at Tamil Nadu Agricultural University, Coimbatore. The experiments were laid out in split plot design with three replications. The experiment in main plot consisted of three sowing times *viz.,* normal sowing week (S_1)[Green gram (33^{rd} Meteorological Standard Week (MSW), Maize 48^{th} MSW and Sunflower 15^{th} MSW] two weeks early (S_2) and late (S_3). In sub plots, five nutrient management *i.e.,* 100 per cent inorganics, 75 per cent + 25 per cent inorganic (N alone), 50 per cent each organic and inorganics, 25 per cent organic + 75 per cent inorganic (N alone) and control.

15. Wheat Production in Changing Climate in Plains *Zones* of Chhattisgarh

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The climate of the globe is slowly but steadily changing. The changing climate has directly or indirectly severe implications on human society. The current accelerated climate change has been triggered by the anthropogenic activities and poses severe threat to the agricultural production. Several Global Circulation Models have been used to predict the future climate scenario, which are capable of foretelling the trends in climate change; however the accurate climate predictions are yet to be achieved. The climate trend shows that the temperatures of globe are increasing. To have an idea of the effect of changing climate on wheat production, crop simulation model, CERES-Wheat has been used to simulate the effect of global warming on wheat production. The results shows that anthesis, physiological maturity, biomass, grains per ear & grain yield were highly sensitive to change in temperature. The biomass and grain yield decreased at varying degree ranging from 7 to 44 % in case of biomass and from 10 to 48 % in case of grain yield, when the temperature was increased in the range of 1 to 3 ^{o}C. When temperature was decreased up to 3 ^{o}C, the increased trends in the biomass and grain yield were observed to the tune of 20 to 80% and 19 to 79%, respectively.

16. Effect of Micro-Weather Variations on Major Crops of the Sub-Tropical Regions[#7]

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Crop growth and development are primarily governed by the conditions of soil and weather. The success or failure of farming and qualitative and quantitative aspects of crop production is intimately related to the prevailing weather conditions. Vagaries of weather phenomena also affect agriculture by interfering with routine agricultural operations and plant protection measures. Further, influence of weather on crop growth and yield depends on crop growth stages. Crops growth and development is often influenced significantly by a few weather factors. Modification of weather, except on a limited scale, is yet on the realm of the experimentation. Nevertheless, it is possible to optimize crop production by adjusting cropping patterns and appropriate agronomic practices to suit the climate of the locality. With these background considerations, a comprehensive field investigation was undertaken with the wheat, groundnut and potato crop during the post monsoon season of 2002-03 through 2004-05 and with rice crop during monsoon season of the years 2003 through 2005 at the experimental farm of Agricultural and Food Engineering Department, Indian Institute of Technology, Kharagpur, India. The reported study was undertaken to examine the effect of weather variability on crop growth parameters of the major crops grown in this sub tropical region. Experimental results revealed that the yield of potato, wheat and groundnut crop during Experiment 3 (2004-05) were greater than the Experiment 1 (2002-03) and 2 (2003-04) due to more rainfall during Experiment 3 than Experiment 1 and 2. In case of rice crop during Experiment 3 (2005), the crop yield was less than the other two experiment 1 (2003) and 2 (2004) due to non uniform distribution and low magnitude of rainfall during Experiment 3 than Experiment 1 and 2. These experiments were also conducted to generate data for establishing crop-weather relationship for all the major rainfed and irrigated crops in different agro-climatic region required for crop growth modeling. The results of the study would be very useful to farmers for appropriate scheduling of irrigation and for choosing the optimum timing for spraying of pesticides, application of fertilizers, etc. in relation to the climatic changes.

Keywords: Micro-weather variations, crop-weather relationship, crop growth, crop growth modeling.

17. Implication of Global Warming on Menace of Ragweed Parthenium (*Parthenium hysterophorus* L.)

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Ragweed parthenium (*Parthenium hysterophorus* L.) is an aggressive herbaceous weed of the Asteraceae with an almost worldwide occurrence (Towers et al. 1977). A few plants of this species were first noticed in Pune (India) in 1950s (Rao 1956), and since then the species has spread and become widely distributed over India with a variety of implications and growing public concerns (Anonymous 1997; Towers wt al. 1977). The species continues to spread to newer areas in India including the central Himalayas (Anonymous 1997). The species threatens human and animal health, the environment, agriculture, and natural biodiversity through its prolific growth, copious pollen and seed production, and constituent bioactive and toxic allelochemicals (Das and Das 1995; Kanchan and Jayachandra 1980; Mersie and Singh 1988; Pandey 1996; Towers et al. 1977). It causes allergic contact dermatitis, rhinitis, and respiratory problems in sensitive humans. It also results in allergic contact dermatitis in animals. The weed may cause toxicity, sometimes even death, when consumed by animals, especially during summer, when green forage is scarce. Thus, it has tremendous socioeconomic implications affecting human life in various ways. Unchecked growth and spread of the species may exacerbate the socioeconomic implications more as global climate changes.

18. Climate Change and its Effect on Crop Growth and Yield : A Simulation Study

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Dynamic crop growth simulation models CERES-Wheat for wheat crop, CHICKPGRO for gram CERES-Rice for rice crop, PNUTGRO for groundnut and SOYGRO for soybean were used to study the effect of climate change on growth and yield of crops at Ludhiana under non-limiting water and nitrogen availability conditions. Analysis of recent 30 year historical weather data of Ludhiana has revealed an increase in minimum temperatures (0.07 ^{o}C/year), decrease in maximum temperatures (0.02 ^{o}C/year) and an increase in rainfall (10.5 mm /year). Keeping in view the changes in climate variability, growth and yield of these crops were simulated under selected synthetic climatic scenarios of changes in temperature (maximum and minimum) and solar radiation. In general with an increase in temperature above normal, the phenological stages of winter season crops (wheat and gram) were advanced, whereas similar changes in summer season crops (rice, groundnut and soybean) were less sensitive. With an increase in temperature upto 1.0 ^{o}C the yield of rice, wheat, and groundnut decreased by 3, 10, and 4%, respectively. However, some increase in temperature was found favourable for yield of gram and soybean. An increase in solar radiation by 5% increased the yield of rice, wheat, groundnut, gram and soybean by 6, 3, 8, 4 and 2%, respectively. The interaction effect of increasing minimum temperature but decreasing maximum temperature revealed that the growth and yield of crops was adversely affected by increasing minimum temperatures while, the decreasing maximum temperatures were able to partially counteract the adverse effect only upto a certain limit. When the mean temperature increased by 1.0 ^{o}C and solar radiation decreased by 5% from normal, the grain yield of wheat, rice, groundnut and soybean decreased by 14, 9, 7 and 0.5%, respectively from normal.

19. Application of CERES-Wheat Model in Evaluating the Impact of within-Season Temperature Rise on Wheat Yield in Punjab[#7]

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Wheat is a major winter cereal crop in northern India and it requires cool climate during its early growth stages for potential productivity. Higher temperature during the early growth stages is unfavourable for tillering while during later growth stages it reduces the duration of grain formation and hinders proper grain filling. Unusual changes in weather parameters, especially an increase in maximum/ minimum temperature from normal at any growth stage of crop adversely affects the growth and ultimately the potential yield of wheat. Computer simulation techniques are easy, time-saving and economical for studying the influence of agronomic practices and climatic changes on growth and yield of crops. The CERES type models simulate crop growth, development and yield taking into account the effects of weather, management, genetics, soil water, carbon and nitrogen (Timsina and Humphreys, 2003). Mall and Singh (2000) employed CERES-Wheat and WTGROWS models to determine wheat yield advances against a variable annual wheat yield potential in Punjab. In a simulation study in Punjab the CERES-Wheat model predicted results indicate that intra-and inter-seasonal temperature deviation from normal play a pivotal role in determining the final wheat yields (Prabhjyot-Kaur and Hundal, 2007).

20. Performance of Gladiolus Varieties under closed and open Cultivation under Shervaroy conditions

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Gladiolus is commonly called as sword lilly and one of the most attractive export oriented flower crops. Planting of 38 gladiolus (*Gladiolus* sp.) varieties was done both inside the polyhouse and in openspace during January 2007. The impact on climatic change on sprouting of corms, vegetative and floral characters were studied both in closed and open conditions. Based on the result it was observed that the performance of gladiolus crop was better under polyhouse than under openspace. The varieties evaluated under polyhouse showed that the days taken for corm sprouting was minimum (6.53 days) and plant height was maximum (107.52cm) in the variety Red Ginger. The variety Western Song took minimum number of 65.17 days for flowering. The longest spike length of 150.38cm and spike weight of 76.36g were measured by the variety Pusa Swarnima. Maximum number of flowers per spike (20.27) and number of flowers remained open at a time (8.54) were recorded in Legend. The maximum flower diameter of 13.70cm was recoded by the variety Red Ginger. The longest vase life of 15.37 days was recorded in Legend. The varieties evaluated under open condition showed that the days taken for corm sprouting was minimum (7.63 days) and plant height was maximum (105.37cm) in the variety Harahan. The variety Western Song took minimum number of 68.46 days for flowering. The longest spike length of 145.62cm and spike weight of 71.58g were measured by the variety Pusa Swarnima. Maximum number of flowers per spike (19.63) and number of flowers remained open at a time (8.17) were recorded in Legend. The maximum flower diameter of 12.93cm was recoded by the variety Red Ginger. The longest vase life of 15.37 days was recorded in Legend. The well performance under polyhouse than under openspace is due to the favourable climatic condition prevailed under polyhouse during the growing period.

21. Climate Variability Impact on Small Cardamom (*Elettaria cardamomum* Maton) Across the Western Ghats

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Small cardamom (*Elettaria cardamomum* Maton) - popularly known as the Queen of Spices - is indigenous to the evergreen rain forests of the Western Ghats. It is confined to the States of Kerala, Karnataka and Tamil Nadu, accounting for an area of 41,288 ha, 25,947 ha and 5,085 ha, respectively. Among these States, Kerala accounts for the major portion of production (72.4 %), followed by Karnataka (20 %) and Tamil Nadu (7.6 %). The natural habitat of cardamom is seen in the highranges between 1000 and 1500 m AMSL across the Western Ghats and characterized by cool-humid-microclimate, which provides ideal conditions for cardamom cultivation. The forests exert a domineering influence on soil, water resources and microclimate of cardamom. In the turn of twenty-first century, forests constituted only 24 % when compared to 70 % in the middle of nineteenth century in Kerala. The fast-dwindling forest cover and its consequence over climate are the concern across the cardamom tract of the Western Ghats. Keeping the above in view, a study was undertaken to analyse the variability of rainfall and surface air temperature over a period of time and its influence on the cardamom area and production across the Western Ghats, for which the monthly data on rainfall and the surface air temperature (maximum and minimum) were collected from the six selected locations across the cardamom tract along with the data on area and production of small cardamom. The linear trend method given in MS-Excel was used to compute the trends of rainfall, temperature, cardamom area and production.

22. Evaluation of alternate cropping systems under dryland agriculture

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For providing stability to the farming system under drylands, combining perennial trees with seasonal crops would be more appropriate. Hence, a study was carried out to evaluate the productivity and economics of different cropping systems with trees, moisture conservation and nutrient management practices under dry farming situation. Field experiments were conducted at Research Farm, Department of Agronomy, Tamil Nadu Agricultural University, Coimbatore during North East monsoon seasons of 1999 and 2000. The cropping systems compared were Sorghum (Co 26) + cowpea (CO 4) (grain crops), Sorghum (CO 27) + cowpea (CO 4) (fodder crop) and *Cenchrus glaucus*. The experiment was laid out in split plot design with three replications. The main plot treatments included tree species viz., *Ailanthus excelsa*(T_1), *Ceiba pentandra* (T_2) and *Emblica Officinalis* (T_3) and moisture conservation practices viz., Tied ridges (M_1) and Flat bed (M_2). Sub plot treatments included nutrient management practices viz., 100 per cent N through fertilizer (N_1) and 50 per cent N through fertilizer + 50 per cent N through goat manure (N_2). Tree seedlings were planted during the North East monsoon of 1998 and established. Crops were grown as intercrops in between the tree seedlings during North East Monsoon season. Tied ridges were formed at third week after germination of the seeds as per the treatments. Recommended fertilizer schedule of 40 : 20 kg N and P

ha^{-1} was adopted. Goat mature was applied basally and incorporated as per the treatments assigned. Productivity in terms of grain and fodder yields were recorded and converted into sorghum fodder equivalent yield and expressed as tonnes.

The total drymatter production (DMP) and sorghum fodder equivalent yield of the grain sorghum + cowpea and fodder sorghum + cowpea systems were higher with *E.officinalis* (T_3) with tied ridges (M_1) and applications of 50 percent N through fertilizer and 50 per cent N through goat manure (N_2) in both the years. The tree species and moisture conservation practices had no significant influence on the total DMP and sorghum fodder equivalent yield of *C.glaucus* in both the years. Among the N management practices, application of 50 per cent N through fertilizer and 50 per cent N through goat manure (N_2) recorded the highest total DMP and sorghum fodder equivalent yield of *C.glaucus* in both the years. Among the three systems tried, higher sorghum fodder equivalent yield was recorded with grain sorghum + cowpea as compared to fodder sorghum + cowpea and *C.glaucus*. This was due to higher value of grain than the fodder. Due to adequate supply of moisture through rainfall sorghum fodder equivalent yield was higher during 1999. Crops grown with *E.officinalis* recorded higher sorghum fodder equivalent yield. The possible reason might be due to less competition posed by *E.officinalis* than other trees. Similarly higher sorghum fodder equivalent yield recorded under tied ridges and applications of 50 per cent inorganic N and 50 per cent N through goat manure might be due to adequate moisture and nutrient supply. Arya *et al.* (2000) also reported that higher sorghum grain equivalent yield was obtained with combined application of both organic and inorganic nutrients.

The highest net return (Rs.7385) and B:C ratio (2.18) was obtained under grain sorghum with cowpea intercropped in *E. officinalis* under tied ridges with application of 50 per cent N through fertilizer and 50 per cent N through goat manure during the year 1999. From the above study it could be inferred that less competition posed by *E. officinalis* and improved moisture status of the soil under tied ridges along with combined application of organic manure and inorganic fertilizer under grain sorghum + cowpea utilized the resources in better way and produced higher grain yield during first year, which in turn increased the gross return, net return and B:C ratio. Even with less rainfall, grass produced substantial yield and also due to less cost of cultivation the

C. glaucus system recorded higher gross return, net return and B:C ratio during second year as compared to grain or fodder sorghum with cowpea.

23. Influence of Weather Factors on Finger Millet Blast Disease Development at Coimbatore

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Finger millet (*Eleusine coracana* (L.) Gaertner) serves as food and fodder for millions but it is susceptible to mare than twenty pathogens of which blast disease caused by the pathogenic fungus *Pyricularia grisea* is most severe. The annual yield loss due to this pathogen was up to 50%. Hence it is necessary to protect the crop from disease through the forecasting the disease appearance well in advance before symptom development.In order to study the effect of weather factors on Finger millet blast infection, the parameters temperature (minimum and maximum), relative humidity (morning and evening), rainfall, and sunshine hours were considered. The weather data were obtained Among the weather factors analyzed, morning relative humidity showed positive, significant relation for the development of blast (leaf, neck and finger) incidence. The contribution of maximum and minimum temperatures was significantly higher but negatively correlated with leaf, neck and finger blast. The evening relative humidity was non-significant but contributed positive relationship with the disease incidence. The prediction equation was developed utilizing significant weather factors for finger millet blast disease incidence. The prediction equations revealed that one unit increase of independent variable, relative humidity (morning) increased leaf, neck and finger blast incidence to 0.67, 0.81 and 1.16 per cent respectively.

24. Influence of Weather Parameters on the Seasonal Incidence of Mango Hopper (Idioscopus clypealis)

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The influence of weather parameters on the seasonal incidence of Mango Hopper, *Idioscopes clypealis* established a positive correlation with increase in hopper population with maximum temperature and sunshine hours. The varietal preference was more towards Bangalora followed by Kalapad and low in Neelum. The effect of other parameters on the pest population is discussed. In general climate affects the distribution and incidence of pest population in a given area directly through its influence on the rate of development, fecundity and longevity of the organism and indirectly through its influence on the availability of food (Patel and Shekh, 2006). More than 400 pests have been listed which attack mango (Tandon and Varghese, 1985). Of these, about two dozen insect pests severely injure different parts of the tree. Among them mango hoppers, *viz*., *Idioscopus clypealis* and *Amritodes atkinsoni* are considered as the most destructive. Both the adults and the nymphs are damaging, especially the latter which have a higher rate of feeding. They suck the sap from tender shoots and inflorescence. The inflorescence withers away and the fruit set is adversely affected. The damage potential is estimated to be 25 - 60 per cent of the fruit yield. Until February, the hoppers remain hidden under the bark crevices and become active during the flowering period (Bose and Mitra, 1990). The population of mango hoppers reaches a maximum during that season. Hence, the present study was undertaken at Horticultural Research Station, Pechiparai to study the influence of weather parameters on the seasonal incidence of mango hopper.

25. Weather Variability in different Agroclimatic Zones in Telangana region of Andhra Pradesh

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Indian agriculture is strongly influenced by variability in weather and changes in climate. Crop productivity of a region is largely determined by its climate and prevailing weather. Climate variability, particularly rainfall variability and temperature trends, is the major factor influencing the agricultural productivity and sustainability in the tropics (Viramani, 1994). Telangana region of Andhra Pradesh comprises of three Agroclimatic zones viz., North Telangana, Central Telangana and South Telangana zones. North and Central Telangana zones are high rainfall zones, while South Telangana zone is said to be medium rainfall zone. Climate of the Telangana region is semi-arid with medium to high rainfall and 80 per cent of which received during southwest monsoon season (Reddy et al., 2004). Winter temperatures are low and some times drop down to below 10 ^{0}C in northern parts of the region. Cotton, castor, jowar, maize, groundnut and pulses are the major crops grown under rainfed conditions. The productivity of these crops is largely influenced by the rainfall distribution during *Kharif* and thermal regime during winter season as these two elements decide the crop growth and development, and yield of the crops.

26. Impact of Soil Moisture Initialization on Simulated Indian Summer Monsoon by a Regional Model.

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Of the total rainfall reaches earth surface, the water which remains in the soil is known as soil moisture (SM). Even though only a small portion of the total water is stored in soil (0.0012%, Oki, 1999) it plays a vital role in agricultural productivity. Decrease in soil moisture results in the decrease of latent heat flux (LHF) and increase of sensible heat flux (SHF) and there by reduction of water vapor and clouds which ultimately results in decreased precipitation over the region. Soil moisture is a key variable determining water and energy exchange at the land surface –atmosphere interface (Shukla and Mintz 1982). They suggested that SM anomalies persist long enough to modify the atmospheric circulation over seasonal to interannual timescales. Such anomalies could be sustained through an evaporation feedback mechanism. Fennesy and Shukla (1999) studied the impact of initial soil wetness on seasonal atmospheric prediction and the study strongly suggest that seasonal atmospheric prediction could be enhanced by using realistic initial state of soil wetness. Koster et al. (2000) showed that SM persists on a seasonal time scale and that SM anomalies often lead to precipitation anomalies a few months later. Douville et al. (2001) studied the influence of SM on the Asian and African monsoon and showed that SM-precipitation feedback is regionally dependant and feedback is weak over India because of the competitive impacts of SM on surface evaporation and moisture convergence. Experiments using global climate model by Zhao et al. 2004 also showed the impact of land surface representation in model on predicted dynamical features, such as precipitation and temperature patterns of Indian monsoon.

27. Growth and Yield of Groundnut cultivars (*Arachis hypogaea* L.) as influenced by Climate Change - drought stress

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Groundnut (*Arachis hypogaea* L.) is an important oilseed crop, meeting the needs of vegetable fat, protein; cattle feed and concentrated organic manure. India is the largest producer of peanut in the world, with 6223 mt (Muralidharan and Manivannan, 2003) grown mostly under rainfed cultivation. Average yields in the rainfed areas are very low (750 kg ha^{-1}) because of erratic rainfall and biotic stress factors. The occurrence of moisture stress during flowering, pollination, and grain-filling is harmful to most crops. Increased evaporation from the soil and accelerated transpiration in the plants themselves will cause moisture stress; as a result there will be a need to develop crop varieties with greater drought tolerance. Water is essential for crop production and best use of available water must be made for efficient crop production and higher yields. But information is limited about the effects of varied water supply at different growth phases on crop water use, growth and development. Groundnut has specific need of water owing to its specific morphological and phenotypic features.

28. Prediction of Blast Disease Appearance in Finger Millet Utilizing Different Weather Parameters in Major Finger Millet Growing Area (Paiyur) of Tamil Nadu

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The blast disease caused by *Pyricularia grisea* Sacc.{*Magnaporthe grisea* (Hebert) Barr.} continues to be an enigmatic problem in several finger millet growing areas and is a serious constraint in realizing the full yield potential of finger millet cultivars. Weather based forecasting systems reduce the cost of production by optimizing the timing and frequency of application of control measures and ensures operator, consumer and environmental safety by reducing chemical usage. A major aim of many forecasting system is to reduce fungicide use, and accurate prediction is important to synchronize the use of disease control measures to avoid crop losses. Multiple regression analysis was performed with weather data (temperature, relative humidity (morning and evening), rainfall and sunshine hours) and finger millet blast disease incidence to develop a prediction equation. The correlation and regression analysis revealed that among the different weather parameters, morning relative humidity showed positive influence to the development of blast incidence. The morning relative humidity was positively and significantly correlated with the disease incidence (leaf, neck and finger blast). Maximum and minimum temperatures were significantly negative correlation with neck blast development whereas non-significant negative correlation with leaf blast development. Evening relative humidity showed non-significant positive relationship with the neck and finger blast disease development. Amount of rainfall showed non-significant negative correlation coefficient with the blast disease development.

29. Elevated Temperature Due to Extended Summer into Kharif Growing Season and its Consequence on Sorghum Yield - A Simulation Analysis

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Agricultural Production Systems Simulator (APSIM) has a number of modules that interact with each other on a daily time step, so as to generate outputs. Soil forms the basis for these interactions capturing the actual field dynamics in terms of crops being sown as well harvested at regular intervals, various climatic events and the physical vis-à-vis biological processes. Inputs required to run the model include the daily meteorological data, soil and genotype specific coefficients. The advantage of these tools lies in keeping most variables constant, and running the model with required changes in the components that drive the system so as to generate the consequences. Meteorological data from Regional Agricultural Research Station (RARS) at Palem in Mahbubnagar district of Andhra Pradesh was retrieved and used to run the model.

Few of the assumptions made were based on the analysis of historical temperature data recorded at the centre. In a given year it was observed that the maximum temperature on an average (10 year period) was above 35^0C during the months of April and May. The sorghum crop which was grown with the onset of monsoon in the month of June could be affected if the high temperatures of May month extended for some more time during the crop growth period. Apart from the enhanced level of the temperature, the extant to which, these conditions prevailed were also important while considering the likely shifts (elevated temperature regime) due to climate change. The crop was sown on a fixed date, while the input data was varied as presumed above, in terms of May maximum temperatures extending into June and in the second case April and May temperatures extending into June-July. These were compared with the normal temperatures that prevailed during respective years (1995 & 2005).

The results indicate two different trends, wherein there was decrease in grain yield along with extended crop duration, as compared to the normal temperature regime during 1995. During 2005 the grain yield increased and crop duration was shortened by 4 to 8 days under elevated temperature conditions. The above results indicate the rigor of the model to capture both negative and positive trends, while the simulations also indicate the differences specific to a given year. Elevated temperatures could influence moisture losses due to crop transpiration, which is a biological process and due to soil evaporation which is a physical process. Modern tools thus help in improving our understanding of any given system and its dynamics, under various assumptions that closely match the reality.

30. Global Warming on Rice Productivity of Traditional Rice Belt of Tamil Nadu[#7]

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Climate change is the growing concern on the Earth. Its impact on all walks of life is being projected by the scientists. Possible ways and means to reduce or to mitigate the impact are all the current interest for research. Agriculture seems as a major victim for this change. Rice being the staple food for more than half of the world's population, it is more pertinent to analyze the impact on rice productivity, the season available for cultivation and the need for improvement in rice crop variety. An attempt was made in this direction to predict the rice performance in the traditional rice belt of Tamil Nadu in comparison with a location which is not so important for rice area at present but located on the same latitude but in elevated altitude. Aduthurai (11° 1' N, 79° 32'E and 19.0m + MSL) was considered for the traditional and Coimbatore (11° 0' N, 77° 0'E and 431.0m + MSL) for comparison. Aduthurai is a deltaic rice area, nearer to the sea with warmer weather compared to Coimbatore which is much higher elevation with mild weather for most part of the year. The weather data for these two stations were taken from the 'Normals of agroclimatic observations in India' (IMD, 1982). The model used to predict the rice crop growth was ORYZA2000 an eophysical simulation model(Bouman *et al* 2001).

31. Yield of Rice as Influenced by Weather Parameters at Different Growth Stages

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The investigation was carried out from the yield data of kharif season collected from a permanent manurial experiment conducted at Regional Agricultural Research Station (RARS), Pattambi, Palakkad for a period of 25 years (1960-1985). The weekly weather data for the crop season was collected and correlation analysis was done to identify the critical periods wherein the weather has significant influence. Prediction equations were developed using both linear and curvilinear regression analysis. Influence of different agro meteorological parameters prevailed during different pheno phases on grain yield by correlations and linear regression analysis revealed that the increase in temperatures (both maximum and minimum) and evaporation at different stages of rice growth had a negative influence on grain yield. The mean daily sunshine hours was positively correlated with grain yield from planting to panicle initiation stage. The path analysis study done using the different agro-meteorological parameters and grain yield revealed that mean maximum temperature, mean minimum temperature, and mean evaporation during the period from planting to active tillering stage are negatively correlated with grain yield giving a significantly negative direct effect of -0.5995 , -0.6343 and -0.5677 respectively. The weather parameters like number of rainy days, evening relative humidity and mean daily sunshine hours had significant positive direct effect.

32. Epidemiological Model for Predicting the Occurrence of *Erysiphe Polygoni* DC in *Vigna Mungo* L.

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Field experiments and laboratory studies were carried out to study the effect of degree-days on powdery mildew in *V. mungo*. In the correlation analysis, degree-days were found to influence the disease initiation positively during four days prior to initial disease observations in all four years. Where as morning RH and leaf wetness hours influenced the initiation positively. A stepwise regression analysis shows that, degree-days had strong significant negative influence on the initiation as well as development of the disease. Where as morning RH was found to influence only disease initiation positively along with degree days. The regression analysis suggested that a quadratic model best explains the relationship of degree days to disease development in all years when compared to other models viz., Logistic, Linear, Richards and Gompertz models.

33. Development of an agro climatic model for the rice yield

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It deserves an utmost importance to look out for an agroclimatic model for the expected quantum of the rice production in Andhra Pradesh at an early stage of the concerned seasons in the present era of increasing population to meet the demand for food. Growing degree day or heat unit theory of the crops and Integrated Normalized Difference Vegetation Index are obtained and are related to the rice yield along with the rainfall for a period of 19 years from 1982 to 2000. The atmospheric and oceanic indices such as Southern Oscillation Index and Sea Surface temperature of Nino 3 region are also incorporated and the correlation and multi-regression method have been applied for the estimation of rice yield.

34. Effects of Climate Change on Rice Production in the Tropical Humid Climate of Kerala, India.

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The CERES-Rice v3. Crop simulation model, calibrated and validated for its suitability to simulate rice production in the tropical humid climate Kerala State of India, is used for analyzing the effect of climate change on rice productivity in the state. The plausible climate change scenario for the Indian subcontinent as expected by the middle of the next century, taking into account the projected emissions of greenhouse gases and sulphate aerosols, in a coupled atmosphere-ocean model experiment performed at Deutsches Klimarechenzentrum, Germany, is adopted for the study. The adopted scenario represented an increase in monsoon seasonal mean surface temperature of the order of about 1.5°C, and an increase in rainfall of the order of 2 mm per day, over the state of Kerala in the decade 2040–2049 with respect to the 1980s. The IPCC Business-as-usual scenario projection of plant usable concentration of CO_2 about 460 ppm by the middle of the next century are also used in the crop model simulation. On an average over the state with the climate change scenario studied, the rice maturity period is projected to shorten by 8% and yield increase by 12%. When temperature elevations only are taken into consideration, the crop simulations show a decrease of 8% in crop maturity period and 6% in yield. This shows that the increase in yield due to fertilisation effect of elevated CO_2 and increased rainfall over the state as projected in the climate change scenario nearly makes up for the negative impact on rice yield due to temperature rise. The sensitivity experiments of the rice model to CO_2 concentration changes indicated that over the state, an increase in CO_2 concentration leads to yield increase due to its fertilisation effect and also enhance the water use efficiency of the paddy. The temperature sensitivity experiments have shown that for a positive change in temperature up to 5°C, there is a continuous decline in the yield. For every one degree increment the decline in yield is about 6%. Also, in another experiment it is observed that the physiological effect of ambient CO_2 at 425 ppm concentration compensated for the yield

losses due to increase in temperature up to 2°C. Rainfall sensitivity experiments have shown that increase in rice yield due to increase in rainfall above the observed values is near exponential. But decrease in rainfall results in yield loss at a constant rate of about 8% per 2 mm/day, up to about 16 mm/day.

35. Rice Yields Decline with Higher Night Temperature from Global Warming

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The impact of projected global warming on crop yields has been evaluated by indirect methods using simulation models. Direct studies on the effects of observed climate change on crop growth and yield could provide more accurate information for assessing the impact of climate change on crop production. We analyzed weather data at the International Rice Research Institute Farm from 1979 to 2003 to examine temperature trends and the relationship between rice yield and temperature by using data from irrigated field experiments conducted at the International Rice Research Institute Farm from 1992 to 2003. Here we report that annual mean maximum and minimum temperatures have increased by 0.35°C and 1.13°C, respectively, for the period 1979–2003 and a close linkage between rice grain yield and mean minimum temperature during the dry cropping season (January to April). Grain yield declined by 10% for each 1°C increase in growing-season minimum temperature in the dry season, whereas the effect of maximum temperature on crop yield was insignificant. This report provides a direct evidence of decreased rice yields from increased nighttime temperature associated with global warming.

36. Impact of Elevated CO_2 and Temperature on the Castor Semilooper, *Achaea janata*[#7]

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Carbon cycle models project atmospheric carbondioxide concentrations of 540-970 ppm by the end of next century as a result of fossil fuel consumption and global deforestation. Enriched atmospheric CO_2 can increase plant growth and alter leaf tissue chemistry, there by altering trophic interactions such as those between plants and insects. Many plant species respond to enriched atmospheric CO_2 by enhanced photosynthetic rates and increases in biomass (Bazzaz, 1990) as well as alterations in leaf quality factors that affect leaf consumption, digestibility and insect growth (Lincoln *et al* 1993). In plants grown in enriched CO_2 condition, reduction in leaf nitrogen expressed as a proportion of leaf weight results in a nutritionally poorer food source for leaf eating insects (Lindroth *et al* ,1993). Not many studies have focused on plant insect interactions under elevated CO_2 conditions.

Experiments were conducted at the Central Research Institute for Dryland Agriculture, Hyderabad, to study the effects of elevated CO_2 on castor leaf quality, and implications for the castor semilooper *Achaea janata*. Castor*, Ricinus communis* is an important non-edible oilseed crop grown across many parts of the arid and semi-arid regions in the country. *A. janata* occurs during early vegetative to early reproductive stages of crop growth. At peak level of infestation, the semilooper causes extensive defoliation resulting in reduced photosynthesis.

37. Sunshine /Sunlight/ Solar Radiation and Jaggery Production - A Review

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The sugarcane would thrive only in certain climatic conditions. Climate plays a vital and important role in accumulation of sugar in cane and climate and varieties play a dominant role in increasing the yield and quality of jaggery or sugar. Various climatic factors like diurnal temperature, humidity, rainfall, solar radiation, agronomic practices, soil types irrigation practices influence the composition of juice and cane variety ultimately reflect the quality of jaggery, different varieties are cultivated in different parts of India and these factors affect the tonnage of gur produced from the cane produced. It needed two thousand or so hours of sunshine in a year, that it would not survive frost and that it had to have quite a lot of rain. High rainfall and low sunshine during maturity phase resulted in drop of jaggery recovery because sucrose accumulation was inhibited under these conditions. Quality of gur is directly related to the quality of juice obtained from cane, whereas, quality of juice is affected by various factors viz. climate, temperature, rainfall, and solar radiation, soil type, fertilizers and irrigation etc. These factors affect the tonnage of gur produced from the cane produced.

38. Effect of Different Agro-Climatic Conditions on the Genetic Diversity of Velvet Bean[#1]

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Each and every organism lives in particular ecological niche with optimum environmental conditions. If there is any change in environmental conditions, the organism tries to adapt itself to the new environmental conditions by morphological change with or without genetic change. Morphological change is easily observable. The study of genetic changes among different populations with different environmental conditions requires advanced techniques. In the present study on eleven different accessions of an under utilized food legume, *Mucuna pruriens* (L.) DC. var. *utilis* (Wall. ex Wight) Baker ex Burck (velvet bean) collected from different agro-ecological regions of South India were assessed for genetic variability by using random amplification of polymorphic DNA (RAPD) technique. The DNA samples extracted from velvet bean accessions were found to be relatively pure with the purity index (OD value of 1.78 — 1.84. A total number of 59 polymorphic RAPD-PCR bands were scored with 10 different random primers (OPA 1 — 10). Among the ten primers employed in the present study, OPA-6, 7 and 9 registered higher level of polymorphism (87, 83 and 82%, respectively). The phylogenetic tree constructed by using multivariant analysis software NTSYSpc showed a substantial degree of genetic diversity within the velvet bean accessions. The level of genetic variability within the velvet bean accessions was positively correlated with their agro-ecological locations. The level of genetic variability recorded among the velvet bean accessions of the present study will enables the formulation of appropriate strategies for the development of new cultivars through traditional plant breeding or genetic engineering approaches.

39. Radiation interception and Heat Unit Efficiency studies in Senna (*Cassia angustifolia* L) under dryland vertisol

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The variation in the agricultural production is mostly attributed to the effect of seasonal weather condition on plant growth (Sastry *et a*l, 2000). Agriculture is an exploitation of solar energy made by an adequate supply of water and nutrients to maintain plant growth (Monteith, 1958). Solar radiation is a natural resource, which essentially controls plant growth, development and drymatter production. The study of solar radiation absorption in crop canopies and its use to determine the crop response is essential in assessing the crop productivity. Therefore information on yield dynamics with respect to PAR interception, dry matter production and LAI is rather lacking particularly in senna crop, hence the present study was undertaken.

The study was conducted at Black soil farm, Agricultural Research Station, Kovilpatti during 2005-06 rabi season. The experiment was laid out in split plot design with two sowing window (M1-Monsoon sowing; M2-Late monsoon) and nine management practices (S1-control,S2-100%NPK, S3-100%NPK with FYM, S4-100% NPK with FYM and Biofertilizers,S4-100% NPK+FYM+Biofertilizers and DAP foliar spray, S6-75 % NPK, S7-75%NPK with FYM, S8-75% NPK with FYM and Biofertilizers, S9-75% NPK+FYM+Biofertilizers and DAP foliar spray) replicated thrice. The photosynthetically active radiation (PAR) was measured with help of Line quantum sensor. The heat unit efficiency (HUE) was calculated as the ratio of dry matter to growing degree-days. The mean maximum temperature, minimum temperature prevailed and total rainfall received during rabi season are 32.2 °c, 21.9°c and 468.8mm. The amount of drymatter production by a crop depends on the distribution of leaf area in time and space in relation to solar radiation utilization. Separately measured growth indices such as LAI and dry biomass yield are useful index of crop productivity. The dry matter production was very closely related to LAI. The maximum LAI observed during late monsoon period with 100 % NPK+FYM+Biofertilizers The photosynthetic active radiation interception was also higher when the crop was sown during late monsoon period with 100% NPK +FYM+Biofertilizers. Heat unit efficiency was computed to determine biomass yield per unit of growing degree-day for senna. In general, it was observed that biomass yield HUE was more in senna crop sown in 43^{rd} standard week (Oct 22-28) as compared to 41^{st} standard week (Oct 8-14). The highest biomass HUE of 0.95 g/m2/C^{o}day recorded when the crop was sown during late monsoon period by following management practices viz.,100% recommended NPK+FYM+Biofertilizers application. High moisture availability during monsoon sowing affected the crop stand and reduced the growth parameters led to poor yield.

Sowing during late monsoon period registered increased growth parameters viz., plant height, LAI, DMP that ultimately reflected on higher leaf and pod yield. Among the management practices tried, 100% recommended dose of NPK with FYM and Biofertilizers recorded higher growth attributes and increased leaf and pod yield. The increased yield might be due to more interception of PAR led to luxurious growth that reflects on higher heat unit efficiency observed in that treatment. There was no significant increase in leaf and pod yield was observed in DAP foliar application.

40. Studies on Agro-Meteorological Indices on Growth and Yield of Blackgram Under Dryland Vertisol

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The growth and productivity of crops depends on the elements of the physical environment in a particular ecosystem. The application of agroclimatic indices provides a scientific basis for determining the effect of temperature, radiation or photoperiod on phenological behaviour of the crop. Climate and weather variability especially temperature significantly affect crop management strategies. A better understanding of weather resources can help to increase the crop productivity. Temperature based agrometeorological indices such as growing degree days (GDD) and heat use efficiency (HUE) can be quite useful in predicting growth and yield of crops. The total heat energy available to any crop is never completely converted to dry matter under even the most favourable agro climatic conditions. Efficiency of conversion of heat energy into dry matter depends upon genetic factors, sowing time and crop type (Rao et al, 1999). Keeping this in view, an attempt was made to study the growth and yield of blackgram with respect to temperature based agrometeorological indices.

41. Climatic Requirements for Maximising Sugarcane Yield and Quality

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The ideal climate for sugarcane is in the southern parts of the country, such as Maharashtra, parts of Karnataka, the Telengana area of Andhra Pradesh and Tamil Nadu. The following are the climatic requirements for sugarcane. Optimum cane growth is achieved in temperatures between 24 and 30°C. Temperature less than 5°C is harmful even to resistant varieties. Temperatures above 38^0 C reduce the rate of photosynthesis and increase respiration. As far as rainfall is considered, in India sugarcane is grown in areas ranging in rainfall of about 600 mm to 3000 mm. The crop can survive normal variation around a mean of 1200 mm. for obtaining higher yields, a rainfall of 2000 to 2500 mm per annum, evenly distributed is considered ideal.

The relative humidity does not have much influence, if water supply is not limiting. A moderate value of 45 to 65 per cent coupled with limited water supply is favourable during the ripening phase. Sugarcane is a sun loving plant. Therefore, greater incident radiation (Sunshine) favours higher sugarcane and sugar yields. About 7 to 9 hours of bright sunshine is highly useful both for active growth and ripening. Severe cold weather inhibits bud sprouting in ratoons and arrests cane growth. At temperature -1° to 2° C the cane leaves and meristem tissues are killed (Miah *et al* 2003). High velocity winds exceeding 60 km/hour are harmful to grown up canes leading to lodging and cane breakage. Also leaves get damaged even at early stage. Winds enhance moisture loss from the plants and thus aggravate the ill effects of moisture stress. The sugarcane productivity and juice quality are profoundly influenced by weather parameters during the various growth phases of cane (Samui et al 2001). Maharashtra records higher recoveries than the other states. In Maharashtra the period from November to March (the main crushing period) is dry with very less rainfall and low humidity and a lower daily mean temperature, the nights are cooler and the sunshine hours are greater. The diurnal variations in temperature are also fairly wide. These conditions favour higher sugar accumulation. The latitudes between 15°and 20°north or south where ideal climatic conditions are met with record higher sucrose levels than the other latitudinal positions.

VI. Coastal Environment and Climate Change

1. Olive Ridley Sea Turtle as An Indicator of Climate Change[#1]

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About 50% of Olive Ridley of world population and 90% of Indian population are seen in the three rookeries of Orissa coast such as Gahirmatha, Devi and Rushikulya river mouth areas. Environmental Sex Determination (ESD) in sea turtle is well established. It has been proved that the temperature less than 30°C shows the chances of getting more male hatchings while in rise of above (i.e. about 32°C) the chances of getting female become more. It is also reported that to much rise of beach temperature i.e. more than 34°C becomes lethal to many embryos in the nests of sea turtle other animals such as alligators and crocodiles, rising of temperature help to increase the probability of male hatchlings more. Few researchers suggested that the mean rise of global temperatures about 4°C, may eliminate the male turtle hatchlings due to which the production new generation will be hampered greatly. Sea turtles have emerged as good indicators of environmental or global climate change and also playing a crucial role in marine food web. But the present day situation is bitter than ever else existed on earth. Rapid industrialization, use of fossil fuels, global warming and climate change including melting of polar ice and sea level rise either rise or fall of the beach or climate temperature shows some negative influence on sex ratio of marine turtles. Difference in sex ratio will be a fundamental cause for extinction of any organism leading to loss of biodiversity

2. Vulnerability of Indian coastline to sea level rise

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Indian coastline stretches about 5700 kms on the mainland and about 7500 kms including the two island territories and exhibits most of the known geomorphological features of coastal zones. Presently, Indian coastline is facing increasing human pressures *e.g.*, overexploitation of marine resources, dumping of industrial and toxic wastes, oil spills and leaks which have resulted in substantial damage to its ecosystems. The impact of global warming-induced sea level rise due to thermal expansion of near surface ocean water has great significance to India due to its extensive low-lying densely populated coastal zone. Sea level rise is likely to result in loss of land due to submergence of coastal areas, inland extension of saline intrusion and ground water contamination and may have wide economic, cultural and ecological repercussions. Observations suggest that the sea level has risen at a rate of 2.5 mm year-1 along the Indian coastline since 1950s. A mean sea level rise of between 15 and 38 cm is projected by the mid- 21st century along India's coast. Added to this, a 15% projected increase in intensity of tropical cyclones would significantly enhance the vulnerability of populations living in cyclone prone coastal regions of India. Other sectors vulnerable to the climate change include freshwater resources, industry, agriculture, fisheries, and tourism and human settlements. Given that many climate change impacts on India's coastal zone feature irreversible effects, the appropriate national policy response should enhance the resilience and adaptation potential of these areas.

3. Global warming and its impacts on sea level rising

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Global warming and the resulting climate changes are among the most serious environmental problems facing the world community. Many of the world's experts on climate change predict a future of rising sea levels, without doubt one of the greatest threat facing humanities. The Ocean plays an important role as an agent with Global climate system as well as relevant resources for humans in the coastal zones. The presently undergoing anthropogenic climate change has an impact on the performance of the Global player "Ocean" as well as on the risks in coastal zone. Dramatically increasing the rate of melting of snow and ice means rising, sea levels, tide gauge data indicate that global sea levels rose by between 10 and 20 centimetres during the Twentieth Century and this rise is expected to escalate drastically in the coming hundred years, with sea levels predicted to be 40 cms and perhaps over 80 cms higher by 2100. Most of the recent and predicted rise comes from the thermal expansion of the oceans as they warm up or by the condition of water from the rapidly melting mountain Glaciers. Sea level rising due to global warming is discussed in this paper. Strategies for mitigation options and solutions for global warming are suggested**.**

4. Nitrogen Cycling: a Review of the Processes, Transformations and Fluxes in Coastal Ecosystems

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The coastal and marine nitrogen cycle occupies a complex, central role within the biogeochemical cycles. Human interventions in the earth system have risen to unprecedented levels, strongly influencing the global nitrogen cycle. The nitrogen cycle in the open ocean compared to coastal ecosystems appears to have remained unharmed, although recent observations have shown increasing anthropogenic influence. Projections suggest that global nitrogen cycle is being altered either directly by the continued addition of anthropogenically created fixed nitrogen to the earth system and its cascading effects, or indirectly through anthropogenically induced climate change. These alterations have the potential to cause positive feedbacks in the climate system, but they are neither well understood nor quantified. In the atmosphere, concentrations of the greenhouse gas, nitrous oxide and of the nitrogen-precursors of smog and acid rain are increasing. This unprecedented nitrogen loading has contributed to long-term decline in coastal fisheries. This article reviews some of the major processes, transformations and fluxes of nitrogen in the coastal ecosystems with reference to mangroves, occurring naturally and also due to human perturbations.

Keywords: Coastal ecosystem, nitrogen cycling, processes, transformations.

5. Biogeochemistry of Nitrogen in Seagrass and Oceanic Systems

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The coastal and marine nitrogen cycle occupies a complex, central role within the biogeochemical cycles, and yet we have just barely begun to understand its major processes and the factors that regulate them. Spatial variations of dissolved inorganic

nutrients (NO_3^-, NO_2^-, NH_4^+, PO_4^{3-}, and TDP) and its fluxes from different coastal ecosystems (seagrass ecosystems and brackish water lagoon) of South India to the Bay of Bengal. The results show a strong spatial variability in nutrient distribution and highlight the effects of anthropogenic land-based input. There was a consistent decline in nutrient concentration from freshwater reaches to the Bay of Bengal, displaying a strong negative correlation (-0.99) with surface water salinity. Other factors that probably influence nutrient distribution in the coastal ecosystems include: i) phytoplankton primary productivity and ii) nutrient utilization by phytoplankton (N: P ratio) and iii) dissolved oxygen (O_2) content. Here, we review some of the major processes, transformations and fluxes of nitrogen in the coastal and marine ecosystems, occurring both naturally and as an effect of human perturbation in a seagrass ecosystem.

Keywords: Biogeochemistry, Nitrogen, Seagrass, Oceanic systems

6. Observed Sea Level Rise along the Coasts of the North Indian Ocean[#3]

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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 guage records have given estimates of about 1.7mm/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 guage 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 Harbour (Kolkata), vary between 1 to 2 mm/year. The tide guage at Diamond Harbour is located in the delta region, which is known to undergo subsidence (Goodred 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 found to be consistent with global estimates, with an average of about 1.30 mm/year.

Keywords: Sea level rise, tide guage records

7. Sea Level Changes Along the Indian Coast: Observations and Projections[#2]

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Sea level changes can be of two types: (i) changes in the mean sea level and (ii) changes in the extreme sea level. The former is a global phenomenon while the latter is a regional phenomenon. Estimates of mean sea level rise made from past tide gauge data at selected stations along the coast of India indicate a rise of slightly less than 1 mm/year; however these estimates need to be corrected by including the rates of vertical land movements, whose measurements are not available at present. Simulation results of a regional climate model, HadRM2, were analysed for the northern Indian Ocean to provide the future scenarios of the occurrence of tropical cyclones in the Bay of Bengal for the period 2041–60. These model simulations consist of a control run with concentration of CO_2 kept constant at 1990 levels and a perturbed run with transient increase in the concentrations of CO_2 (GHG) according to the IS92a scenario for the period 2041–2060. The simulation results show increase in frequencies of tropical cyclones in the Bay, particularly intense events during the post monsoon period, for the increased GHG run. A storm surge model was used to compute the surges associated with the cyclones generated by the climate model. The storm surge model was forced by the wind field from HadRM2 over the model domain and tides prescribed along the open boundary from a global tidal model. The frequency of high surges is found to be higher in the model run forced by winds from increased GHG run than in the model run forced by winds from the control run.

8. Impact of Global warming on marine fisheries and Ecosystems

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This paper explains the impact of global warming on marine environment and its various components under different projected scenarios. The recent changes in the trends of ocean atmospheric systems are indicated as rapid manifestation of the impact of global warming and climate change. The changes in fish species composition, distribution, regime shifts, changing pattern of migration and cycle of reproduction are explained with examples in the background of relevant oceanographic factors. The impact of sea surface temperature rise and sea level rise on protected organisms like corals and turtles are explained. The socioeconomic impact on the coastal fishing communities depending on marine fisheries for livelihood is also touched upon. The uncertainty of predictions is underlined before suggesting a precautionary approach to adaptation and mitigation. The need for reducing carbon emission by adopting a low carbon life-style by global community is reiterated and some measures to mitigate the impact are suggested as conclusion.

9. Global Warming and its impact on the chemistry of the oceans

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The earth's atmosphere along with certain gases called as greenhouse gases absorbs the infrared energy emitted by the earth and warms the atmosphere just like a greenhouse. Carbon dioxide is an important green house gas. The release of carbon dioxide into the atmosphere is mainly due to the burning of fossil fuels such as oil, coal and natural gases. Pre-industrial level of carbon dioxide was about 280 parts per million by volume (ppmv), and current level is about 370 ppmv. CO_2 moves between the atmosphere and the ocean by molecular diffusion due to difference in CO_2 gas pressure (pCO_2) between the atmosphere and oceans. The conversion of CO_2 gas into non-gaseous forms such as carbonic acid, bicarbonate and carbonate ions effectively reduces the CO_2

gas pressure in the water, thereby allowing more diffusion from the atmosphere. The ocean's daily uptake of 22 million tonnes of carbon dioxide is starting to have a significant impact on the chemistry and biology of the oceans. Both the hydrographic surveys and modelling studies reveal that the chemical changes in seawater resulting from the absorption of carbon dioxide are lowering the seawater pH by about 0.1 units from an average of about 8.21 to 8.10 since the beginning of the industrial revolution. The interaction between CO_2 and seawater reduces the availability of carbonate ions, which play an important role in shell formation for a number of marine organisms such as corals, marine plankton, and shellfish. A global reduction in dissolved O_2 is predicted by ocean general circulation models (OGCMs) driven by increasing greenhouse gases. Trace element cycles also influence the biological and carbon cycle response to global warming. Warming of the oceans could destabilise methane hydrates below the ocean floor, the sudden release of which 50 million years ago may have caused the sudden global warming and its associated mass extinction. Scientific coordinated efforts are needed to understand the chemistry and biology of the oceans in order to mitigate the adverse effects of climate change.

VII. Water resources and climate Change

1.Assessment of Water Resources Availability in the Brahmani Basin under Climate Change Scenarios: A Distributed Hydrological Modeling Approach

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Changes in global climate may alter hydrologic conditions and have a variety of effects on human settlements and ecological systems. The effects include changes in water supply for domestic, irrigation, industrial and recreational uses; in instream flows that support aquatic ecosystems, hydropower, navigation etc.; and in the frequency and severity of floods and droughts. This paper presents the results of distributed hydrological modeling to assess the impact of climate change in temporal variability in water resources availability under climate change scenario in the Brahmani basin, which is located in the eastern part of India and is spread over the states of Orissa, Jharkhand and Chattisgarh. The Precipitation Runoff Modeling System (PRMS) (Leavesely *et al.* 1983), which is a distributed parameter, physical process based watershed model, is used in this study. Distributed parameter capabilities of the model are provided by partitioning the watershed into units, using characteristics such as slope, elevation, aspect, vegetation type, soil type, and precipitation distribution. Each unit, termed as hydrologic response unit (HRU) is assumed to be homogenous with respect to its hydrological response and to the above listed characteristics. Using DEM along with soil and land use layers, the entire basin was delineated into 66 spatially distributed HRUs. The calibration and validation of the model by matching the observed and simulated streamflow on annual, monthly and daily basis for showed a good agreement between observed and simulated streamflow at Jenapur. The coefficient of determination and modeling efficiency (Nash-Sutcliffe coefficient) (ASCE, 1993) was found to be 0.96 and 0.90, respectively during calibration phase, and 0.99 and 0.98 respectively during validation phase. Further, ssensitivity analysis was carried out by varying the temperature (1 to 4°C) and precipitation (-10 to 10%) showed that the stream flow in the basin is more sensitive to change in rainfall than change in temperature.

2. Impact of Climate Change (Drought) on Water Use Efficiency of Groundnut (*Arachis hypogaea* L.) Genotypes

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Agriculture of any kind is strongly influenced by the availability of water. Climate change will modify rainfall, evaporation, runoff, and soil moisture storage. Changes in total seasonal precipitation or in its pattern of variability are both important. The occurrence of moisture stress during flowering, pollination, and grain-filling is harmful to most crops. Increased evaporation from the soil and accelerated transpiration in the plants themselves will cause moisture stress; as a result there will be a need to develop crop varieties with greater drought tolerance. Promoting farming practices that withstand climate variability - the use of drought-resistant crop varieties, for instance, or more efficient use of water resources - also builds up farmers' capacity to adapt to long-term change.An increase in the frequency of droughts, declining water tables and increased cost of irrigation prompted us to revaluate water management of peanuts. Where irrigation is possible, higher yields of peanuts have been achieved and there has been a substantial increase in areas of irrigated peanuts in India. Water is essential for crop production and best use of available water must be made for efficient crop production and higher yields. But information is limited about the effects of varied water supply at different growth phases on crop water use, growth and development. However, moisture stress does not affect these processes equally as some are highly susceptible while others are far less affected to increasing water stress (Straw and Laing, 1968). Keeping these points in view a study was undertaken to study the influence of drought stress on water use efficiency and yield in groundnut genotypes.

3. Changing Streamflow Patterns in the Rivers of North Western Himalaya: Implications of Global Warming in the 20th century.

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The results of trend analyses of the discharge data of four rivers in northwestern Himalaya, namely Beas, Chenab, Ravi and Satluj, are presented here and the impact of climate change in the last century is discussed. In the case of Sudluj river, studies indicate an episodic variation in discharge in all three seasons on a longer timescale pf about 82 years (1922-2004). Statistically significant decrease in the average annual and monsoon discharge and insignificant increase in winter and spring discharge, despite increasing temperatures during all the three seasons can also be seen. Decreasing discharge during winter and monsoon seasons in the post-1990 period, despite rising temperatures and average monsoon precipitation strongly indicates decreasing contribution of glaciers to the discharge and their gradual disappearance. On a shorter timescale of the last four decades of the 20th century, barring the Beas river, which shows a significantly decreasing trend, the other three rivers have shown a statistically insignificant change (at 95 % confidence level) in their average annual discharge. Annual peak flood discharges show significant increasing trends in the Satluj and Chenab basins, significant decreasing trends in the Beas river and insignificant trend in the Ravi river. Notwithstanding these variations the studies indicate an increase in the number of 'high-magnitude flood' events in the rivers in northwestern Himalaya in the last three decades.

4. Climate change impact assessment on hydrology of Indian river basins[#2]

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As part of the National Communication (NATCOM) project undertaken by the Ministry of Environment and Forests, Government of India, the present study has been taken up to quantify the impact of the climate change on the water resources of Indian river systems. The study uses the HadRM2 daily weather data to determine the spatio-temporal water availability in the river systems. A distributed hydrological model namely SWAT (Soil and Water Assessment Tool) has been used. Simulation over 12 river basins of the country has been made using 40 years (20 years belonging to control or present and 20 years for GHG (Green House Gas) or future climate scenario) of simulated weather data. The initial analysis has revealed that under the GHG scenario, severity of droughts and intensity of floods in various parts of the country may get deteriorated. Moreover, a general reduction in the quantity of the available runoff has been predicted under the GHG scenario. This paper presents the detailed analyses of two river basins predicted to be worst affected (one with respect to floods and the other with respect to droughts).

5. Water resources and climate change:An Indian perspective

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In recent times, several studies around the globe show that climatic change is likely to impact significantly upon freshwater resources availability. In India, demand for water has already increased manifold over the years due to urbanization, agriculture expansion, increasing population, rapid industrialization and economic development. At present, changes in cropping pattern and land-use pattern, over-exploitation of water storage and changes in irrigation and drainage are modifying the hydrological cycle in many climate regions and river basins of India. An assessment of the availability of water resources in the context of future national requirements and expected impacts of climate change and its variability is critical for relevant national and regional long-term development strategies and sustainable development. This article examines the potential for sustainable development of surface water and groundwater resources within the constraints imposed by climate change and future research needs in India.

Keywords: Climate change, groundwater recharge, hydrology, run-off, water resource.

6. Impact of Climate Change on Water Availability and Crop Production[#7]

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Irrigation water withdrawals account for almost 70% of global water withdrawals and 90% of global consumptive water use. In most countries of the world, water use has increased over the last decades due to demographic and economic growth, changes in lifestyle, and expanded water supply systems. Water use, in particular irrigation water use, generally increases with temperature and decreases with precipitation. Detailed analysis of the climate change on area and productivity of crops in Tamilnadu state using Ricardian type of models along with the GOAL programming results has been done to study the impact of climate change

7. Climate and water resources of India

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We attempt to synthesize available quantitative, precisely dated and high-resolution palaeorecords of the South Asian summer monsoon from different natural archives, highlighting their similarities and differences. We distinguish between the palaeorecords of monsoon winds and monsoon rainfall and underscore the importance of quantitative rainfall reconstruction using the amount effect in monsoon rainfall, which has been demonstrated based on actual measurements. Predicting the future of water resources of India in the context of Global Change, intimately coupled with the variations of monsoon, depends on how well we understand the palaeomonsoon.

Keywords: Climate, global change, palaeoclimate, water resources.

8. Seasonal Influence on Water Productivity of Rice Hybrids under SRI Strategy

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Rice is a profligate user of water. Irrigated rice culture consumes more than two thirds of the available water. More than 5 tonnes of water is needed to grow one kilogram of rice. Water use efficiency of rice is only 3.7 kg/ha/mm (Subbian *et al*., 2000) which is the lowest compared to any other cereal crop. Opportunities for the development of new water resources are dwindling. If food security must be maintained, ways of increasing the productivity of water must be explored. Water saving irrigation in SRI strategy is a step forward to achieve enhanced water productivity in rice ecosystem. The current research focuses on the seasonal impact in water productivity of two rice hybrids, CORH 2 and ADTRH 1, both cultivated adopting SRI strategies

9. Impact of Climate Change on Rainfall, Rainy days, Run off and Soil Loss in Selected Watersheds of India during 21st Century

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The climate change now is the reality during 21st century not only throughout the globe but in our country too. The increased CO_2 concentration (this is the basic/primary climatic parameter which has been universally accepted to increase substantially and which triggers other climatic parameters viz. temperature, rainfall, humidity and sunshine hours etc to vary both: temporally and spatially) is responsible for causing changes in temperature and rainfall – the crucial climatic parameters for evapo-transpiration, runoff and soil loss.

Runoff and soil loss as we all understand is very important for crop management. Both, the runoff and soil loss are affected by rainfall and its characteristics, soil and its characteristics, land topography (length and degree of slope), crop cover and its management, supportive land and water management practices prevailing all over the area of study. Knowledge and information of these parameters is therefore necessary to assess/compute runoff and soil loss for the study locations. Under this study the projected daily rainfall of seven watersheds located in different agro-ecological regions of the country having an area of 491 ha to 816 ha was obtained from Indian institute of Tropical Meteorology (IITM), Pune on a pixel size of $0.44^0 * 0.44^0$ run under Regional Circulation Model (RCM; PRECIS; generated from GCM of HADCM3 for A2a Scenario) for the period of 1961-1990 and 2071-2100. These data were analyzed and run off and soil loss was assessed for all the 7 watersheds using soil conservation service (curve number method) method and AVSWAT respectively.

VIII. Health and Climate Change

1. Global warming and human health

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A warmer world is in all likelihood going to be a sicker world for everything from plants, animals to human beings. What is more surprising is the fact that climate sensitive outbreaks are happening with so many different types of pathogens, viruses, bacteria, fungi and parasites. The number of disease incidence increase is astonishing. The pathogens and their carriers are sensitive to climate and will have an adverse effect on disease rates. Warmer winters could reduce seasonal die – off of many pathogens and their carriers and allow them to move into areas that were previously too cold. Other possibilities include the spread of pathogens that thrive on warmer water, the joining of pathogen and potential hosts populations previously separated by climate factors. According to Intergovernmental Panel of Climate Change (IPCC), the global mean temperature could increase by 1.4^{o}C to 5.8^{o}C between 1990 and 2100. The climate effects of such a temperatures increase might include. More frequent extreme high maximum temperatures and less frequent extreme low minimum temperatures, An increase in the variability of the climate, with changes to both the frequency and severity of extreme weather events, Alterations to the natural biological range of certain infectious diseases, Rising sea level , In August 2003, the temperature peaked at about 40^{o}C in France, unprepared for that kind of heat, many people, mostly the sick and elderly were vulnerable and nearly 15,000 died. That summer was scorching in Europe, it might have claimed as many as 35,000 lives. Northern countries with severe winters have a high mortality rate in winter because more sick and elderly people succumbs in cold weather and because extreme cold create dangerous conditions in which accidental deaths are more likely. Computer models generated indicate that the future climate will be more variable and that droughts and floods will be more severe. Some of the health effects of weather related disasters besides damage to property and injury to people, Increases in psychological stress, depression and feelings of isolation among people affected by natural disasters, Decrease in nutrition due to poor agricultural yields and problems of food distribution.

2. Climate Change and its Environmental Impacts[#3]

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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 cliamte 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[1] 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 morality 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 diarrohoea.

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 environmental water demands, rainfall and precipitation etc.;
- Aberrations in flooding patterns, desertification etc;
- Impact of rising sea-levels on coastal lands;
- Impact of 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 socio-economic routes and linkages with the health impacts. Then, different ecosystems will have different kind of impacts of 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 adapatability;
- 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-chemicals cycles and their resultant impacts on human health.

Key words: Climatic variability, global warming, population dynamics, wind patterns

3. Climate change and malaria in India[#2]

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The focus in this paper is to understand the likely influence of climate change on vector production and malaria transmission in India. A set of transmission windows typical to India have been developed, in terms of different temperature ranges for a particular range of relative humidity, by analysing the present climate trends and corresponding malaria incidences. Using these transmission window criteria, the most endemic malarious regions emerge as the central and eastern Indian regions of the country covering Madhya Pradesh, Jharkhand, Chhatisgarh, Orissa, West Bengal and

Assam in the current climate conditions. Applying the same criteria under the future climate change conditions (results of HadRM2 using 1S92a scenario) in 2050s, it is projected that malaria is likely to persist in Orissa, West Bengal and southern parts of Assam, bordering north of West Bengal. However, it may shift from the central Indian region to the south western coastal states of Maharashtra, Karnataka and Kerala. Also the northern states, including Himachal Pradesh and Arunachal Pradesh, Nagaland, Manipur and Mizoram in the northeast may become malaria prone. The duration of the transmission windows is likely to widen in northern and western states and shorten in the southern states. The extent of vulnerability due to malaria depends on the prevailing socio-economic conditions. The increase or decrease in vulnerability due to climate change in the 2050s will therefore depend on the developmental path followed by India. Therefore it is important to understand the current adaptation mechanisms and improve the coping capacities of the vulnerable section of the population by helping to enhance their accessibility to health services, improved surveillance and forecasting technologies.

IX. Technologies and Climate Change

1. Alternate Fuel Options for Transport sector in the Global Warming Context[#4]

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As far as transport systems are concerned we look forward to systems which are efficient use less energy to transport more- and affordable. Transportation has long been at the forefront of the research, development, and demonstration of alternatives to traditional fossil fuel powered systems. Alternative fuels are of interest since they can be refined from renewable feedstock, their emission levels can be much lower than those of conventional petrol and diesel engines. Today the alternative fuelled engines can be modified or retrofitted engines that were originally designed for petrol or diesel fuelling. They are, therefore not the optimum design for the other fuels. The energy density of alternative fuels by volume is less than gasoline or diesel fuel and thus the cost of alternative fuel per unit of energy delivered can be greater than gasoline or diesel fuel. Hence extensive research are required to make such systems viable. However, the R&D is difficult to justify until the fuels are accepted as viable for large numbers of engines. This paper focuses on the different options available LPG (Propane), Natural gas(CNG), Alcohols (methanol and ethanol), DME, F-T Fuel, Bio-Diesel and Hydrogen. The development in these areas, challenges, advantages, disadvantages, sustainability, affordability and their impact on environment will be presented in detail. Typical phases of vehicle propulsion technologies for transport vehicles such as Concept development, technology research and development, vehicle development, - design, and integration, manufacturing and assembly integration, - vehicle demonstration, testing, and preproduction, deployment, marketing, and support are explored.

2.Wind Energy to mitigate Global warming

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The ancient scientific men of India classified wind as one of the five elements of nature. They used the power of wind to sail around the world in ships. There is evidence in the Arthasasthra to show that windmills were used around 400 BC for lifting water. Even now, in India, many poor fishermen depend on wind driven boats for their living. With the expansion industrialization, man began to experiment with various forms of energy. Experience shows that electricity is a very handy form of energy. But electricity is not available for being directly tapped from nature. It has to be produced by burning of coal, oil, gas and, of late, by nuclear reaction. India depends, mostly, on thermal power produced from burning of coal. When coal is burnt in thermal power stations, large volume of CO_2 escapes into the atmosphere leading to global warming. Therefore, alternative forms of power generations have been thought of for long. Wind energy is one of the clean forms of energy. India is the fourth largest producer of electricity from wind energy in the world. The installed capacity of wind turbines in India is 8000 MW, almost five times the capacity of Tuticorin thermal power station. Every unit of electricity generated from a wind turbine results in a saving of roughly one kg of CO_2. Tamil Nadu alone generates more than 6000 million units of electricity every year. The extent of relief that wind turbines give to mitigate global warming may be just imagined and appreciated.

3. Solar thermal technology: A sustainable means to mitigate global warming

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Solar energy is the most promising renewable source of energy. It is abundant and is well distributed all over the country making it the prime choice. It can be used by converting it into heat energy. In fact, the fossil fuels used at present to produce heat energy release significant amount of sulphur dioxide, nitrogen oxides, carbon monoxide, particulate matter and green house gases into the atmosphere. While the emitted gaseous and particulate pollutants cause the local effects like decline in human health, decrease in agricultural production and decrease in the economic and aesthetic values of the materials, the green house gases cause the global effects like global warming, sea level rise and climate change. By utilizing the solar thermal gadgets in energy intensive sectors, the emissions of gaseous and particulate pollutants as well as green house gases can be mitigated. It is imperative at this juncture to understand the working principle, characteristics of the components and thermal performances of the solar thermal devices along with their application avenues so that they can be effectively utilized as per the temperature and performance requirements of the end users. In this connection, the present research paper presents mainly the thermal characteristics and performances of the solar thermal gadgets like solar water heating systems, solar air heating systems, solar cookers and solar desalination systems in various application sectors. The experimental investigation on solar fluid heating and cooking systems shows that these systems possess satisfactory thermal performances with the additional benefits of energy savings, mitigation of pollutant emissions and minimum pay back periods. On the basis of the present experimental investigations in energy, environment and economic perspectives, it is concluded that solar thermal technology is a viable option for energy conservation, environmental protection and economic development.

4. Use of Cost-Effective Construction Technologies in India to Mitigate Climate Change.

Nilanjan Sengupta

Concentration of greenhouse gases play major role in raising the earth's temperature. Carbon dioxide, produced from burning of fossil fuels, is the principle greenhouse gas and efforts are being made at international level to reduce its emission through adaptation of energy-efficient technologies. The UN Conference on Environment and Development, 1992 made a significant development in this field by initiating the discussion on sustainable development under the Agenda 21. Cost-effective construction technologies can bring down the embodied energy level associated with production of building materials by lowering use of energy-consuming materials. This embodied energy is a crucial factor for sustainable construction practices and effective reduction of the same would contribute in mitigating global warming. The cost-effective construction technologies would emerge as the most acceptable case of sustainable technologies in India both in terms of cost and environment.

5. Challenges & Opportunities in Controlling Automobile Pollution for Better Environment[#4]

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Transportation is the exponentially growing source of greenhouse gases and automobile pollution is the subject of growing public awareness and concern. Different modes of transportation are affecting the climate, and it is the time to think how they could become more sustainable. Detrimental air pollution related to the traffic flow in the road and street infrastructure has reached the critical level in many Indian cities. Cars account for half the oil consumed in the United States, about half the urban pollution, and one-fourth the greenhouse gases. Carbon monoxide, Carbon dioxide, oxides of nitrogen, particulates, hydrocarbons and aldehydes are the main contributors to air pollution. These gases are released into the air by incomplete burning of these chemicals in automobiles. Planes, trains and automobiles are more than just means of transportation. They are necessities of any advanced economy. The reduction of such ambient air concentrations, because of the high level of vehicle emissions, is a prime requisite for the future sustainable use of the individual transportation vehicle. At intersections, and other disturbance points in the traffic flow, the transient driving patterns, i.e.; the decelerations and accelerations of vehicles, excessive idling at heavy traffics give substantial increase in the amounts of exhaust pollution. It is therefore necessary to pay attention to the infrastructural design aspects, when looking for ways of reducing the traffic related emission.

This paper is designed to present an overview of sources of vehicular emissions and the strategies to reduce vehicular emission in developing countries. The adaptable strategies for vehicular emission control and plan of action are also discussed. A systematic approach is also discussed about redesign of automobile's key elements using advances in electronics, software, materials, manufacturing and other techniques. An insight into pilot projects like implementation of hyper cars as alternative to the conventional fleet is also discussed. The other challenging factors influencing the automobile pollution are infrastructure development, Quality of fuel, Emission legislation, Vehicle maintenance and Public awareness. There are numerous technological advances beginning to clean up these toxic gases emitted automobiles.

However, they are going to take the cooperation of every one globally to change their ways of living.

X. Climate Change adaptation and mitigation measures

1. Assessing vulnerability to climate change: The link between objectives and assessment[#2]

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The vulnerability of developing countries to potential impacts of climate change and the options for adaptation are rapidly emerging as central issues in the debate around policy responses to climate change. In order to prioritize, design and implement interventions to adapt to climate change, it is essential to adopt a coherent and consistent set of definitions and frameworks for examining vulnerability, adaptation and adaptive capacity. In practice, a variety of definitions of vulnerability and adaptation are found in the literature. This paper uses the base of literature from the context of the coastal impacts of climate change to draw some explicit linkages between the objectives of vulnerability and adaptation assessment and the definitions used in the analysis. We find that such a linkage is helpful for identifying the nature of assessment required, and the data and information necessary. The paper concludes with some thoughts regarding directions for research with regard to vulnerability and adaptation assessment.

2. Problems with geoengineering schemes to combat climate change

Bala. G

The accelerated rate of increase in atmospheric CO2 concentration in recent years has revived the idea of stabilizing the global climate through geoengineering schemes. Majority of the proposed geoengineering schemes will attempt to reduce the amount of solar radiation absorbed by our planet. Climate modelling studies of these so called ‘sunshade geoengineering schemes’ show that global warming from increasing concentrations of CO2 can be mitigated by intentionally manipulating the amount of sunlight absorbed by the climate system. These studies also suggest that the residual changes could be large on regional scales, so that climate change may not be mitigated on a local basis. More recent modelling studies have shown that these schemes could lead to a slowdown in the global hydrological cycle. Other problems such as changes in the terrestrial carbon cycle and ocean acidification remain unsolved by sunshade geoengineering schemes. In this article, I review the proposed geoengineering schemes, results from climate models and discuss why geoengineering is not the best option to deal with climate change.

Keywords: Carbon cycle, climate change, geoengineering schemes, global warming, ocean acidification.

3. Climate Change and Forests: Making Adaptation a Reality "Setting the Stage"

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The global climate is changing; furthermore the rate of change is expected to accelerate in the 21st century. Forests systems (e.g. forest management areas, protected areas, forest-based communities) have strong linkages to climate and climate change. Effects of climate change on the forest and forestbased communities in northern latitudes in the continental interior are numerous and far-reaching, with implications to economic, social and environmental sustainability. Adaptation to climate change refers to adjustments in the ecological, social and economic systems in response to actual or expected climatic stimuli and their effects or impacts. Forests will adapt naturally to climate change, however these adaptations may not be consistent with the long-term survival of the existing ecological, social or economic systems that depend on the forest. There is need for planned adaptations in the forest sector in order to maximize benefits and minimize adverse effects of climate change. In this regard, climate simulation models do provide forest managers with useful projections of future climate scenarios to support planning and management across a range of space and time scales. A risk-based approach to climate change adaptation places climate change in a similar context to other risks faced by forest and forest-based community managers. Such an

approach:• includes the notion of the inherent capacity of an affected biophysical or socio-economic system to cope with the potential impacts of climate change, and provides a framework for a move from knowledge and understanding of climate/forest interactions (vulnerability) to proactive and planned adaptation

4. Combining climate change adaptation and mitigation measures at the local level

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The vulnerability of individuals and communities to climate change impacts is not simply determined by the location of their settlements, but also by how those settlements are serviced, how effective and capable their local governments are and to what extent communities are able to cope with climate change impacts. It is widely accepted that the poorest communities are the most vulnerable, because they lack access even to the most basic urban services placing them at a comparative disadvantage and challenging their capabilities to take on additional stresses caused by climate change. Such complex vulnerabilities require comprehensive responses that link climate change adaptation and mitigation efforts to the sustainable development of these communities enhancing their adaptive capacity. It is not sufficient to concentrate on either mitigation or adaptation, but a combination of these results in the most sustainable outcomes. Yet, these two strategies do not always complement each other, but can be counterproductive. A similar argument can be made for linking climate change adaptation with sustainable development. In order to avoid these conflicts, priorities need to be set This calls for a methodology and comparison tool to assess the most cost-effective and appropriate strategies for each community. Strategies need to be evaluated in terms of their negative consequences and priority given to those that minimize these. This article includes case studies of successful adaptation and mitigation strategies suggesting that these successes be translated into local contexts and communalized with the involvement of local authorities using participatory approaches. Successful outcomes integrate different adaptation and mitigation strategies with the overall development goals of the community through local government leadership, comprehensive planning and prioritization.

Keywords: Climate change; Adaptation; Mitigation; Vulnerability; Tools; Urban areas

5. An overview of sustainability assessment methodologies

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Sustainability indicators and composite index are increasingly recognised as a useful tool for policy making and public communication in conveying information on countries and corporate performance in fields such as environment, economy, society, or technological improvement. By visualizing phenomena and highlighting trends, sustainability indicators simplify, quantify, analyse and communicate otherwise complex and complicated information. There are number of initiatives working on indicators and frameworks for sustainable development (SD). This article provides an overview various sustainability indices applied in policy practice. The paper also compiles the information related to sustainability indices formulation strategy, scaling, normalisation, weighting and aggregation methodology.

Keywords: Sustainable development; Sustainability indicators; Index; Composite index; Ratings

6. Adaptation & Mitigation Initiative to the Challenges of Global Warming — Uttarakhand Perspective[#4]

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In the background of IPCC reports and the relevance of National Missions on Climate Change to Uttarakhand, the key vulnerabilities for the state have been identified in the paper. The adaptation and mitigation initiatives to the challenges of Global Warming from Uttarakhand perspective have been included sector wise. Important sectors include Forestry, Water Resources, Eco-systems and Biodiversity, Non Timber Forest Produce, Eco-tourism, Energy and Housing sectors. The paper further focuses on sector wise initiatives towards meeting the global warming challenges for Uttarakhand on one hand and ensuring sustainable development on the other end. The important and

critical interventions include generation of livelihood options through community involvement by way of sustainable management of forests & natural resources with the active delivery based networking of Van Panchayats. The initiatives in the paper provide an opportunity to strategically manage the challenges of global warming. Key initiatives discussed in the paper are rehabilitation of degraded forests with focus on mixed species, community involvement in rejuvenation of broad leave oak forests, pragmatic use of pine needles & lantana for forest fire management and meeting energy needs, developing bio-fuel plantations on degraded land, bringing industrial and urban areas under green cover along with waste management, soil conservation and water & harvesting through revival of traditional & scientific knowledge, generation of additional income for community, and Appropriate Rangeland management in alpine areas with emphasis on shrubs of high medicinal value. Other mitigation interventions suggested in the paper are support to private tree-shrub growers, maintaining habitat integrity by rationalizing protected area boundaries, improving energy efficiency performance, extending wood product life cycle, and multi-stakeholder partnerships for eco-friendly tourism.

7. Human Dimensions of Climate Change: Geospatial Perspective[#3]

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Climate change is a cumulative impact of the anthropogencially 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 patters 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 corals 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.

Keywords: Climate Change, ecological footprints, change models, biodiversity

8. Bamboo Resources, People and the Environment[#4]

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Bamboo is considered as one of the world's best sustainable natural resources. With a growth rate of up to a meter or more per day, bamboo holds the world record as the fastest growing plant. In Asia, the major bamboo producing countries are India (almost 11.4 million hectares) and China (over 5.4 million hectares), followed by Indonesia (2 million hectares) and the Lao People's Democratic Republic (1.6 million hectares). India accounts for roughly half the total area of bamboo reported for Asia and, together with China, approximately 70 percent. There are over 111 genera of bamboo with about 1575 species globally and distributed in many countries. About 134 species belonging to 18 genera have been described from Indian sub-continent. Bamboo is able to adapt to a wide variety of ecosystems and climatic conditions. China has the highest bamboo biodiversity in Asia, with over 500 species.Bamboo has so many amazing qualities and greater interest which will lead to more bamboo forests and plantations which is a bonus for the environment and the health of our planet. Bamboo takes in nearly 5 times the amount of greenhouse gasses, and produces 35% more oxygen, making it an efficient replenisher of fresh air Some bamboo even sequester up to 12 tons of carbon dioxide from the air per hectare. Bamboo can also lower light intensity and protects against ultraviolet rays. Bamboos play an important role in local economies throughout the world and are of major national and international commercial importance in the Asia-Pacific region. The commercial consumption of bamboo globally is worth around $10 billion, which is expected to reach $20 billion by 2015. India's share in the global market is estimated to be $1 billion and is expected to increase to $5.7 billion by 2015. Worldwide, more than 2.5 billion people trade in or use bamboo. The international market in bamboo products is worth more than US$2 billion per year, as much as American beef. Bamboo related industries already provide income, food, and housing to over 2.2 billion people worldwide.Bamboos are traditionally important raw material for housing, tools and other implements, musical instruments and other handicrafts. Due to modern technological advances bamboos have become important in world markets in the form of pulp for paper, parquet, ply bamboo and as a canned vegetable. They are also of great conservation significance because of their own diversity and because of the animal species that depend on them, the best known being the Giant Panda. Despite the economic, social and conservation significance of bamboos, data on bamboo distribution and resources, especially in natural forests, are very limited.

XI. Green House Gas and Climate Change

1. Spatial pattern of methane emissions from Indian livestock

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Methane is an important greenhouse gas which significantly contributes to global warming. Livestock is a major anthropogenic source of methane emission from agriculture. India possesses the world's largest livestock population of 485 million, with a high degree of diversity in its composition. Among the livestock categories, cattle dominate with 38.2% followed by goat (25.7%), buffalo (20.2%), sheep (12.7%) and others (3.3%). The detailed state/district-level methane emission inventory by age-groups, indigenous and exotic breeds of different livestock categories was estimated using the country-specific and Indian feed standard based emission coefficients and recent livestock census 2003. The total methane emission from Indian livestock, which includes enteric fermentation and manure management, was 11.75 Tg for 2003. Enteric fermentation accounts for 10.65 Tg (~91%) compared to 1.09 Tg (~9%) by manure management. Dairy buffalo and indigenous dairy cattle together contribute 60% of the total methane emission. The three high methane emitter states are Uttar Pradesh (14.9%), Rajasthan (9.1%) and Madhya Pradesh (8.5%). The detailed district-level spatial analysis in GIS environment resulted in the identification of clusters of districts with high emissions. Among these, Mednipur District (West Bengal) reported the highest total methane emission of 0.12 Tg. Using the remote sensing-derived livestock available feed/fodder area, the average methane flux from Indian livestock was computed as 74.4 kg/ha.

Keywords: Enteric fermentation, livestock census, manure management, methane emission coefficient.

2. Methane Emissions from a Coastal Lagoon: Vembanad Lake, West Coast, India

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An attempt has been made to estimate methane fluxes from a tropical coastal wetland the Vembanad Lake, a lagoon along the West Coast of India. It has been found that Vembanad Lake contributes significant amount of methane to the atmosphere. Average emissions varied spatially within the lake. Methane emissions were 193.2±24.5 $mgm^-2\ h^-1$ at Kumaragam (fresh water) as compared to 9.3±9.6 $mgm^-2\ h^-1$ at Pullot (brackish water) site. Seasonal variation was significant between pre- and post-monsoons. Soil temperature, time of the day, salinity sediment organic carbon, all controls the rate of methane emissions from the Vembanad Lake.

Keywords: Methane emission; Variation; Coastal; Vembanad; Wetland

3. Greenhouse Gas Emissions from Municipal Solid Waste Management in Indian Mega-Cities: A Case Study of Chennai Landfill Sites

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Municipal solid waste generation rate is over-riding the population growth rate in all mega-cities in India. Greenhouse gas emission inventory from landfills of Chennai has been generated by measuring the site specific emission factors in conjunction with relevant activity data as well as using the IPCC methodologies for CH_4 inventory preparation. In Chennai, emission flux ranged from 1.0 to 23.5 mg $CH_4\ m^-2\ h^-1$, 6 to 460 µg $N_2Om^{-2}\ h^{-1}$ and 39 to 906 mg $CO_2\ m^2\ h^{-1}$ at Kodungaiyur and 0.9 to 433 mg $CH_4\ m^{-2}\ h^{-1}$, 2.7 to 1200 µg $N_2Om^{-2}\ h^{-1}$ and 12.3 to 964.4 mg $CO_2\ m^{-2}\ h^{-1}$ at Perungudi. CH_4 emission estimates were found to be about 0.12 Gg in Chennai from municipal solid waste management for the year 2000 which is lower than the value computed using IPCC, 1996 [IPCC, 1996. Report of the 12th session of the Intergovernmental Panel of Climate Change, Mexico City, 1996] methodologies.

Keywords: Methane (CH_4); Carbon dioxide (CO_2); Nitrous oxide (N_2O); Landfill; Open dumping

4. Tidal Dynamics and Rainfall Control N_2O and CH_4 Emissions from a Pristine Mangrove Creek

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Dissolved CH_4, N_2O, O_2, and inorganic nitrogen nutrients (NH_4^+, NO_3^- and NO_2^-) were measured over tidal cycles in pristineWright Myo mangrove creek waters during dry and wet seasons. Dissolved CH_4 and N_2O showed no seasonality (dry season; 491 ± 133 nmol CH_4 l_1, 9.0 ± 2.3 nmol N_2O l_1, wet season; 466 ± 94 nmol CH_4 l_1, 8.6 ± 1.3 nmol N_2O l_1). Creek water dissolved gas and inorganic nitrogen distributions reflect sediment porewater release during hydrostatic pressure drop toward low water. Creek water CH_4 emission was suppressed by oxidation during rainfall, consistent with changes to dissolved nitrogen speciation, although N_2O emissions were unaffected. Scaling up emissions flux estimates from mangrove creek waters and intertidal sediment gives worldwide mangrove emissions_1.3_1011 mol CH_4 yr_1 and 2.7_109 mol N2O yr_1; mangrove ecosystems are thus small contributors to coastal N_2O emissions but could dominate coastal CH_4 emissions. Comparing our data with mangrove CO_2 fluxes, mangrove ecosystems could be small net contributors of atmospheric greenhouse gases.

5. Fluxes of Methane and Nitrous Oxide from an Indian Mangrove

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Fluxes of greenhouse gases, CH_4 and N_2O, were measured from a mangrove ecosystem of the Cauvery delta (Muthupet) in South India. CH_4 emissions were in the range between 18.99 and 37.53 mg/sq. m/d, with an average of 25.21 mg/sq. m/d, whereas N_2O emission ranged between 0.41 and 0.80 mg/sq. m/d (average of 0.62 mg/sq. m/d). The emission of CH_4 and N_2O correlated positively with the number of pneumatophores. In addition to the flux measurements, different parts of the roots of

Avicennia marina were quantified for CH_4 concentration. Invariably in all the seasons, measured CH_4 concentrations were high in the cable roots, with gradual decrease through the pneumatophores below water level and the above water level. This clearly indicates the transport of CH_4 through the roots. We were able to establish that CH_4 was released passively through the mangrove pneumatophores and is also a source to the atmosphere. We present some additional information on transport mechanisms of CH_4 through the pneumatophores and bubble release from the mangrove ecosystems.

Keywords: Mangroves, methane, nitrous oxide, pneumatophores.

6. Effect of Elevated Atmospheric CO_2 on Competitive Interactions Between Wheat and Associated Weeds (*Phalaris minor, Chenopodium album* and *Avena fatua*).

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The CO_2 level in the atmosphere has been rising, which is due to several human activities such as burning of fossil fuels, deforestation, industrialization, urbanization, etc. If the present trend continues, the concentration of CO_2 in the atmosphere would be around 600 ppm by the middle of the 21^{st} century. This exponentially increasing concentration of CO_2 in the atmosphere aroused considerable interest in the agricultural research due to variability in the response of plants to elevated CO_2. The balance between existing competitive interactions may also be affected by differential physiological response of crops and weeds to the elevated CO_2. Because of this differential response of the plants to the CO_2, it has been postulated that with higher CO_2 levels in the atmosphere, there may be significant alterations in the competitive interactions and certain genotypes or species may become extinct after several generations of altered competition. Many aspects of plant development are affected by $CO_{2,}$ such as, rates of germination, leaf initiation, tillering, branching flowering and senescence, all of which could affect crop/weed interaction. The present work is under taken to study the response of wheat and associated weeds [*Phalaris minor* (PHAMI), *Chenopodium album* (CHEAL) and *Avena fatua* (AVEFA)]. The experiments were conducted in Open Top Chambers (OTCs). In one chamber the CO_2 concentration was maintained at 360±20 ppm (Normal air CO_2 Concentration at the experimental site, NRCWS Jabalpur.) and in the other chamber the CO_2 concentration was maintain at 550±30 ppm by injecting CO_2 gas (commercial grade) from the cylinders (45 Kg Capacity). The CO_2 concentration was monitored and controlled using λ- T CO_2 monitor /controller .

7. Methane and nitrous oxide fluxes in the polluted Adyar River and estuary, SE India

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We measured dissolved N_2O, CH_4, O_2, NH^+_4 , NO^-_3 and NO^-_2 on 7 transects along the polluted Adyar River– estuary, SE India and estimated N_2O and CH_4 emissions using a gas exchange relation and a floating chamber. High NO^-_2 implied some nitrification of a large anthropogenic NH^+_4 pool. In the lower catchment CH_4 was maximal (6.3 ± 4.3 _ 104 nM), exceeding the ebullition threshold, whereas strong undersaturation of N_2O and O_2 implied intense denitrification. Emissions fluxes for the whole Adyar system _2.5 _ 108 g CH_4 yr_1 and _2.4 _ 106 g N_2O yr_1 estimated with a gas exchange relation and _2 _ 109 g CH_4 yr_1 derived with a floating chamber illustrate the importance of CH_4 ebullition. An equivalent CO_2 flux _1–10 _ 1010 g yr_1 derived using global warming potentials is equivalent to total Chennai motor vehicle CO_2 emissions in one month. Studies such as this may inform more effective waste management and future compliance with international emissions agreements.

Keywords: Tropical and subtropical coasts, Methane (CH_4) and nitrous oxide (N_2O) Nutrients, Methane ebullition, Denitrification, Emissions fluxes.

8. Free Air CO_2 Enrichment Technology (FACE Technology) [#3]

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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 elevations 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 sample plot, avoids many of the problems associate 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 ate 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 (Migilietta at 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).

Keywords: High CO_2, FACE technology

9. Development of Methane Emission Factors for Indian Paddy Fields and Estimation of National Methane Budget

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A state-wise assessment of methane (CH_4) budget for Indian paddies, based on a decadal measurement data across India is presented for the calendar year (CY) 1994, the base year for India's Initial National Communication (NATCOM) to the United Nations Framework Convention on Climate Change (UNFCCC), along with national trend from CY 1979 to 2006. The NATCOM CH_4 emission factors (EFs) for Indian paddy cultivation areas, generally having less than 0.7% of soil organic carbon (SOC), have been estimated as 17.48 ± 4 g m^{-2} for irrigated continuously flooded (IR-CF), 6.95 ± 1.86

g m^{-2} for rain-fed drought prone (RF-DP), 19 ± 6 g m^{-2} for rain-fed flood prone (RF-FP) and deep-water (DW), 6.62 ± 1.89 g m^{-2} for irrigated intermittently flooded single aeration (IR-IF-SA) and 2.01 ± 1.49 g m^{-2} for IR-IF multiple aeration (MA) paddy water regimes. The state-wise study for 1994 has indicated national CH_4 budget estimate of 4.09 ± 1.19 Tg y_1 and the trend from 1979 to 2006 was in the range of 3.62 ± 1 to 4.09 ± 1.19 Tg y^{-1}. Four higher emitting or ‘‘hot spot” states (West Bengal, Bihar, Madhya Pradesh and Uttar Pradesh) have accounted for 53.9% of total CH_4 emission with RF-FP paddy water regime as the major contributor. CH_4 emissions were enhanced by factors such as SOC (~1.5 times due to increase in SOC by ~1.8 times), paddy cultivars (~1.5 times), age of seedlings (~1.4 times), and seasons (~1.8 times in Kharif or monsoon than in Rabi or winter season).

10. Natural and Anthropogenic Methane Emission from Coastal Wetlands of South India

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For the first time, the methane emissions from diverse coastal wetlands of South India have been measured. Annual emission rates varied widely, ranging from 3.10 $mg/m^2/hr$ (Bay of Bengal) to 21.56 $mg/m^2/hr$ (Adyar River), based on nature of the perturbance to each of the ecosystems studied. Distinct seasonality in methane emission was noticed in an unpolluted ecosystem (mangrove: 7.38 $mg/m^2/hr$) and over a twofold increase was evident in the ecosystem that was disturbed by human activities (21.56 $mg/m^2/hr$). The wide ranges in estimate suggest that methanogenesis occurs by both natural and anthropogenic activities in these coastal wetlands. Several physical and chemical factors such as salinity, sulfate, oxygen, and organic matter content influenced methanogenesis to a large degree in each of these ecosystems in addition to individual responses to human-induced stress. For example, there was a clear negative correlation between oxygen availability (0.99), sulfate (0.98), and salinity (0.98) with CH_4 emission in the Adyar river ecosystem. Although similar results were obtained for the other wetland ecosystems, CH_4 emission was largely influenced by tidal fluctuations, resulting in a concomitant increase in methanogenesis with high sulfate concentrations. This study demonstrates that coastal wetlands are potentially significant sources of atmospheric methane and could be a greater source if anthropogenic perturbations continue at the current rate.

KEY WORDS: Methane emissions, Coastal wetlands; Mangroves; Lagoon;

11. Plant-mediated methane emission from an Indian mangrove

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Mangroves have been considered for a long time to be a minor methane source, but recent reports have shown that polluted mangroves may emit substantial amounts of methane. In an unpolluted Indian mangrove, we measured annual methane emission rates of 10 gCH4 $yr^{-}1$ from the stands of *Avicennia marina*. This rate is of the same order of magnitude as rates from Northern wetlands. Methane emission from freshwater influenced area was higher, but was lower from a stunted mangrove growing on a hypersaline soil. Methane emission was mediated by the pneumatophores of Avicennia. This was consistent with the methane concentration in the aerenchyma, which decreased on average from $350ppm_v$ in the cable roots to $10ppm_v$ in the emergent part of the pneumatophores. However, the number of pneumatophores varied seasonally. The minimum number occurred during the monsoon season, which reduced methane emissions largely. Bullition from unvegetated areas may also be important, at least during monsoon season when measured bubble fluxes were occasionally about five times as high as pneumatophore-mediated emissions.

Keywords: Mangrove, marine, methane emission, plant-mediated transport, pneumatophore

12. Methane emission modelling from wetlands and waterlogged areas using MODIS data

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In the present study, a Semi-automated Empirical Methane Emission Model (SEMEM) has been developed and used for estimation of methane from wetlands using MODIS (MODerate resolution Imaging Spectroradiometer) data. The model has two key factors, namely temperature and productivity. Area extent of different wetlands has been estimated based on knowledge-based classifier using Normalized Difference Vegetation

Index, optical bands (1, 2 and 3) with thermal channel (31 and 32) data. Land surface temperature has been generated using Split Window Method of first-order approximation. Based on the analysis of MODIS data, methane emission from wetlands has been estimated for India pertaining to the months of May and October 2005. Results show that emitted methane in May 2005 was 0.329 Tg with 29,308.27 km^2 total methane-emitting area, whereas in October 2005 the total emitted methane was 0.466 Tg with 76,340.92 km^2 methane-emitting area.

Keywords: Emission, land surface temperature, methane, wetlands.

13. Spatial and Temporal Distribution of Methane in an Extensive Shallow Estuary, South India

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Sedimentary methane (CH_4) fluxes and oxidation rates were determined over the wet and dry seasons (four measurement campaigns) in Pulicat lake, an extensive shallow estuary in south India. Dissolved CH_4 concentrations were measured at 52 locations in December 2000. The annual mean net CH_4 flux from Pulicat lake sediments was 3.7 × 109 g yr−1 based on static chamber measurements. A further 1.7 × 109 g yr−1 was estimated to be oxidized at the sediment–water interface. The mean dissolved concentration of CH_4 was 242 nmol l−1 (ranging between 94 and 501 nmol l−1) and the spatial distribution could be explained by tidal dynamics and freshwater input. Sea–air exchange estimates using models accounts only for ~13%(0.5 × 109 g yr−1) of the total CH_4 produced in sediments, whereas ebullition appeared to be the major route for loss to the atmosphere (□ 63% of the net sediment flux). We estimated the total atmospheric source of CH_4 from Pulicat lake to be 0.5 to 4.0 × 109 g yr−1.

14. Emerging Markets of Carbon Credits under International Climate Policy Treaty: Potential Gains for Smallholder Milk Producers

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The Indian dairy sector can attract projects under CDM as enteric methane emissions from bovine animals contribute significantly to the national GHG inventory. The share of agriculture sector in total GHG emissions in India is estimated to be 28% and livestock contributes more than 59% to the total emissions from agriculture. Methane is produced in herbivores as a by-product of enteric fermentation. In general, in ruminants, 8-12 percent of dietary energy is lost in form of methane. As the losses of methane represent inefficiencies and losses of energy in our current dairy production systems, it therefore stands to reason that reducing these losses will improve the efficiency of dairy farming and potentially increase milk production. Even though per head methane emission from Indian bovines are lower than the emissions from animals in developed countries, the methane mitigation projects in India under CDM should unambiguously be a welcome option. Such projects will have two fold benefits, one- increase in income of milk producers from increased milk production and two- increase foreign exchange earnings of India from sale of GHG emission reduction credits. This paper presents the emerging opportunities to gain from this development for Indian dairy sector, in general, and smallholder milk producers who contribute over 70 percent of the total milk production, in particular. The paper also focuses on the policy and research imperatives to realize this potential. The annual enteric methane emissions from bovine population in India is estimated to be about 9-10 Teragrams (Tg). Various mitigation options like improving nutrition of animals through feed additives, strategic supplementation and dietary manipulation are commercially available for increasing rumen efficiency and thereby decreasing methane emissions from enteric fermentation. Field experiments in India involving some of these options have shown encouraging results with reduction potential ranging from about 6% to 32%. The theoretical potential of dairy sector CDM projects can be gauged from the fact that achieving just a 10% annual reduction in enteric methane emissions in India would generate 18 million carbon credits (called Certified Emission Reductions (CER) under CDM projects). However, given the vast size of the country and the immense number of stakeholders that would have to be involved, a single project cannot cover the entire ruminant population to achieve these reductions. Nevertheless, even small scale CDM projects in the sector - covering a group of districts have the potential to generate reasonable amounts of CERs. In a number of districts from Andhra, Maharshtra, U.P. and W.B., there is a possibility of generating more than 2500 CERs annually from each district. In 14 out of 28 states, even a conservative coverage of 15% of bovine population for methane mitigation, has the likelihood of rendering over 1000 CERs per annum in the majority of the districts. It is amply evident that broadly, besides states from northern Himalayas, north-eastern and south coastal region, implementing a CDM project even in a small group of 5-6 districts can give substantial amount of carbon credits to the investors.

The existence of the opportunities to generate reasonable CERs from a project is evident from the above discussion, but from the point of view of project viability the cost of methane abatement is equally important. The cost estimates of various methane mitigation strategies in India show that the cost of reducing enteric methane emissions through certain options is much lower than the current market price for CERs of €3-5/t CO_2 . This implies a net earning of foreign exchange for India through methane trading together with much desired increase in productivity of dairy animals by reducing loss of dietary energy from methane mitigation. A part of the revenue earned through selling carbon credit generated in dairy sector, can be passed on either directly to the smallholder milk producers for participating in the project or can be utilized for providing support services to enhance milk production.

In order to encash on these opportunities, concerted policy and research efforts are required. The stakeholders in dairy sector need to sensitise the policy makers in this direction and make a case for explicitly covering this sector in the ambit of national strategy on CDM. The multidisciplinary research efforts involving both, the animal scientists and social scientists for cost-effective and region specific methane mitigation strategies also need to be intensified.

15. Response of Castor Bean (*Ricinus communis* L.) Primaries Yield and its Components to Enhanced CO_2 Levels[#7]

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Castor bean (*Ricinus communis* L.) is an indeterminate, non-edible oil seed crop grown in low rainfall regions of semi-arid tropics and sub tropics. Castor is drought tolerant but its productivity is low (350 kg/ha) in rainfed area and physiological knowledge on this hardy crop is limited. Castor bean (*Ricinus communis* L.) cv DCS-9 crop was raised in open top chambers (OTCs) up to the maturity of first order spikes (primaries) to study the effect of increased CO_2 levels (550 and 700ppm) on growth and yield and compared with ambient level CO_2 (365ppm) chamber control (Ch-control). The response of castor bean to 150ppm increment over and above 550ppm CO_2 was also calculated by comparing the response at 550ppm with 700ppm CO_2 levels. The CO_2 concentrations in OTCs were maintained and continuously monitored during experimental period as described by Vanaja *et al.,* (2006). Castor crop showed significant response with increased CO_2 levels i.e, 550 & 700ppm in terms of growth, biomass and yield. The observations were recorded on root and shoot lengths, leaf area, root, stem, and leaf dry weights at different growth stages along with yield and yield components of primaries. Root length and root dry weight increased throughout the crop growth period i.e., from 10 to 105 DAS. The root length under elevated CO_2 was higher at all stages when compared to Ch-control. The percentage of increase in root dry weight was 43.1 % under 550ppm and 87 % with 700ppm of CO_2 level at 20 DAS than Ch-control. Root volume showed maximum increase from 60 to 90 DAS in all the treatments. This was mainly due to the formation of more lateral roots and root hair formation under elevated CO_2 levels. Shoot length, shoot dry weight also increased from 10 to 105 DAS in all the treatments. Elevated CO_2 significantly enhanced the stem dry weight in castor. The stem dry weight increased to the extent of 18 % under 550ppm and 43.1 % with 700ppm of

CO_2 level over the Ch-control from 45 to 60 DAS. Leaf area, leaf dry weight, leaf area duration were increased from 10 to 105 DAS in all the treatments. The maximum response of leaf area to increase in CO_2 from 550 to 700ppm was at 45 DAS (38.1%). Root shoot ratio was high under elevated CO_2 levels compared to Ch-control and this could be due to the better response of root than shoot with enhanced levels of CO_2. Elevated CO_2 levels increased the crop growth rate in castor bean crop at all growth stages. The ANOVA for all the growth characters *viz*., root and shoot lengths, root shoot ratios, leaf area, root, stem, and leaf dry weights and specific leaf area were found to be significant at 550 and 700ppm CO_2 levels. The seed yield of primaries (first order spikes) was enhanced under elevated CO_2 both at 700 and 550ppm. The seed yield of primaries was more under 550ppm when compared to 700ppm and Ch-control. The other yield parameters like spike length, number of capsules/spike, spike dry weight, capsule dry weight and seed weight per spike were more under 550ppm followed by 700ppm, Ch-control. The increased CO_2 levels also influenced the quality of the castor bean oil by changing the fatty acid composition. The ricinoleic acid, which is a major constitution of castor seed, decreased under elevated CO_2 levels i.e., 700 and 500ppm than Ch-control while, the palmitic and stearic acid contents were more under 700ppm and 550ppm CO_2. Thus, it may be concluded that castor crop is positively responding to increasing CO_2 for not only biomass but also for seed yield.

16. Need for a FACE System to Evaluate Interactive Effects of CO_2 and O_3 on Plants in India[#3]

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Atmospheric carbon dioxide (CO_2) concentrations have increased dramatically since pre-industrial times and 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 (NO_x) 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 "ahamber 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 represent the accumulated dose of O_3 over a threshold of 40 ppb is computed for the region. The Indo-Gangetic plain in Northeast region of India has been found to have very high AOT40. It is of significant concern for agricultural productivity. More thatn 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

17. Raising Level of CO_2 in Atmosphere - Physiological Implications on Crops

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Climate change poses a new threat to Agriculture. The alarming rise in CO_2 concentration is one of the components that leads to climate change influences the productivity and food security of Indian sub continent. The CO_2 in lower atmosphere is continuously increasing due to the burning of fossil fuels, urbanization, deforestation and expansion of Agriculture. The rate of increase in CO_2 in quite high developed countries and moderate in developing and under developed countries. The CO_2 concentration was 205 ppm about 20,000 years ago. During past 10,000 years, it was 280 ppm. In 1958 it was 316 ppm and the present level is around 380 ppm. The CO_2 level in increasing about 1.8 ppm per year and if the trend continues, by 2100 it may touch 550-950 ppm (Colltte, 1995). The increase in CO_2 concentration along with rise in atmospheric temperature influences the photosynthesis and yield of crop plants. C_3 crops respond very well to the elevated CO_2 level. Photo respiration, a unique physiological process in C_3 crops is reduced due to the inhibition or partial reduction of RUBP oxygenase and there by increased crop yield is expected in C_3 crops (Uprety,2001). The other physiological changes due to increased CO_2 level are, alteration in stomatal aperture, increase in thickness of epidermis and size of leaf mesophyll cells. However, the elevated atmospheric temperature could increase transpiration loss of water from plants and also decreases the biomass of the crop. So, the increase in Temperature probably could accelerate the dark respiration and thereby low biomass production and subsequently low yield. Data from across the globe from simulation studies showed that the yield of wheat and rice in India could be reduced by 20-30 % due to elevated CO_2 and increase in temperature. However, the effects of increasing temperature may be advantageous in regions where crop duration are limited by low temperature. So, our future perspective is to evolve varieties that could resist high temperature particularly to night temperature with minimum respiratory loss of biomass, is likely to be more productive under new challenging environmental conditions.

XII. Energy and Environment

1. Food security: The challenges of climate change and bioenergy

R. T. Gahukar

Agriculture must supply all people with enough food to prevent widespread hunger and starvation. However food security is aggravating day by day, resulting in more number of undernourished/malnourished persons in the world. The ever-increasing population in the developing and less developed countries is also a major constraint. With climate changes in future, natural calamities (drought, flood, forest fire, fluctuation in rainfall pattern, etc.) will be a serious threat to human survival by way of availability of foods. Moreover, if food plants (cultivated and wild species) are utilized for the production of renewable liquid biofuel, there would be enormous changes in agroecosystems, destabilizing the natural balance and leading to lower productivity of food crops.

2. Energy and Environment[#4]

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The environment in which we live changes continuously due to 'natural" causes. Over which we have limited control. The seasons of the year are most evident of these changes, primarily in geographical locations with high latitudes. There are many other variations, such as the inclination of the earth's axis, sunspots and those with their origin in the Earth itself, such as volcanic eruptions, earth quakes, typhoons, floods and forest fires. Life on Earth has shown a surprising resilience in withstanding changes in the environment, and humanity in particular has adapted well to changing climate after the last glaciations some 10,000 years ago, when most of the northern hemisphere was covered by ice and snow. All the natural changes in our environment, except natural disasters, occurred slowly over long periods of time, typically centuries. Until recently humanity's actions have been of negligible importance in changing the environment, except perhaps in denuding large forest areas in Europe, China and Central and South America. After the industrial revolution at the end of the 18th century, and particularly in the 20th century, anthropogenic aggression towards the environment has become more important due to population growth, and the enormous increase in personal consumption mainly in the industrialized countries. What characterizes these environmental changes caused by humanity is that they take place in a short period of time. As a result many new problems or areas of interest in the environmental field have become the object of study and great concern.The paper discusses the positive and negative aspects of the supply and use of energy. Pollution is the principal negative aspect with local effect, such as smoke from traffic and factory chimneys; regional effects such as acid rain and oil spills, and global effects of which the main one would be the effect of green house gases.

3. Climate Change and World Peace

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The ancient scientific men of India classified wind as one of the five elements of nature. They used the power of wind to sail around the world in ships. There is evidence in the Arthasasthra to show that windmills were used around 400 BC for lifting water. Even now, in India, many poor fishermen depend on wind driven boats for their living. With the expansion industrialization, man began to experiment with various forms of energy. Experience shows that electricity is a very handy form of energy. But electricity is not available for being directly tapped from nature. It has to be produced by burning of coal, oil, gas and, of late, by nuclear reaction. India depends, mostly, on thermal power produced from burning of coal. When coal is burnt in thermal power stations, large volume of CO_2 escapes into the atmosphere leading to global warming. Therefore, alternative forms of power generations have been thought of for long. Wind energy is one of the clean forms of energy. India is the fourth largest producer of electricity from wind energy in the world. The installed capacity of wind turbines in India is 8000 MW, almost five times the capacity of Tuticorin Thermal Power Station. Every unit of electricity generated from a wind turbine results in a saving of roughly one kg of CO_2. Tamil Nadu alone generates more than 6000 million units of electricity every year. The extent of relief that wind turbines give to mitigate global warming may be just imagined and appreciated.

4. Energy and Environment[#4]

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The usage of fossil fuels in agricultural as well as in industry leads to environmental damages by polluting the atmosphere. Some of the air pollution gases produced by fossil fuels are sulphur dioxide (SO_2), nitrous oxide (NOx) and carbon monoxide (CO). In chemical and fertilizer industries, toxic gases are released. Cement and power plants spew out particulate matter. Hence the energy use has attracted huge attention in present times due to its associated global climatic impacts. Ensuring access to ample, affordable, clean and sustainable sources of energy is unquestionably one of the greatest challenges facing the present world. The integrated goals of energy security and poverty alleviation are also inextricably linked with the need to reduce harmful air pollution and address climate change. We will need a diversified approach that includes conventional, advanced and renewable energy and energy efficient technologies. These include new biofuels from nonfood crops; clean coal technologies; hydrogen fuel cell technologies; more efficient proliferation-resistant nuclear systems and fusion technology. India is pursuing a clean energy future that rises to the significant challenge before us. Our approach draws upon the best scientific research, harnesses the power of markets, fosters the creativity of entrepreneurs and works with the gross root level people to meet our duel aspirations for vibrant economies and a clean environment.

XIII. Pollution & Climate Change

1. Quantifying the Minimum Possible Aerosol Load (RSPM and SPM) in Delhi[#3]

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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 metrological factors. Sequential eight hourly aerosol samples in two size fractions ($\leq 10\mu$m known as PM_{10} & $\geq 10\mu$m known as SPM) were collected and analyzed for the elemental signatures associated with the tractor 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 Source (APCS) method. Discrete Fourier Analysis (DFT) of the resolved mass contribution 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 suggested that Delhi will register $57.5\mu g$ 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.

2. Undulation of Particulate (aerosol) Load in Ambient Environment, Driven by Early Winter Meteorology, Identification of New Anthropogenic Source, and Morphological Attributes of Carbonaceous Aerosols[#3]

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The presence of particles, also known as aerosols in atmosphere, is and ubiquitous natural trait. Morphologically, dimensionally, structurally, and chemically they mainfest 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 activity. 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 related 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

3. Distribution of PCBs, HCHs and DDTs, and their ecotoxicological implications in Bay of Bengal, India

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Analyses of environmentally persistent pollutants like polychlorinated biphenyls (PCBs), hexachlorocyclohexane (HCH) isomers, and dichlorodiphenyltrichloroethane (DDT) and its metabolites in seawater and sediment samples collected from six locations along the east coast of India were carried out using High-Resolution Gas Chromatograph with High-Resolution Mass Spectrometer (HRGC-HRMS). Sediment and water from Chennai harbour and Cuddalore fishing harbour contained higher concentration of all the compounds. The highest concentration (6570 pg/g dry weight) of total PCB was found in sediment from Chennai harbour followed by sediments sampled in Chennai (opposite to Cooum River mouth) (505 pg/g), Cuddalore fishing harbour (335 pg/g) and Mandapam (251 pg/g). Concentrations in other locations were two orders of magnitude lower than Chennai harbour. A distinct PCB distribution pattern in sediment was observed between harbours and other locations. Greater concentrations of tetra-, penta- and hexachlorobiphenyls were observed in sediments of harbours and opposite to Cooum river mouth, but in other locations lower chlorinated biphenyls (di, tri and tetra-) were more. In seawater, HCH concentration was greater than DDT, but it was quite opposite in sediments. Elevated levels of DDT in sediment were observed only at highly populated urban locations, reflecting the local usage and input of this pesticide. Based on sediment/water quality criteria/guidelines, some coastal locations of the Bay of Bengal could be designated as being polluted by DDTs and g-HCH (lindane), but not by PCBs. This investigation reveals the declining trend on the environmental burden of persistent pesticides in Indian marine environment. Data on the organochlorine concentrations found in this survey can be used as reference levels for future POPs monitoring programme.

Keywords: Organochlorine pesticides; PCBs; Seawater; Sediment; Bay of Bengal; Ecotoxicological assessment

4. Morphological Characterization of Carbonaceous Aerosols and its Role in Global Climate Change[#3]

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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. 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 adsorb 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 appropriation the source 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.

5. Mathematical Model Accounting for Generalized Eddy Diffusivities and Wind Speed[#7]

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Air pollution affects the regional and global climate both directly and indirectly. Black carbon or soot particles, has a warming effect, other particles, for instance sulphates and nitrates, may cool the climate. The current high levels of sulphates and nitrates mask the effects of climate change to some degree. The concentration distribution of the emitted pollutants, from various sources such as industrial chimneys, vehicular exhaust, power plants, nuclear and chemical plants, exhaust from satellite launch, forest fires etc., needs to be described for a wide variety of climate studies, air quality analysis, emergency preparedness, impact assessment and management, etc.In the present study, an attempt has been made to develop a mathematical model for the dispersion of a pollutant from a continuously emitting elevated source in a finite layer. The arbitrary functional form of wind speed in terms of vertical height and eddy diffusivity in terms of distance from the source in longitudinal and vertical directions are considered. The ground is assumed to be a perfectly reflecting surface. The effect of capping inversion at the top of the planetary boundary layer (PBL), where upward turbulent diffusion may cease and the pollutant become concentrated near the top of PBL, is accounted through the upper boundary conditions which is known as reflecting boundary condition. In general, the Dirac-delta function is used to represent the point source. However, due to the computational limitation associated with Dirac-delta function, the source term is approximated by a function similar to a normal distribution through one of the boundary conditions. Resulting advection-diffusion equation solved numerically using the method of finite differences. The accuracy of the employed numerical scheme has been examined by comparing the results obtained from present model with those available analytical solutions in the literature (Demuth, 1978; Sharan and Modani, 2006) for the specific forms of wind speed and eddy diffusivity. The computations have also been made using the logarithmic profile of wind speed (Stull, 1988) and the generalized functional form of eddy diffusivity from Degrazia and Moraes (1992) and Degrazia et al. (2001) in stable and unstable conditions respectively.

6. Emission Trends of Road Transport in Delhi, India in a local and Global Perspective[#3]

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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 (eg. introduction of Tata-nano car), would severly 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.

7. Historical Pollution Trends in Coastal Environments of India

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Seventeen sediment cores were collected from different coastal ecosystems of Tamil Nadu, India that include coastal lagoon (Pulicat), polluted rivers in Chennai (Adyar and Cooum), Coral reef (Gulf of Mannar) and a perennial river (Tamiraparani). Radiometric dating has been used to determine the modern sedimentation rates in these ecosystems. The Pulicat Lake and the polluted rivers (Adyar and Cooum) yield an average sediment accumulation rate of 12.34 and 7.85 mm yr^{-1}, respectively. In the Gulf

of Mannar coral reef, the sedimentation rate averages 17.37 mm yr−1, while the rate in Tamiraparani River is 11.00 mm yr−1. In the Tamiraparani River basin, the deposition rates were an order of magnitude higher when compared to the erosion rates, which may be due to bank erosion and the intense human activity. In general high rates of sedimentation observed in the coastal ecosystems not only reflect the capacity of the coastal regions as sinks for trace metals but also denote increased input of pollutants into the coastal environments in the recent past. The deposition rates of heavy metals – Fe, Mn, Zn, Cu, Cr and Ni in the depth profiles have been computed using sedimentation rates and their distribution is discussed. It can be seen that the mean deposition rates of all the measured elements in the Tamil Nadu coastal ecosystems are high compared with rates determined for the sediments of the deltaic regions of India and the Bay of Bengal.
Keywords: coastal ecosystems, India, ^{210}Pb dating, trace metal contamination, time span

8. Correlation between Ground Level Ultra-violet Radiation and Lower Atmospheric Aerosol Load in Delhi[#3]

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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} ($\leq 10\mu$m) and SPM ($\geq 10\mu$m) 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 12:00 hrs) 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.

XIV. Global Warming and climate change with special reference to India

1. Evaluation of LARS-WG for Generating Long Term Data for Assessing Climate Change Impact [#7]

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LARS-WG (**Long Ashton Research Station Weather Generator**) (Semenov & Barrow, 2002) is a 'serial' type weather generator and uses semi-empirical distributions for the generation of lengths of wet and dry day series, daily precipitation and daily solar radiation. The simulation of precipitation occurrence is modeled as alternate wet and dry series, where a wet day is defined as a day with precipitation >0.0mm (Semenov *et al.* 1998). Daily minimum and maximum temperatures are considered as stochastic processes with daily means and daily standard deviations conditioned on the wet or dry status of the day. The seasonal cycles of means and standard deviations are modeled by finite Fourier series of order 3 and the residuals are approximated by a normal distribution. In this paper an attempt has been made to test the applicability of a stochastic weather generator LARS-WG for generation of daily rainfall and temperature data for different sites located in and around the Brahmani basin. The LARS-WG is tested for ten sites (Anandpur, Gomlai, Panposh, Swampatna, Talcher, Dhenkanal, Jenapur, Chandbali, Paradip Port, and Ranchi) located in and around the Brahmani basin situated in the eastern part of India. The basin has a sub-humid tropical climate with an average annual rainfall of 1305 mm, most of which is concentrated in the Indian southwest monsoon season of June to October. For each of the 10 sites, 100 years of daily data were generated using LARSWG. Observed daily data were first used to calculate site-specific parameters. These parameters were then used by LARS-WG to generate synthetic data series. The performance of the generator was tested using number of statistical tests such as t-test for monthly means, F-test for standard deviations, and the χ^2 test for goodness-of-fit to compare the probability distributions for the lengths of wet and dry series for each season and for the distribution of precipitation for each month (Semenov *et al.* 1998).

2. Climate Change Vulnerability Mapping: A GIS Based Approach for Identifying Vulnerable Regions in India

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The changes in the climate of the earth during the past few decades have become the focus of scientific and social attention. Studies indicate that the last decade (1990-2000) across the globe have recorded the warmest years during the past century, the years, i.e. 1997, 1998 and 1999 recording more warmer conditions increasing in sequence. As a result climate change has become one of the hot topics and is considered a threat to the entire world, posing adverse impacts on the ecosystem, forests, water resources, agriculture, livelihood etc. Climate change threat is real and will affect all economic sectors to some degree, but the agricultural sector is perhaps the most sensitive and vulnerable. The impact of climate change may be felt more severely in developing countries such as India, whose economy is largely dependent on agriculture. This sector is particularly vulnerable to present day climate variability, including multiple years of low and erratic rainfall.

3. Rainfall and temperature trend analysis in the Red and Lateritic zone of West Bengal [#7]

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Due to inherent problems of water holding capacity of soil in the Red and Lateritic zone of West Bengal, the zone is very much vulnerable to any change of weather parameters (Milly, 1994; Milly and Dunne, 1994). Hence, the trend of climate change in the said zone has been assessed in the present study. Twenty rain gauge stations covering three districts (namely Bankura, Birbhum and Purulia) in the said zone were considered for the rainfall pattern study. Daily rainfall for the period of 1970 to 2000 for the months of May to November and yearly total rainfall were analysed decade wise. The monthly average of maximum and minimum temperature were analysed to determine the temperature trend. In case of rainfall data analysis, an increasing trend of yearly rainfall and shifting pattern of rainfall are observed in the said zone as a whole. The average yearly rainfall of 1990 – 2000 has been increased in the tune of 81 mm to

837 mm compared to the average of 1970-80. The rainfall during May decrease in most of the selected stations, where as in October the rainfall amount increases in 75 % cases and in November it increases in 95 % cases. Analysis of maximum temperature data shows that average monthly temperature of summer month (April – May) of 1990-2000 decrease marginally compared to that of 1970-80. The decreasing trend of maximum temperature is observed in almost all months. Only in few stations like Bankura the maximum temperature increases in the month of June, which may be due to decrease of rainfall amount in this month. The minimum temperature of the zone, as a whole shows an increasing trend. For e.g. in Bankura monthly minimum temperature in January increased by 1°C and in Asansole by 0.5°C. So, the monthly mean temperature does not show any changed pattern during the study period. The probable impact of rainfall pattern change may be envisaged on the degree of soil erosion. During the end of monsoon i.e. in October-November when the soil is already been saturated with water, little more rain will accelerate sheet erosion. By utilizing November rainfall crops with low water requirement may be adopted after kharif season. Moreover, as during prior or onset of monsoon the rainfall amount shows a decreasing trend, optimum showing window based on the changed climatic scenario should be assessed.

4. A Suggested Index for Assessment of Vulnerability of a Location to Climate Change

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With a view to develop a tool to assess the vulnerability of a region to local climate 15 criteria / vulnerability proxies as main factors relevant to reflect their impact on local climate were selected based on the opinion. Each criterion was provided with an optimum value. The value below and above the optimum were considered to indicate lesser and severe vulnerability respectively and scores were assigned accordingly. An interaction table was developed between the 15 criteria selected. By adding main factor points with interaction points for a particular region, one could assess the vulnerability nature of the region selected for studying the impacts to climate change based on the five scales framed for this purpose. A trial run was made for two locations and the results were found valid.

Keywords: Climate change, vulnerability, region, assess and empirical tool

5. Reliability and Success of Rainfall Forecasting in Different Years for Mid-Hill Sub – Humid Sub- Temperate Zone of Himachal Pradesh[#7]

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Rainfall distribution is the main factor influencing agricultural production. Farmers mainly need the accurate and reliable information on rainfall amount and distribution during monsoon season. The verification of weather forecast serves many purposes like for providing required information to the users for making decisions and for planning the sowing of crop variety i.e. early, normal or late variety. The present investigation was done to compare the medium range weather forecasting issued by NCMRWF, Noida, for Aromet Advisory Services unit-Solan with the actual rainfall recorded at of mid-hills sub-humid sub-temperate zone of Himachal Pradeshduring the last five years (2002-2006). The reliability of rainfall forecast was evaluated by using error structure using 2X2, ratio score, HK score and RMSE values for monsoon season. The results showed considerable increment in terms of HK score, ratio score and RMSE values in forecast accuracy of rainfall.

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6. Global warming: causes and concerns

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The climate change that we all are witnessing today is the outcome of the alteration in the energy balance of the climate system due to changes in the atmospheric concentrations of greenhouse gases (GHGs) and aerosols, land cover and solar radiation. Human activities since the beginning of the industrial revolution in 1750 have contributed largely to the rapid growth of global atmospheric concentrations of long-lived GHGs such as CO_2 CH_4 and N_2O (due to fossil fuel use, changes in land-use and agriculture). Based on the assessments of the Intergovernmental Panel on Climate Change (IPCC),

these human activities have not only influenced the increase of the average earth temperature, but also contributed to the risks of heat waves, changes in wind patterns, large-scale changes in land precipitation in some areas and droughts in others. Natural systems in the ocean and on land are being affected by regional climate changes, such as enlargement and increased number of glacial lakes, increasing ground instability in permafrost regions and rock avalanches in mountain regions, and changes in some Arctic and Antarctic ecosystems. It is also strongly affecting biological systems on the earth, mainly in the form of earlier timing of spring events (earlier greening of vegetation, bird migration and egg-laying). Also, marine and freshwater biological changes have been observed as a result of rising water temperatures and related changes in ice covers, salinity, oxygen levels and circulation.Other effects of regional climate changes are likely to be on agricultural and forestry management at higher latitudes of the Northern hemisphere, some aspects of human health, losses of coastal wetlands and mangroves and increase damage from flooding in coastal areas. Studies show that the current climate change mitigation policies and related practices will result in continued GHG growth over the next few decades and induce much greater changes in the global climate system than those observed during the 20^{th} century, resulting in adverse impacts on systems, sectors and regions. As far as Asia is concerned, fresh water availability, particularly in large river basins, is projected to decrease. Countries experiencing rapid urbanisation, industrialisation and economic development are likely to face greater pressure on natural resources and the environment. Last but not least is the threat of human health associated with the projected changes in the hydrological cycle.

7. Palaeoclimatic scenario during Holocene around Sangla valley, Kinnaur northwest Himalaya based on multi proxy records

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Pollen, C/N ratios and *d*13COM from a 1.2 m thick palaeolake deposit at Sangla, Kinnaur, Himachal Pradesh provide records of climatic changes during the past 10,000 years. The C/N ratios together with pollen data indicate high lake level between 10,000 and 4,000 yrs BP. Following this, an increase in *d*13C (+2‰) indicates stressed climatic

conditions, whereby *d*13COM attained a value of –23‰, being the maximum for the available record. This event is bracketed between 3500 and 1500 yrs BP. Subsequently, the lake underwent a few dry spells ca. 1000 yrs BP. Finally, it got completely desiccated around 800 yrs BP.

Keywords: Carbon isotope, C/N ratio, holocene, palaeoclimate, pollen.

8. Global climate changes and their impact on agriculture- A review in Indian Perspective

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It has been estimated that the atmospheric CO_2 had increased from 180 ppm to 300 ppm in 1,60,000 years but it took only a few decades to increase the atmospheric CO_2 from 300 ppm to 360 ppm. The Working Group-I of IPCC in their fourth report concluded that most of the observed increase in the globally averaged temperature since mid-20th century is very likely due to observed increase in the anthropogenic green house gas concentrations. The working Group II of IPCC is working on the impact, adaptation and vulnerability of global warming and the WG-II had submitted their fourth assessment report in April 2007. According to the report there are significant changes in many physical and biological systems in the world due to global warming. This was concluded based on more than 29,000 observation data series. The fourth assessment report of WG-II of IPCC contains a detailed analysis of the impacts based on several studies. Some of the impacts on agriculture as the WG-II found were:

1) Due to warmer and more frequent hot days and nights, there might be increased crop yields in cold environments and decreased yields in warmers environments as well as increased insect out breaks

2) Due to increased warm spells and heat waves the crop yields would be reduced in warmer regions.

3) Increased heavy rainfall frequencies shall cause damage to crops, increase in soil erosion and water logging conditions in the plains.

4) Due to increased drought-affected areas there will be land degradation, lower crop yields as well as increased liver-stock deaths

5) There will be increased tropical cyclone activity causing damage to crops.

6) Salinisation problems will arise in coastal areas due to increased sea level

In fact, the global scale changes are the aggregates of many regional and micro-regional changes, which might be of higher scale and more damaging to agriculture than the global estimates. In view of this it is necessary to develop comprehensive strategic planning for agricultural development in the changing climate scenario. For this purpose, it is necessary to identify the sensitive areas in different states/districts/micro-regions and make efforts for containing the same as well as adapting to the changed climate scenarios. In this paper some of these issued are discussed for proper agricultural planning at micro-regional level for sustainable agricultural development.

9. High Resolution Forecast for Farmers of Tamil Nadu using Weather Research and Forecast (WRF) Model[#7]

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The weather Research and Forecasting (WRF) model is a next-generation mesoscale numerical weather prediction system designed to serve both operational forecasting and atmospheric research needs. The National Centre for Atmospheric Research Mesoscale model version WRFV2.2 was adopted for developing high resolution forecast over Tamilnadu region. The model was built on 3:1 nested domains with horizontal resolution of 15km and 5 km for mother and nest, respectively. The initial and boundary conditions are taken from NCEP/GFS six hourly data available at 0.5° grid scale, and interpolated to the mother domain which in turn provides the same to its nest. The model is being integrated for 120 hours every day to produce four days forecast in order to coincide with Indian Standard Time. The weather parameters viz., maximum temperature, minimum temperature, relative humidity, wind speed, and rainfall are being forecasted for all the 385 blocks of Tamil Nadu using its centroid from a GIS platform. The model is run daily on a Mac Pro 2x2.66 MHz Dual-Core Intel Xeon machine fitted with 8 GB memory. The results are posted at www.agmet.tnau.ac.in/acrc/index.html as Agri Weather Bulletin using grads scripts and fortran programmes both graphically and quantitatively. This is the first attempt in India for such a high resolution forecast aimed at farmers needs and the initial forecast verification results are encouraging. The forecast is expected to help extension officials and formers of Tamil Nadu for taking tactical decisions on farm operations. Further improvement in forecast is possible when the real time weather data are ingested in to the model from Automatic Weather Station (AWS) established by Indian Space Research Organisation throughout Tamil Nadu.

10. Climate change, sustainable development and India: Global and national concerns[#2]

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Climate change is one of the most important global environmental challenges, with implications for food production, water supply, health, energy, etc. Addressing climate change requires a good scientific understanding as well as coordinated action at national and global level. This paper addresses these challenges. Historically, the responsibility for greenhouse gas emissions' increase lies largely with the industrialized world, though the developing countries are likely to be the source of an increasing proportion of future emissions. The projected climate change under various scenarios is likely to have implications on food production, water supply, coastal settlements, forest ecosystems, health, energy security, etc. The adaptive capacity of communities likely to be impacted by climate change is low in developing countries. The efforts made by the UNFCCC and the Kyoto Protocol provisions are clearly inadequate to address the climate change challenge. The most effective way to address climate change is to adopt a sustainable development pathway by shifting to environmentally sustainable technologies and promotion of energy efficiency, renewable energy, forest conservation, reforestation, water conservation, etc. The issue of highest importance to developing countries is reducing the vulnerability of their natural and socio-economic systems to the projected climate change. India and other developing countries will face the challenge of promoting mitigation and adaptation strategies, bearing the cost of such an effort, and its implications for economic development.

11. Sensitivity of some potential evapotranspiration estimation methods to climate change

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Climatic change and its impact on environment, and thus the consequent effects on human, animal and plant life, is a hot topic for discussion at national and international forums both at scientific and political levels. However, the basis for such discussions are scientific reports. Unless these are based on sound foundation, the consequent effects will be costly to exchequer. The paper of McKenney and Rosenberg (McKenney, M.S. and Rosenberg, N.J., 1993. Sensitivity of some potential evapotranspiration estimation methods to climate change. Agric. For. Meteorol., 64: 81–110.) is looked into in this context.

12. Global Warming and Climate Change in India during the Recent Hundred Years[#4]

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The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) released in early 2007 has given an account of the ongoing Global Warming scenario and its effects which include the decrease of the area covered by sea ice, loss of glacier mass and the increase of the heat content of the ocean's top 3000 metres and the consequent increase of the sea level. The average temperature of the global atmosphere just above the surface of the earth has warmed through 0.74 degrees during the 20 century. Arctic air temperatures have increased at twice the global average. The IPCC report states with a high degree of confidence that global warming since 1750 has been the net effect of human activities. All India average air temperature has increased through about 0.6 degree Celsius during the 20 century. It is comparable to the global average. The sea surface temperatures over the Arabian sea and the Bay of Bengal have shown increase during this period. The climate of India has also changed during the last 100 years. The observed change in climate has been in two ways (a) decadal change (a few decades of increase followed by a few decades of decrease, a sort of multi-decadal oscillation) and (b) long term trends, either decreasing or increasing. Monsoon onset dates over Kerala and the number of tropical cyclones per year in the Indian seas did not have any long term trend but had long period oscillations in the last 100 years. Annual number of monsoon depressions and the monsoon rainfall of south Kerala (particularly over the slopes of the Western Ghats) had strong decreasing trends. On the other hand very heavy one day rain rainfall occurrences in India and the annual number severe tropical cyclones of the Indian seas had increasing trends. The strength of the low level monsoon winds through peninsular India (the Low Level Jetstream) had a decreasing trend through about 20% during the recent 50 years of good reanalysis wind data which goes well with the observed decreasing trend in monsoon depression frequency. A new finding is that the Sea Surface Temperature of the equatorial central Indian ocean has had a phenomenal increasing trend through about 1.5 degrees Celsius in the recent 50 years which is much larger than anywhere else in the global tropics. This is feared to have adverse impact on the Indian monsoon by creating an area of increasing rainfall (and the consequent heating of the atmosphere through latent heat release) near the equator already seen through satellite observations, which will weaken the monsoon heat engine (the vertical Monsoon Hadley Cell that drives the monsoon circulation).

13. Climate Variability over Kerala During l901-2007[#4]

D.R. Kothawale and P Rorgaonkar
Indian Institute of Tropical Meterology, Pashan Pune 411008

In the context of ever increasing interest in global warming, the regional climate variability also have a acquired great importance. In view ‘it his, temperature and rainfall variability over Kerala have been studied for the period 1901-2007. In this study, Kerala state , which spread from 80 N to 12° N Latitude, have been separated in to two regions, i.e. North Kerala (North of 10° N) and South Kerala (South of 8°N). The two representative stations Kozikode and Trivandrum have been selected from North and South Kerala to examine temperature variability. Maximum temperature of North as well as South Kerala show significant warming trend in all the seasons viz., Winter, Monsoon, Post-monsoon and Annual for the period 1901-2007 and recent period 1971-2007. Annual maximum temperature of North and South Kerala have increased by 1.2° C and 1.0°C per hundred years over the period 1901-2007. While, temperature of both the regions showed accelerated warming in recent three and half decades, and increase in temperature is about 0.4°C per decade. In the ease of minimum temperature, South Kerala showed significant negative trend in all the seasons, while, North Kerala showed significant positive trend, for the period 1901-2007. However, in recent period. South Kerala showed no significant trend, it suggests the intensity of cooling have decreased. Kerala subdivision showed decreasing trend in monsoon rainfall for the period 1901-2007 and it is important to note that after 1999, rainfall of Kerala is below long term average rainfall except the year 2006, when the rainfall is just above normal.

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15. Dynamics of Global Warming

Dr.R.S.LAL MOHAN,
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The history of Global Warming is discussed and the causes of Global Warming are elaborated in detail. Global Warming is due to the accumulation of the green house gases like carbondioxide, Methane, Nitrous oxide in the atmosphere which forms as a blanket radiating back the sun rays to the earth. It also traps the sun's heat and causing the planet to warm up. The coal burning power plants produces 2.5 billion tons of Carbon dioxide every year. The automobile produces an emission of 1.5 billion tons of carbon dioxide annually. It is estimated that CO_2 has increased by 29%, methane 150% and nitrous oxide by 15 percent in the last 100 year. This has resulted in the rise of 0.4 -0.8°C degree. The sea level has also increased at the rate of 10cm to 20cm for the last 100 years. If this trend continues it will result in catastrophic changes in the ecosystems resulting in disastrous disruption in livelihood, economic conditions, living condition and human health. But we are not heeding to the warning signs. It is true that the developed countries are contributing nearly 70% of the total global emission. But the developing countries like India and China are also increasing the GHG fast. The Carbon particle and aerosols which are polluting the atmosphere can cause serious health problem like asthma and allergies as they can penetrate deep into the lungs. Global Warming is already causing damages in many parts of the U.S.A In 2002 many parts of U.S.A experienced worst wild fire. In 2003 extreme heat wave caused 20,000 deaths in Europe and 1500 death in India. Global Warming causes hurricanes and storms. The Global Warming is a complex phenomena and it is difficult to predict it fully. The impact of Global Warming in India includes steady sea level rise, increased cyclones, change in ambient temperatures and precipitation pattern. People of Sunderbans, will be affected. Himalayan glaciers will shrink affecting the water flow in Ganges & Brahmaputra. Various alternate source of energy is suggested ways and means to mitigate the impact of Global Warming is discussed.

16. Climate Change and its Impact on Natural Resources of India[#1]

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Climate describes weather conditions and is calculated from the average of 30 years of weather data. The weather is described in terms of temperature, humidity, levels and frequency of precipitation, wind, cloud cover and weather features. Climate has to play a vital role in the economic development of any country, be it developed or under developed. The impacts of climate change have spared neither the developed nor the developing nations. The climate change events that have occurred in various parts of the world bear testimony to this fact. Today America, China, Indonesia and India, in that order are considered to be four largest emitters of carbon-dioxide. Climate Scientists are very certain that Earth's climate will change at an unprecedented rate over the 21 century. India has also not been spared the impact of climate change. The country which is home to 1028.7 million people has a high population density of 344 persons per sq. km which makes areas of the country extremely vulnerable to various kinds of disasters which are bound to escalate with climate change. Another major threat that climate change poses to the country is through is impact on agriculture which would have serious effects on the economy of the country. In addition it will also have an impact on food security and health. Climate change has its impact on Agriculture, Forest Ecosystems, Water resources and on vulnerability also. The Action plan on Climate change announced by Dr. Manmohan Singh, Prime Minister on 30.06.2008 is the panacea to cure climate change challenges.

17. Global warming and its impact in transport sector[#4]

R.M. Nair
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Transport faces an increasingly difficult challenge how to meet the needs of businesses and people for more and better transport services while mitigating congestion. Reducing the number of road accidents and victims, and limiting CO_2 emissions and climate change. Transport accounts for about 20% of total CO_2 emissions, and the problem is that with motorisation growing rapidly while in other sectors such emissions are expected to decline, the transport sector is the only one in which they are expected to increase. Promoting a greater use of rail and inland water transport, now under-utilised, and improving their connectivity with road and maritime transport so that all modes can work in a much more integrated manner than today, should be a priority. Within transport the three major modes are rail, road and water; water way mode being the least polluting. One litre of fuel is known to generate 24 ton/km by road, 85ton/km by rail and 105 ton/km by inland water mode. One horse power of energy can move 1 Kg by road, 500 Kg by rail and 4000Kg bywater/IWT. For every ton/km movement of cargo by road the Carbon dioxide (CO_2) produced is 120 gm. The corresponding figures for IWT is 30gms.A shift of one billion ton/km of inland cargo from road to IWT can result in a reduction of "green house effect" by about 90000 tons of CO_2 or to generate 90000 carbon credit. India has an extensive network of inland waters consisting of rivers, canals and lakes, natural and manmade and a coast line of over 6000 kilometers, dotted with a number of major and minor ports. Inland Water Transport (IWT) represents a significant resource for India. The total length of navigable waterways in India is about 14500 kms, of which 5700 kms are navigable by mechanically propelled vessels. The major benefits of the IWT are the achievable fuel savings, reduction in environmental cost, reduction in overall cost of transportation and line cost savings. In general, to make the IWT a viable and acceptable mode, certain conditions are to be fulfilled. These relate to rationalizing tariff structures, ensuring sufficient reductions in line haul, travel time, improved safety of goods in transit and providing sufficient financial incentives to consignees and end users of the transport product by providing. The basic policy objectives of Indian IWT have 'short term' and 'long term' components. The short term objective is to effect a sizeable increase in the traffic volume, from the present level of around 1 billion tonne km to at least 20 billion ton-km within a five year period. The long term objective is to develop the full IWT potential of the country which going by successful examples of other countries - could be as much as a 5 to 8 per cent of the total national transport output. A veritable IWT revolution is thus a key component of plans to improve India competitiveness among the leading industrial nations of the world. A major spin-off benefit will be its contribution in reduction of fossil fuel consumption and reduction in CO_2 emission.

18. Hydro-climatic Variability of Wet and Dry Spells across India: 1951-2007[#4]

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Characteristics of wet spells (WSs) and intervening dry spells (DS5) are perhaps most useful information in water-related sectors. The information assumes greater significance in the wake of global climate warming background and climate change scenario projections. Features of 42 attributes of wet and dry spells as well as their extremes have been studied for 19 sub-regions across India using available daily rainfall gridded on 10 latitude x 10 longitude for the period 1951-2007. Derived from local climatology, the rainfall threshold *'daily mean rainfall of the climatological monsoon period over the area of interest'* has been applied to identify yearly wet and dry spells. The threshold shows spatial variation in the range of 2.6mm/day (extreme southeast peninsula; ESEP) and 20.2mm/day (central southern West Coast). Climatologically, the number of wet spells (WSs) varies from 4 (northwest) to 11 over ESEP, and the total duration of the WSs following similar pattern from 29 to 101 days. For individual WS the duration varies from 7-12 days. Following annual/monsoonal rainfall distribution the total rainfall of the WSs varies from 284-2130mm; the rainfall of individual WS 74-467mm and the rainfall intensity during a WS 8-37mm/day. The rainfall due to WSs contributes 47-79% to the respective annual total. The first WS starts the earliest on 20 March over the ESEP and the latest on 21-23 Jun over the northwest. The last WS ends on 12 September from northwest and on 16 December from ESEP following normal withdrawal pattern of the summer monsoon. The total duration of all the intervening DSs (3-10 nos.) varies across the country from 45-173 days and the duration of individual DS 11-22 days. Total rainfall of all DSs varies from 28-459mm, rainfall amount of individual DS 10-116mm and rainfall intensity during a DS 1-10mm/day, following annual/monsoonal rainfall spatial pattern. The percentage contribution of the rainfall due to DSs to the respective annual total varies from 10-19%. For the whole of India, the rainfalls due to WSs as well as due to DSs contribute about 85% to the annual total. In general, the wet and dry spell parameters do not show significant long term trend. Important features (total rainfall, rainfall intensity and duration, starting date) of extremes of wet as well as dry spells in respect of rainfall amount, rainfall intensity and duration

have also been examined. Changing tendencies in recent years/decades have been noticed in some isolated cases.

19. Economic impact of climate change on Mumbai, India

Rakesh Kumar†, Parag Jawale* and Shalini Tandon**

Climate change impacts will lead to economic losses for various sectors. In this paper the impacts of climate change on the financial capital of India, Mumbai, have been delineated. These include the impact of temperature rise on rains and floods, and their consequent effects on health. The other consequences such as rise in deaths from vector-borne diseases, dislocation due to floods and sea-level rise have been shown as projected economic losses for the years 2025 and 2050. The economic costs of sea-level rise in terms of loss of property along the coastline have also been projected for a 25- and 50-year timescale respectively. The costs arising due to increase in malaria, diarrhoea and leptospirosis outbreaks have been projected till 2050. The conservative estimate of total costs of all these impacts, including the impact of climate change on tourism, is found to be enormous.

20. Global Warming with special reference to India

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The earth is heated not by the insulation (short wave solar radiation). It is heated due to the absorption of long wave radiation from earth. Due to industrialization and other anthropogenic activity has resulted in production of gases which absorb longer wave radiation from earth. This has resulted in increase in global temperature and it would ultimately affect the climate. This increase in global temperature is expected to cause sea level rise, possible increase in extreme weather events, glacial retreat and increase in range of disease vectors. There are other possible adverse effects. The solution lies in adaptation to face challenge by changing our life style and efforts to reduce the generation of green house gases. Data on the climate change with special reference to Tamil nadu and India is given. Extreme values of maximum temperature in

Chennai are analysed. Graphical representation is given for the better understanding of the Phenomena.

21. Variability and Secular Changes in Climate of Arid Rajasthan[#7]

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The impact of projected climate change by IPCC (2007) is more likely in arid ecosystem than in semi-arid or sub-humid regions of India by the end of 21st Century. Arid Rajasthan which spreads in twelve western districts of the State covering 1,96,150 sq. km, is very fragile and is subjected to excessive stresses due to frequent droughts and low rainfall. The arid phase of northwest India has a history of about 3000 years (Pant and Maliekel, 1987). In the northwest India covering Punjab, Haryana, west Rajasthan and west Madhya Pradesh. There was a marginal increase in the rainfall by 141 mm and fall in air temperature by -0.52°C in the past 100 years (Pant and Hingane 1988). The studies for Jodhpur region showed that the changes in rainfall and air temperatures were not alarming, but the increase in human population (by 400%) and livestock (by 127%) during the twentieth century resulted a major shift in land use pattern and put tremendous pressure on surface and groundwater resources (Rao,1996; Rao and Miyazaki, 1997).

22. Climate change and its impact on the Himalayan glaciers – a case study on the Chorabari glacier, Garhwal Himalaya, India

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Glaciers and small ice caps in temperate environments are sensitive indicators of the change in climate. Mountain glaciers provide a valuable tool for reconstruction of Holocene climate changes. The present work, thus, deals mainly with climatic change and its impact on the Himalayan glaciers based on the dating of lichens, developed on loops of moraines formed due to various stages of advance and retreat of the glacier. Here it has been shown that the date of the largest lichen on the loop of moraine that indicates the position of maximum advance of the glacier is 258 years. It shows the period when the Chorabari glacier started receding from the point of its maximum advancement in this part of the Himalaya. Earlier work in the Dokriani Bamak (glacier) has shown that the period of retreat in the respective part of the Himalaya is around 314 years. Research on various glaciers of the northern and southern hemisphere has shown that most of them started their retreat in the mid-eighteenth century, thereby indicating the end of the Little Ice Age maximum. These results suggest that climatic changes in the world started during early to mid-eighteenth century, though this needs further work for confirmation. There is every possibility that its effect was sensed first in the zone close to the equator by the north facing Himalayan glaciers such as the Dokriani Bamak.

Keywords: Climate change, geomorphology, glaciers, lichenometry, Little Ice Age.

23. High-resolution climate change scenarios for India for the 21st century[#2]

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A state-of-art regional climate modeling system, known as PRECIS (Providing Regional Climates for Impacts Studies) developed by the Hadley Centre for Climate Prediction and Research, is applied for India to develop high-resolution climate change scenarios. The present day simulation (1961–1990) with PRECIS is evaluated, including an examination of the impact of enhanced resolution and an identification of biases. The RCM is able to resolve features on finer scales than those resolved by the GCM, particularly those related to improved resolution of the topography. The most notable advantage of using the RCM is a more realistic representation of the spatial patterns of summer monsoon rainfall such as the maximum along the windward side of the Western Ghats. There are notable quantitative biases in precipitation over some regions, mainly due to similar biases in the driving GCM. PRECIS simulations under scenarios of increasing greenhouse gas concentrations and sulphate aerosols indicate marked increase

in both rainfall and temperature towards the end of the 21st century. Surface air temperature and rainfall show similar patterns of projected changes under A2 and B2 scenarios, but the B2 scenario shows slightly lower magnitudes of the projected change. The warming is monotonously widespread over the country, but there are substantial spatial differences in the projected rainfall changes. West central India shows maximum expected increase in rainfall. Extremes in maximum and minimum temperatures are also expected to increase into the future, but the night temperatures are increasing faster than the day temperatures. Extreme precipitation shows substantial increases over a large area, and particularly over the west coast of India and west central India.

24. Economic recession and climatic change[#4]

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Developed and developing nations have been striving for achieving faster economic growth for satisfying the material wants of their people. In the pursuit of faster economic growth every nation has been more vigorously axing nature by way of burning more fossil fuels, deforestation and industrial production. These unbridled human intervention in nature lead to the more devastating issues faced by mankind such as global warming, climate change etc. Many Countries across the world are now witnessing deterioration in their economic growth owing to the turbulence in the U.S financial market initiated with the sub-prime crisis. There is substantial world faced during the Great depression in 1930s. This may lead to further Economic cycles and emission trajectories; less economic activity means lower emissions. Deutsche Bank recently forecasted that due to the looming global recession, Europe's industrial $C0_2$ emissions would fall by 100 million tones next year, compared with last year. Governments across the world are desperately trying to fight recession by injecting more liquidity in the economy through tinkering monetary and fiscal policy measures, The U.S has announced a $700 billion economic stimulus package, while China has announced a $ 586 billion package (14 percent of its GDP). The Indian Government has also announced various measures to combat the slowing economic growth and shore up confidence. The Government has announced to increase plan expenditure by Rs.50,000 crore in infrastructure. As the global economic crisis takes precedence in governmental initiatives, climate change caused by $C0_2$ emissions remains one if not “the “most serious challenges facing the world. Developing nations like India needs financial aid from developed nations to acquire cleaner technology and fight climate change. There should be a special fund for developing nations, which should not be less than 0.5 percent of the GNP.

25. Gain maximizaTion for a Few Vs Risk Minimization for All: Choice that Society will have to make to Survive this Century[#4]

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We face three tipping points today, each with the potential to pose grave risk to human society as we know it. The first is the rapid exhaustion of our primary energy sources-oil and gas, with no techno-economically viable alternative source nuclear, green, geotectonic available as a replacement. A steep energy price rise and a consequent deep global recession are predicted to happen in the near future. The second is global warming, which is expected to drastically impact the environment, human health and livelihoods within this century. And the last is the rapid deterioration of the environment and its life support systems land, water, air and biodiversity. The classic response to these issues has been to suggest technical, legal and economic fixes alternate energy sources, Kyoto Protocol, supply side management of energy. None of these will work as the global economy is based on greed, and has permitted energy accumulation on a massive scale in the hands of a few. Its consequences peak oil and climate change have interfered with the Carbon cycle to such an extent, and in such a fundamental way, that many believe that we have already crossed the point of no return, or have a very narrow window of a couple of decades to rectify the situation. Development as understood growth, equity and social justice has failed. Economic growth will slow down and even become negative with rapidly rising energy prices and climate change impacts setting in. Trickle-down theory has failed and inequity has only grown in the last 150 years. By going against the laws of nature, capitalism has become self-limiting. Sustainable development has become an oxymoron. Development must therefore be re-defined as:

- Powering down energy and natural resource throughputs in society.

• Conservation of natural capital is vital for the survival of human society and can only be done along with addressing issues related to equity, and vice versa.

• Ensuring that all people have equal: i) access to energy and other natural resources, ii) consumption levels of energy and other natural resources, iii) participation levels in decision making over all issues related to energy and natural resources.

The above can only be achieved if global thinking shifts from "gain maximization for a few people" to "risk minimization for all of life ". Implicit within the latter is the acceptance of three equities: a) between people, b) between generations, c) between species. If equity between species is accepted, it challenges the very definition of "economic value" as we understand it today. The currently anthropocentric political and sociological structures must also become bio-centric.

26. Validation of Monsoon Forecasts for the Southern Zone of Kerala

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The role of weather and climate in agriculture is a knowledge gained by man from time immemorial. However, due to the lack of a proper understanding of the dynamic relationships existing in the soil –plant – atmosphere continuum, little efforts were made in the past to exploit the weather information for a better agricultural scenario. All the key biological and physiological processes in the plants are controlled by the various weather parameters. We are facing a situation where we are under pressure to produce more from less land with less water, less resources and moreover, may be under adverse weather conditions . Indian agriculture, as it is said is a gamble with the monsoon. The spatial and temporal distribution of rainfall is decisive in the selection of crops and cropping systems for an area. From the point of view of a farmer, he will be more interested in the onset of monsoon, various amounts of rainfall likely to be received in the different stages of the crop at different probability levels. In this connection the process of rainfall forecasting assumes paramount importance. It is imperative that the medium range forecasts be validated for their accuracy (Singh et al.,1999). In this paper, attempt has been made to validate the rainfall forecasts issued by the NCMRWF as against the rainfall pattern experienced.

27. India's GHG emission scenarios: Aligning development and stabilization paths[#2]

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This paper presents emission scenarios for India, constructed following the IPCC SRES framework. Analysis spans 21st century and is centered on energy sector CO_2 emission. Scenario stories presume no explicit climate intervention; however differences in endogenous profiles of key drivers like technologies have profound indirect impact on GHG emissions. Across scenarios, aggregate emission trajectories vary significantly, thus proving that endogenous development choices are key determinants of emission paths. The paper therefore argues that development policies and actions, which alter profiles of key drivers of development, should be essential elements of climate mitigation strategies. Scenario results show that India's per capita emission during the century would rank amongst the lowest. Stabilization at a 550 ppm_v CO_2 concentration would induce significant changes in energy and technology mix and economic losses in India. Stabilization burden would be lower in scenarios where underlying development paths are sustainable. The near-term energy choices, given their path dependence, could deliver sustained development and climate benefits. Aligning development and climate actions, therefore, is advisable and feasible. The regime instruments, the paper concludes, should aim to first support endogenous climate-friendly actions and then to induce climate centric actions in addition.

28. Greenhouse gas emissions from India: A perspective[#2]

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Climate change arising due to the increasing concentration of greenhouse gases in the atmosphere since the pre-industrial times has emerged as a serious global environmental issue and poses a threat and challenge to mankind. The United Nations

Framework Convention on Climate Change enjoins upon the Parties to the Convention to protect the climate system according to their common but differentiated responsibilities. The parties to the convention are also required to report to the convention on a regular basis a comprehensive and comparable inventory of anthropogenic greenhouse gases and the steps taken to protect the climate. Towards the fulfillment of its obligations, India submitted its initial national communication to the UNFCCC in June 2004. This paper analyses the improvements made in greenhouse gases (GHG) inventory estimation reported in the Initial National Communication with respect to the earlier published estimates and highlights the strengths, the gaps that still exist and the future challenges for inventory refinement. An assessment of the current and projected trends of GHG emission from India and some selected countries indicates that though Indian emissions grew at the rate of 4 per cent per annum during 1990 and 2000 period and are projected to grow further to meet the national developmental needs, the absolute level of GHG emissions in 2020 will be below 5 per cent of global emissions and the per capita emissions will still be low compared to most of the developed countries as well as the global average.

29. The melting of the Siachen glacier

Siachen (5Q131084), the 74 km long valley glacier is located in the eastern Karakoram region of northern Ladakh, India. This is the largest glacier in the Karakoram and second largest glacier known outside the polar and sub-polar regions. Siachen lies between the Saltoro Range immediately to the west and the main Karakoram Range to the east It ranges from an altitude of 5753 m (18,875 ft) above sea level at its source at Indira Col (pass) on the Indo-China border, to its snout at 3620 m (11,875 ft) in the Nubra Valley, northern Ladakh. In Survey of India Toposheet No. 52 E, it is situated1 within the coordinates 35°12′–35°41′N and 76°47′– 77°11′E. The word ‘Siachen’ ironically means ‘the place of wild roses’ or specifically refers to the thorny wild plants which grow on the rocky outcrops near the snout. The melting waters of the glacier are the main source of the Nubra River, which drains into the Shyok River of northern Ladakh. The Shyok in turn joins the Indus River; thus the glacier is a major source of water for the Indus. In 1821, Moorcroft reported for the first time the existence of

Siachen glacier in the Karakoram region. It was Strachey who stepped on the Siachen glacier in 1848 and later Drew in 1949. Subsequently, Ryall from the Survey of India sketched the lower part of the Siachen glacier in 1861 and estimated its length as 16 miles. In 1909, Longstaff3 alongwith Neve and Lt. Slingsby were the first to traverse the length and breadth of the Siachen glacier. They further established the size of the glacier up to the Turkestan La, its northern limit4. The global climate change has a significant impact on the high mountain environment. The Himalayan glaciers are in the state of general retreat5 since 1850 and the average air temperature of the Himalayan region6 has risen by 1°C since mid-1970.

XV. Global Warming and climate change with reference to other countries

1. Benefits from a renewable energy village electrification system

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More than 100 years after Edison's life changing discovery, 1.6–2 billion people around the globe still live without light, in dark and smoke filled homes. The remote and impoverished Himalayan villages of upper Humla, in north-west Nepal, belong to some of the 2.4 billion people who still depend on the use of traditional biomass for their daily energy services such as cooking, heating and light. These activities on open fireplaces have a direct chronic impact on the health and extremely low life expectancy of the women and children along with devastating deforestation. There is a strong relationship between prosperity and access to electricity. The more remote and isolated communities in Nepal generally live in great poverty. Eighty percent of Nepal's 28.5 million people live in rural areas, with around half of these so remote, that neither a road, nor the national grid is ever likely to reach them. While Nepal has no fossil fuel resources, it is a country that is rich in renewable energy resources such as hydropower and solar energy. These abundant and locally available renewable energy resources can be tapped into with appropriate locally developed technologies. Generating and storing electrical energy derived from these rich local energy resources can provide for appropriate and sustainable lighting, which brings potential health, education, social and economic benefits to the people who have previously lived in homes with excessive indoor air pollution. This paper describes the living conditions of some villages in upper Humla, and the possible benefits of a simple village electrification system that provides basic lighting for the homes and the consequent improvements in the living conditions of the villagers.

Keywords: Poverty; Elementary village electrification; Holistic community development (HCD); Indoor air pollution; Renewable energy; Human development index (HDI)

2. Absolute Sea Level Measurements, Climate Change and Vertical Crustal Movements

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Annual mean sea level observations from tide gauges around the world, usually show interannual and decadal variations of order 5–10 cm. Because of these variations, several decades of data are normally required for a reliable determination of the secular trend in mean sea levels. Tide gauges only give relative sea level trends, since a rise in sea level cannot be distinguished from a subsidence of the crust at the tide gauge and thus estimates of the "global" rise of mean sea levels must be corrected for these vertical crustal movements. A brief review is given of recent work on relative mean sea levels, which shows the importance of these land movements. Modern space geodetic techniques and absolute gravity have now achieved the equivalent accuracy of a few centimetres that is compatible with the above variability in annual mean sea levels. Measurements of vertical crustal movements at tide gauges using these techniques are now being carried out in various parts of the world. A summary is given of the recommendations of an international working group on the geodetic fixing of tide gauge bench marks and some of the measurement errors that are now being investigated are discussed. These measurements are of interest to oceanographers working on climate change and to geophysicists working on vertical crustal movements.

3. Oceanic implications for climate change policy

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Under the United Nations convention on the law of the sea (1982), each participating country maintains exclusive economic and environmental rights within the oceanic region extending 200 nm from its territorial sea, known as the exclusive economic zone (EEZ). Although the ocean within each EEZ is undoubtedly an anthropogenic CO2 sink, it has been overlooked within international climate policy. In this paper I use an area-weighted scaling argument to show that the inclusion of the EEZ CO2 sink within national carbon accounts would have significant implications in tracking national greenhouse commitments to any future climate change policy initiative. The advantages and disadvantages for inclusion of the EEZ CO2 sink into global climate change policy are also explored. The most compelling argument for including the EEZ CO2 sink is that it would enhance the equity and resources among coastal nations to combat and adapt against future climate change that will inherently impact coastal nations more so than land locked nations. If included, the funds raised could be used for either monitoring or adaptive coastal infrastructure among the most vulnerable nations. On the other hand, the EEZ anthropogenic CO2 sink cannot be directly controlled by human activities and could be used as a disincentive for some developed nations to reduce fossil-fuel related greenhouse gas emissions. This may therefore dampen efforts to ultimately reduce atmospheric greenhouse gas concentrations. In consideration of these arguments it is therefore suggested that an ‘‘EEZ clause’’ be added to Kyoto and any future international climate policy that explicitly excludes its use within national carbon accounts under these international climate frameworks.

Keywords: Climate, Policy, Ocean, Carbon Sink

4. Mapping the Return Periods of Extreme Sea Levels: Allowing for Short Sea Level Records, Seasonality, and Climate Change

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This study of extreme sea levels is motivated by concern over increased coastal erosion and flooding under plausible climate change scenarios. Extremal analyses are performed on the annual and seasonal maxima from 24 tide gauge stations in the Northwest Atlantic. At data poor locations, a 40 yr surge hindcast and information from short observation records are used to reconstruct sea level records prior to the annual and seasonal analysis of extremes. A Digital Elevation Model is used to generate spatial maps of the return period of extreme sea levels associated with specified flooding probabilities under current conditions and under projected global sea level rise scenarios for the next century. It is the first time such maps have been produced. Their primary advantage is that extreme sea levels are expressed in terms of inundated areas as opposed to a critical flood value about an arbitrary datum. Another novel aspect of this study is that the extremal analyses are carried out for specific seasons.

Keywords: sea level; extremal analysis; storm surges; spatial mapping of coastal flooding; Digital Elevation Model; climate change.

5. Guidelines to assist policy makers and managers of coastal areas in the integration of coastal management programs and national climate change action plans

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In response to potential commitments and obligations under the United Nations Framework Convention on Climate Change (UNFCCC), many nations are preparing national climate change action plans that identify management strategies to reduce greenhouse gas emissions and to adapt to the potential impacts of long-term climate change. The successful implementation of these plans and their management strategies within individual countries will depend to a large measure on the extent of their integration into the implementation of other national and sectoral management plans, including coastal management plans. This document provides guidance on integrating coastal management programs and national climate-change action plans.

7. The Economics of Climate Change

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This paper discusses the design of CO_2 taxes at the domestic and international level and the choice of taxes versus a cap-and-trade system. There is a strong case for taxes on uncertainty, fiscal, and distributional grounds, though this critically hinges on policy specifics and how revenues are used. The efficient near-term tax is at least U.S. \$5–\$20 per ton of CO_2 and the tax should be imposed upstream with incentives for downstream sequestration and abatement of other greenhouse gases. At the international level a key challenge is the possibility that emissions taxes might be undermined through offsetting changes in other energy policies.

Key words: Global climate change; CO_2 tax; cap-and-trade; policy design.

8. Predicting Extinction Risks Under Climate Change: Coupling Stochastic Population Models with Dynamic Bioclimatic Habitat Models

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Species responses to climate change may be influenced by changes in available habitat, as well as population processes, species interactions and interactions between demographic and landscape dynamics. Current methods for assessing these responses fail to provide an integrated view of these influences because they deal with habitat change or population dynamics, but rarely both. In this study, we linked a time series of habitat suitability models with spatially explicit stochastic population models to explore factors that influence the viability of plant species populations under stable and changing climate scenarios in South African fynbos, a global biodiversity hot spot. Results indicate that complex interactions between life history, disturbance regime and distribution pattern mediate species extinction risks under climate change. Our novel mechanistic approach allows more complete and direct appraisal of future biotic responses than do static bioclimatic habitat modelling approaches, and will ultimately support development of more effective conservation strategies to mitigate biodiversity losses due to climate change.

Keywords: Population viability analysis, bioclimatic envelope, niche model, uncertainty, fynbos, fire

9. Climate Change, Biofuelss and Eco-Social Impacts in the Brazilian Amazon and Cerrado

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While global technical progress is relatively linear, there is wide variation in its environmental and social impacts at the local level, with cycles of expansion and retraction or boom and bust, of long or short duration. Analysis of previous open-ended stages of extraction and agro commodities in the Amazon indicates a general gravitational trend for technical progress to increase productivity and permit transformation of increasingly generic forms of material or energy, rather than relying on the specific physical or chemical properties provided by nature. While increased demand favours frontier expansion in the periphery when there is no other alternative, technical progress ultimately favours spatial reconcentration of production in central countries. The agroenergy stage now beginning involves rapid frontier expansion and offers various environmental and economic opportunities, but also generates a series of negative ecosystemic and socio-economic impacts, which are both direct and indirect, for tropical regions. The Amazon and the Cerrado are particularly vulnerable. Interacting with

climate change and land use, the upcoming stage of cellulosic energy could result in a collapse of the new frontier into vast degraded pasture. The present and future impacts can be mitigated through crafting of appropriate policies, not limited to the Amazon, stressing intensified and more sustainable use of areas already cleared, minimizing new clearing and consolidation of alternatives for sustainable use of natural resources by local communities. Coping with these scenarios requires knowledge of complex causal relationships.

Keywords: Amazon, Cerrado, frontier, biofuel, impacts

10. Hazards Risk and Vulnerability Assessment at the Community Level: Approaches, Methods and Application

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Climate change is a complex phenomenon and it is difficult to be scientifically certain about its short term trend. However, the current trend of global warming has been an observed phenomenon that has significant implications for our natural resources and environment, and sustainability of social, economic and other aspects of well-being. Our natural resources including forestry resources are at risk of experiencing dramatic shift in their reproduction, growth and long term sustenance. Both the market and no market cost of such shocks to timber and non-timber resources could be so high that a recovery in the short run may not be possible. *Risk Assessment* is an appraisal of both the kinds and degrees of threat posed by an environmental hazard. Such appraisal, conceptually, includes the recognition of a hazard (*hazard identification*), the measurement of its threats (*risk estimation*), and understanding the social meaning of such measurements (*social evaluation*). Risk assessment methodologies have been evolving over the last three decades, and the application of these tools has remained a challenge for practitioners. *Hazard identification* methodology includes an examination of what hazards have occurred, where they have occurred, what kind of damage resulted, and the magnitude of that damage. *Risk estimation* includes intuition of the locals, in which the local community members may be able to predict when another event may occur, based on past experience. *Social evaluation* assesses how the community is prepared, and it asks what resources are available to cope. In light of the above methodological framework, the Office of Infrastructure Protection and Emergency Preparedness Canada (OCIPEP) sponsored an initiative to explore and determine issues on all hazards risk and its reduction in the non-urban communities in Canada. In this paper, four risk assessment components were addressed: initial issue identification, validating issues, research findings, and lessons learned. It was found that forestry-based smaller communities face hazards of spill, and agricultural communities are more concerned with weather-related hazards. Immediate and familiar events are recognized by these communities in the first place, and there is a lack of understanding of the increasing vulnerability and the need for long term adaptation strategy and plan. The paper concludes by presenting a number policy prescriptions concerning risk and vulnerability reduction and enhancing adaptive capacity.

11. The effects of global climate change on seagrasses

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A primary effect of increased global temperature on seagrasses will be the alteration of growth rates and other physiological functions of the plants themselves. The distribution of seagrasses will shift as a result of increased temperature stress and changes in the patterns of sexual reproduction. Indirect temperature effects may include plant community changes as a result of increased eutrophication and changes in the frequency and intensity of extreme weather events. The direct effects of sea level rise on the coastal oceans will be to increase water depths, change tidal variation alter water movement, and increase seawater intrusion into estuaries and rivers. A major impact of all these changes on seagrasses and tidal freshwater plants will be a redistribution of existing habitats. The intrusion of ocean water into formerly fresh or brackish water areas will directly affect estuarine plant distribution by changing conditions at specific locations, causing some plants to relocate in order to stay within their tolerance zones and allowing others to expand their distribution inland. Distribution changes will result from the effects of salinity change on seed germination, propagule formation, photosynthesis, growth and biomass. Also, some plant communities may decline or be eliminated as a result of increased disease activity under more highly saline conditions. Increased water depth, which reduces the amount of light reaching existing seagrass beds, will directly reduce plant productivity where plants are light limited. Likewise, increases in water motion and tidal circulation will decrease the amount of light reaching the plants by increasing turbidity or by stimulating the growth of epiphytes. Increasing atmospheric carbon dioxide will directly elevate the amount of CO_2 in coastal waters. In areas where seagrasses are carbon limited, this may increase primary production, although whether this increase will be sustained with long-term CO_2 enrichment is uncertain. The impact of increases in CO_2 will vary with species and environmental circumstances, but will likely include species distribution by altering the competition between seagrass species as well as between seagrass and algal populations.

Keywords: Seagrass; Climate; Greenhouse effect; Global warming; Carbon dioxide; UV radiation; Sea level rise; Eelgrass; Macrophyte

12. Mitigation needs adaptation: Tropical forestry and climate change

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The relationship between tropical forests and global climate change has so far focused on mitigation, while much less emphasis has been placed on how management activities may help forest ecosystems adapt to this change. This paper discusses how tropical forestry practices can contribute to maintaining or enhancing the adaptive capacity of natural and planted forests to global climate change and considers challenges and opportunities for the integration of tropical forest management in broader climate change adaptation. In addition to the use of reduced impact logging to maintain ecosystem integrity, other approaches may be needed, such as fire prevention and management, as well as specific silvicultural options aimed at facilitating genetic adaptation. In the case of planted forests, the normally higher intensity of management (with respect to natural forest) offers additional opportunities for implementing adaptation measures, at both industrial and smallholder levels. Although the integration in forest management of measures aimed at enhancing adaptation to climate change may not involve substantial additional effort with respect to current practice, little action appears to have been taken to date. Tropical foresters and forest-dependent communities appear not to appreciate the risks posed by climate change and, for those who are aware of them, practical guidance on how to respond is largely non-existent. The extent to which forestry research and national policies will promote and adopt management practices in order to assist production forests adapt to climate change is currently uncertain. Mainstreaming adaptation into national development and planning programs may represent an initial step towards the incorporation of climate change considerations into tropical forestry.

Keywords: Climate change . Adaptation. Tropical forests. Tropical tree plantations.
Natural forest management

13. Climate Change Science

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Although climate change was largely unknown as an environmental issue a mere 15 years ago, today it is a topic of intense discussion, and often tension within the international science community, amongst politicians, and within almost all sectors of our society. It is, however, a very complex issue that is often misunderstood and/or misrepresented by individuals and within the media. The presentation will focus on some key conclusions of the latest IPCC assessment, released two years ago, and of subsequent published science. These conclusions indicate that the global climate is indeed changing.

Average global surface temperatures are now about 0.6°C above pre-industrial levels, and appear to be unprecedented in at least the past millennium. Attribution studies suggest volcanic, solar and human factors were are all implicated in the warming of the first half of the 20th century, but that the warming of the past 50 years is primarily due to human factors alone. Projections for future human induced forcing indicate that global temperatures, by 2100, will almost certainly be unprecedented in human history, and could reach magnitudes similar to past glacialinterglacial climate changes, but occur at rates more than 10 times faster. While these changes will dramatically change weather as we know it, the details of these changes at the regional scale, as well as their consequences, remain quite uncertain. Some aspects of regional projections, such as frequencies and intensities of heat and cold extremes and wet and dry spells, appear to be quite robust. Others, such as the impacts on storminess, are much less certain. Hence the issue is clearly one of risk management. Various studies indicate that measures to reduce human influences on climate can significantly reduce the risks of the most disastrous aspects of potential climate change, but can no longer prevent significant climate change from happening. Hence, adaptation measures must also be a critical aspect of mitigation strategies.

14. Ecological Consequences of Climate Change Altered Forest Insect Disturbance Regimes

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2 North America. Any one of these events would be unusual; their simultaneous occurrence Department of Mathematics and Statistics, Utah State University, Logan, UT 84322

Unprecedented outbreaks of native bark beetles are occurring in forests throughout the mountains of western is nothing short of remarkable. Significant biogeographical events are occurring at a continental scale, and a warming climate is the one commonality across all of these spectacular outbreak events. Mountain pine beetle (*Dendroctonus ponderosae* Hopkins) populations are responsible for three of the more impressive of these events, and we describe recent case histories that illustrate the unique attributes of the current situation. These case histories involve outbreaks within the current range of mountain pine beetle in areas with micro-climate that were previously too cold; unusually large and intense outbreaks in high elevation pines; and range expansion north and east beyond the historical distribution in Canada. In this article we describe each of these three situations and briefly discuss their importance with respect to global climate warming.

15. Risk Management / Vulnerability Approach to Climate Change Adaptation in the Forest Management Sector

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Adaptation to climate change refers to adjustments in ecological, social and economic systems in response to actual or expected climatic stimuli and their effects or impacts. In some circumstances, it may be most appropriate to allow such adjustments to occur autonomously, in a natural and unmanaged way. For example, long-term shifts in species composition in a timber supply area (i.e., ecological system change) might be followed by autonomous adaptations in the private sector to utilize the new type of forest resource (i.e., economic systems change). In other circumstances, it may be most appropriate to undertake system adaptations in a planned, proactive manner. For example, long-term shifts in forest disturbance patterns that threaten ecological, social or economic systems might necessitate planned adaptations in the form of targeted regeneration, silviculture or protection strategies. This presentation introduces a framework for approaching this latter form of planned adaptation. Early management approaches to climate change adaptation emphasized "impact assessment" methodologies, where climate change scenarios were identified, biophysical and socioeconomic impacts were estimated, and management strategies were developed or assumed. More recently, climate change researchers are suggesting the use of "vulnerability assessment" methodologies, where key system vulnerabilities are first identified, and adaptive strategies are developed and evaluated in the context of existing planning and decision-making processes. Integrated with the vulnerability assessment methodology is the notion of assessing the "adaptive capacity" of an affected biophysical or socio-economic system to cope with the potential impacts of climate change. In this presentation, we build on this gradual shift in methodological focus by drawing linkages with practical methods from the general field of environmental risk management. In its broadest sense, risk management refers to the entire process of assessing risks (i.e., vulnerabilities), developing and evaluating strategies, making decisions under uncertainty, and communicating effectively with decision makers and stakeholders. Effective implementation and monitoring using an adaptive management philosophy can also be considered as an integral part of a broad risk-based approach to forest management in the face of climate change.

16. Local Adaptation in Brown Trout Early Life-History Traits: Implications for Climate Change Adaptability

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Knowledge of local adaptation and adaptive potential of natural populations is becoming increasingly relevant due to anthropogenic changes in the environment, such as climate change. The concern is that populations will be negatively affected by increasing temperatures without the capacity to adapt. Temperature-related adaptability in traits related to phenology and early life history are expected to be particularly important in salmonid fishes. We focused on the latter and investigated whether four populations of brown trout (*Salmo trutta*) are locally adapted in early life-history traits. These populations spawn in rivers that experience different temperature conditions during the time of incubation of eggs and embryos. They were reared in a common-garden experiment at three different temperatures. Quantitative genetic differentiation (Q_{ST}) exceeded neutral molecular differentiation (F_{ST}) for two traits, indicating local adaptation. A temperature effect was observed for three traits. However, this effect varied among populations due to locally adapted reaction norms, corresponding to the temperature regimes experienced by the populations in their native environments. Additive genetic variance and heritable variation in phenotypic plasticity suggest that although increasing temperatures are likely to affect some populations negatively, they may have the potential to adapt to changing temperature regimes.

Keywords: Common-garden experiment, global warming, natural selection, phenotypic plasticity, QST versus FST, reaction norm

17. Impacts of Climate Change on Forest Productivity and Large-Scale Disturbance Events

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This presentation will focus on impacts especially relevant to boreal forests in the central portion of the prairie provinces, i.e. the area along the current forest-grassland boundary known as the "forest fringe". The main impacts are changes to forest productivity and changes in disturbance regime. Forest productivity is determined by a number of environmental factors, most of which will be affected by climate change. The most important of these are temperature, moisture availability, nutrient availability (e.g. nitrogen, N) and atmospheric carbon dioxide (CO_2) concentration. By and large, we expect a general increase in temperatures, with temperatures at night rising faster than those in the daytime, and winter temperatures increasing faster than summer temperatures. These changes will result in generally warmer soil temperatures, and fewer frost days. This will change the availability of nutrients and water, and the increase CO_2 will change the ways trees carry out photosynthesis. The ultimate results of these impacts are difficult to predict because of numerous interacting factors, which vary by species and site conditions. However, it appears that there is potential for increased productivity on sites with adequate nutrients (especially N) and water, due to higher temperatures and increased CO_2 levels. However, sites that are currently marginal with regard to water or nutrients are likely to become less productive. We will probably see an increasing divergence between sites, in which the "good" sites get better and the "bad" sites get worse. This will provide added incentive for concentrating management inputs on the more productive sites and avoiding droughtprone, low nutrient sites. While the effects of climate change on productivity will occur over many years, changes to disturbance regimes could have important short-term effects. Recent modeling suggests that fires will be more frequent and more intense, with a long fire season and perhaps higher amounts of the main ignition source, lightning.

18. Predicting the fate of a living fossil: how will global warming affect sex determination and hatching phenology tuatara?

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How will climate change affect species' reproduction and subsequent survival? In many egg-laying reptiles, the sex of offspring is determined by the temperature experienced during a critical period of embryonic development (temperature-dependent sex determination, TSD). Increasing air temperatures are likely to skew offspring sex ratios in the absence of evolutionary or plastic adaptation; hence we urgently require means for predicting the future distributions of species with TSD. Here we develop a mechanistic model that demonstrates how climate, soil and topography interact with physiology and nesting behavior to determine sex ratios of tuatara, cold-climate reptiles from New Zealand with an unusual developmental biology. Under extreme regional climate change, all-male clutches would hatch at 100% of current nest sites of the rarest species, *Sphenodon guntheri*, by the mid-2080s. We show that tuatara could behaviourally compensate for the male-biasing effects of warmer air temperatures by nesting later in the season or selecting shaded nest sites. Later nesting is, however, an unlikely response to global warming, as many oviparous species are nesting earlier as the climate warms. Our approach allows the assessment of the thermal suitability of current reserves and future translocation sites for tuatara, and can be readily modified to predict climatic impacts on any species with TSD.

19. Climate change, sea level rise and integrated coastal zone management: An IPCC approach

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Expansion of economic activities, urbanisation, increased resource use and population growth are continuously increasing the vulnerability of the coastal zone. This vulnerability is now further raised by the threat of climate change and accelerated sea level rise. The potentially severe impacts force policy-makers to also consider long-term planning for climate change and sea level rise. For reasons of efficiency and effectiveness this long-term planning should be integrated with existing short-term plans, thus creating an Integrated Coastal Zone Management programme. As a starting point for coastal zone management, the assessment of a country's or region's vulnerability to accelerated sea level rise is of utmost importance. The Intergovernmental Panel on Climate Change has developed a common methodology for this purpose. Studies carried out according to this Common Methodology have been compared and combined, from which general conclusions on local, regional and global vulnerability have been drawn, the latter in the form of a Global Vulnerability Assessment. In order to address the challenge of coping with climate change and accelerated sea level rise, it is essential to foresee the possible impacts, and to take precautionary action. Because of the long lead times needed for creating the required technical and institutional infrastructures, such action should be taken in the short term. Furthermore, it should be part of a broader coastal zone management and planning context. This will require a holistic view, shared by the different institutional levels that exist, along which different needs and interests should be balanced.

20. The Coincidence of Climatic and Species Rarity: High Risk to Small-Range Species from Climate Change

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Why do areas with high numbers of small-range species occur where they do? We found that, for butterfly and plant species in Europe, and for bird species in the Western Hemisphere, such areas coincide with regions that have rare climates, and are higher and colder areas than surrounding regions. Species with small range sizes also tend to occur in climatically diverse regions, where species are likely to have been buffered from extinction in the past. We suggest that the centres of high small-range species richness we examined predominantly represent interglacial relict areas where cold-adapted species have been able to survive unusually warm periods in the last *ca* 10000 years. We show that the rare climates that occur in current centres of species rarity will shrink disproportionately under future climate change, potentially leading to high vulnerability for many of the species they contain.

Keywords: Hot spots, refugia, range shifts, extinction

21. Climate and the range dynamics of species with imperfect detection

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Reliable predictions for species range changes require a mechanistic understanding of range dynamics in relation to environmental variation. One obstacle is that most current models are static and confound occurrence with the probability of detecting a species if it occurs at a site. Here we draw attention to recently developed occupancy models, which can be used to examine colonization and local extinction or changes in occupancy over time. These models further account for detection probabilities, which are likely to vary spatially and temporally in many datasets. Occupancy models require repeated presence/absence surveys, for example checklists used in bird atlas projects. As an example, we examine the recent range expansion of handed ibises (*Bostrychia hagedash*) in South African protected areas. Colonization exceeded local extinction in most biomes, and the probability of occurrence was related to local climate. Extensions of the basic occupancy models can estimate abundance or species richness. Occupancy models are an appealing additional tool for studying species' responses to global change.

Keywords: Bostrychia hagedash, colonization, detection probability, extinction, global change, occupancy model

22. Performance of Climate Envelope Models in Retrodicting Recent Changes in Bird Population Size from Observed Climatic Change

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Twenty-five-year population trends of 42 bird species rare as breeders in the UK were examined in relation to changes in climatic suitability simulated using climatic envelope models. The effects of a series of potential ‘nuisance’ variables were also assessed. A statistically significant positive correlation was found across species between population trend and climate suitability trend. The demonstration that climate envelope models are able to retrodict species' population trends provides a valuable validation of their use in studies of the potential impacts of future climatic changes.

Keywords: Rare Breeding Birds Panel, climate envelope models, climate response surface models, population trends, climate suitability

23. Practical Application of a Risk-Based Approach to Climate Change Adaptation in the Forest Management Sector Climate Change - Past and Future

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Warming and increased precipitation has been observed in many regions of Canada during the past century. Climate "normals" and extremes, based on much less than 100 years length often form the basis for decision-making in Canada. These so-

called "normals" are affected by climate variability and when taken in a longer context, they are unlikely to represent the full range of climate variability or extremes from the past or indeed, for the future. In order to determine the future climate, General Circulation Models of the atmosphere-ocean system are used. From these the future climate system can be projected, quantified and the uncertainty estimated. These models are driven by emission scenarios, derived from estimates of population growth and fossil fuel use amongst many others. While there is uncertainty particularly in regard to the magnitude of change, the projected direction of climate change amongst climate models is consistent - warmer and wetter for most of Canada. Climate model output is presented as a series of 'Climate Scenarios'. They are a tool for those socio-economic sectors that are sensitive to climate and may be affected by climate in the future. A wide range of projected variables is now available for North America from the Canadian Climate Impacts Scenarios Project. The projections for the Boreal Forest are for increased average temperatures, decreased diurnal range and increased precipitation.

24. Incorporating the Effects of Changes in Vegetation Functioning and CO_2 on Water Availability in Plant Habitat Models

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The direct effects of CO_2 level changes on plant water availability are usually ignored in plant habitat models. We compare traditional proxies for water availability with changes in soil water (fAWC) predicted by a process-based ecosystem model, which simulates changes in vegetation structure and functioning, including CO_2 physiological effects. We modeled current and future habitats of 108 European tree species using ensemble forecasting, comprising six habitat models, two model evaluation methods and two climate change scenarios. The fAWC models' projections are generally more conservative. Potential habitats shrink significantly less for boreo-alpine and alpine species. Changes in vegetation functioning and CO_2 on plant water availability should therefore be taken into account in plant habitat change projections.

Keywords: Soil water content, BIOMOD, habitat models, CO2 effect, climate change, ensemble forecasting.

25. Contemporary Perspectives on the Niche that can Improve Models of Species Range Shifts Under Climate Change

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Pioneering efforts to predict shifts in species distribution under climate change used simple models based on the correlation between contemporary environmental factors and distributions. These models make predictions at coarse spatial scales and assume the constancy of present correlations between environment and distribution. Adaptive management of climate change impacts requires models that can make more robust predictions at finer spatio-temporal scales by accounting for processes that actually affect species distribution on heterogeneous landscapes. Mechanistic models of the distribution of both species and vegetation types have begun to emerge to meet these needs. We review these developments and highlight how recent advances in our understanding of relationships among the niche concept, species diversity and community assembly point the way towards more effective models for the impacts of global change on species distribution and community diversity.

Keywords: Global change, species distribution, biodiversity, modeling, cross-scaling;

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1. Modeling rice-plant-mediated methane emission

J.R.M. Arah and G.J.D. Kirk

Late-season methane emissions from flooded ricefields appear to be fuelled by root exudation and death, and to be transmitted to the atmosphere largely through the plant. We present a general transport-reaction model which accommodates these phenomena, together with a simplified ("cartoon") version intended to reproduce the salient features of most plant-dominated methane-emitting systems. Our cartoon model is capable of reproducing measured concentration profiles and fluxes. Sensitivity analysis suggests that cultivars with high specific root transmissivity may, other things being equal, reduce rather than enhance net emission. Simulations assuming exponential growth of the root system followed by Gaussian die-back resemble measured flux trajectories, and also point to great variability in the fraction of methane oxidised before it reaches the atmosphere. Air-entry on drainage reduces simulated methane fluxes and the fractions of those fluxes mediated by plants. It also increases the fraction of methane oxidised.

2. Effect of elevated CO2 and temperature on methane production and emission from submerged soil microcosm

W. Cheng, K. Chander, and K. Inubushi

Incubation experiments were conducted under controlled laboratory conditions to study the interactive effects of elevated carbon dioxide (CO2) and temperature on the production and emission of methane (CH_4) from a submerged paddy soil microcosm. Soil samples (unamended soil; soil + straw; soil + straw + N fertilizer) were placed in four growth chambers specifically designed for a combination of two levels of temperature (25 oC or 35 oC) and two levels of CO_2 concentration (400 µmol mol-1 or 800 µmol mol-1) with light intensity of about 3000 Lx for 16 h d-1. At 7, 15, 30, and 45 d after incubation, CH_4 flux, CH_4 dissolved in flood water, subsurface soil-entrapped CH_4, and CH_4 production potential of the subsurface soil were determined. The results are summarized as follows: 1) The amendment with rice straw led to a severalfold increase in CH_4 emission rates, especially at 35 oC. However, the CH_4 flux tended to decrease considerably after 15 d of incubation under elevated CO_2. 2) The amount of entrapped CH_4 in subsurface soil and the CH_4 production potential of the subsurface soil were appreciably larger in the soil samples incubated under elevated CO_2 and temperature during early incubation period. However, after 15 d, they were similar in the soil samples incubated under elevated or ambient CO_2 levels. These results clearly indicated that elevated CO_2 and temperature accelerated CH_4 formation by the addition of rice straw, while elevated CO_2 reduced CH_4 emission at both temperatures.

3. Methane transport capacity of rice plants. I. Influence of methane concentration and growth stage analyzed with an automated measuring system

M.S. Aulakh, J. Bodenbender, R. Wassmann, and H. Rennenberg

A major portion (60 -90 %) of the methane (CH_4) emitted from rice fields to the atmosphere is transported through the aerenchyma of the rice plants. However, a rapid and accurate method to study the CH_4 transport capacity (MTC) of rice plants is not available. We developed a gas sampling and analytical device based on a closed 2-compartment chamber technique and analyzed the enrichment of the CH_4 mixing ratio inside the shoot-compartment of cylindrical cuvettes enclosing individual rice plants under ambient conditions. The computer-controlled analytical system consists of a gas chromatograph (GC), and a pressure controlled autosampler for 8 cuvettes (7 for plants and one for CH4-calibration gas). The system automates closure and opening of plant cuvettes using pneumatic pressure, air sample collection and injection into the GC, and CH4 analysis. It minimizes sources of error during air sampling by continuously mixing headspace air of each cuvette, maintaining pressure and composition of the headspace inside the cuvettes, purging the dead volumes between the sampler induction tube and GC, and running a reference CH4-calibration gas sample in each cycle. Tests showed that the automated system is a useful tool for accurate sampling of headspace-air of cylindrical cuvettes enclosing individual rice plants, and enables the rapid and accurate fully automated analysis of CH4 in the headspace air samples. A linear relationship was obtained between CH4 transported by rice plants of two cultivars (IR72, a high yielding dwarf, and Dular, a traditional tall cultivar) and concentration of CH4 up to 7500 ppm used for purging the nutrient culture solution surrounding the roots in the root-compartment of the chamber. Further increase in CH4 emission by shoots was not observed at 10000 ppm CH4 concentration in the root-compartment of the chamber. MTC of rice plants of IR72 measured at six development stages showed that MTC was lowest at seedling stage and increased gradually until panicle initiation, no further change at flowering, but marked decrease at maturity. These results suggest that the plants have 45 to 246 % greater potentials to transport CH4 than the highest CH4 emission rates reported under field conditions, and plants would not emit CH4 at early growth and at a reduced rate near to ripening.

4. Modeling methane emissions from rice paddies: Variability, uncertainty and sensitivity analysis of processes involved

P.M. van Bodegom, P.A. Leffelaar, A.J.M. Stams, and R. Wassmann

Estimates of global methane emissions, to which rice cropping systems contribute significantly, are uncertain. The variability and uncertainty of variables governing emission rates and the sensitivity of emissions to these variables determine the accuracy of methane emission estimates. A good tool for quantification of sensitivities is a process-based model. This paper describes a model that has been validated previously by experimental data. Variability and uncertainty in processes and variables underlying methane emissions are reviewed and the sensitivities of modelled methane emission estimates for process variables are tested. The sensitivity analysis is carried out for two sites in the Philippines at which methane emissions have been measured for several years. The sensitivities of the model are compared to measured sensitivities, both as a function of input parameters. The model sensitivity analysis shows that the system is not sensitive to mechanisms of methane production or the pathway of gas transport through the plant. Methane emissions are very sensitive, however, to the description of substrate supply (both from the soil and from organic fertilisers). Unfortunately, this description also represents a main uncertainty. Uncertainty in methane emission estimates will thus remain large as long as these processes are not well quantified.

5. Methane emissions from irrigated rice fields in northern India (New Delhi)

M.C. Jain, S. Kumar, R. Wassmann, S. Mitra, S.D. Singh, J.P. Singh, Ramlakhan Singh, A.K. Yadav, and S. Gupta

Methane emission from rice fields as affected by water regime, organic amendment and rice cultivar were measured at the Indian Agricultural Research Institute, New Delhi, using manual and automatic sampling technique of the closed chamber method. Measurements were conducted during 4 consecutive cropping seasons (July to October) from 1994 to 1997. Emission rates were low, 16 and 40 kg CH4 m -2 per season when the field was flooded permanently. These low emissions were indirectly caused by high water percolation rates where frequent water replenishment resulted in constant inflow of oxygen in the soil. The local practice of intermittent flooding that encompasses short periods without standing water in the field further reduced emission rates. Over the course of 4 seasons, the total methane emission from intermittently irrigated fields was 22% lower as compared to continuous flooding. The experiments conducted during 1995 with one cultivar developed by IRRI (IR72) and two local cultivars (Pusa 169 and Pusa Basmati) showed that the average methane flux from the intermittently irrigated plots without any organic amendment ranged between 10.2 and 14.2 mg m-2d-1. The impact of organic manure was tested in 1996 and 1997 with the varieties IR72 and Pusa 169. Application of organic manure (FYM+ wheat straw) in combination with urea (1:1 Nitrogen basis) enhanced methane emission by 12-20 % as compared to the fields treated with urea only. The rice cultivars did not show marked difference in methane emission from rice paddy fields. The site in New Delhi represents one example for very low methane emissions from rice fields. Emissions from other sites in Northern India may be higher than the observed values for New Delhi, but still in a low range in comparison to other rice growing regions in India. The abundant practice of intermittent irrigation - in combination with low organic inputs - is commonly found in Northern India and will impede further significant mitigation of methane emissions. In turn, the results of this study may provide clues to reducing emissions in other parts of India that have higher baseline emissions.

6. Simulation of CH4 production in anaerobic rice soils by a simple two-pool model

Y. Lu, J.R.M. Arah, R. Wassmann, and H.-U. Neue

Methane (CH4) is produced in flooded rice fields by anaerobic decomposition of applied organic residues, root-derived materials and native soil organic matter (SOM).

Since CH_4 is an important greenhouse gas it is important to understand, and to be able to model, the processes which produce it. Anoxic incubation of soils employed in the cultivation of irrigated rice, with and without the addition of various potentially-available organic substrates, provides information on potential CH_4 emissions which can be incorporated into process-based models. In this study, a simple two-pool model is employed to simulate the CH_4 production of a number of anaerobically-incubated rice soils, and their responses to amendment with a variety of organic substrates. The model differs from most accounts of SOM transformation in that kinetics are microbially-mediated rather than first-order. Simulation yields a reproduction of the general trends of CH_4 production in response to amendments of acetate, glucose and rice straw.

Note: #1, #2, #3, #4, #5, #6, #7, #8 , #9, #10 , #11, #12, #13 (References to Climate Change)

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