Organized jointly by
Divecha Centre for Climate Change, Indian Institute of Science, Bangalore, Indian Institute of Technology, Delhi, Indian Institute of Technology Madras and Centre for Science and Environment

Third National Research Conference on Climate Change Report

November 3-4, 2012

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Chapter 1: Executive Summary

The Third National Research Conference on Climate Change was held at Indian Institute of Science (IISc) Bangalore on November 3-4, 2012. Over 250 researchers and scientists attended the conference organized by IISc Bangalore, IIT Delhi, IIT Madras and Centre for Science and Environment. Of the attendees, over 90 scientists presented papers and posters on their ongoing research.

The talks were broadly divided into four categories: climate science/impacts, mitigation, adaptation and climate policy and politics. The conference saw a range of different kinds of poster presentations and talks under each category. Under science/impacts, the dominant themes were modeling, ongoing research, monsoon and glaciers.

Those under mitigation covered forest and renewable sectors, greenhouse gas measurements, heat stress in metropolitan cities, emissions reduction measures in the cement industry and future of electricity storage systems in India.

Adaptation saw an equally broad range of presentations. Topics spanned agenda for research in adaptation, marine system sustainability, vulnerability and adaptation practices in Himalayas, impact in coastal areas and vulnerability indicators for agriculture, water and forest sectors. Participants from South Asia actively participated and presented case studies from Bangladesh and Sri Lanka — how information and communication technology was helping people adapt in Bangladesh and how traditional water management practices of Sri Lanka offers insight into how water should be managed sustainably.

Presentations on climate politics and policy included topics such as climate financing and climate policy, state action plans on adaptation, international negotiations on climate change and an evaluation of India's climate policies.

The ICRN website (www.icrn.in) was launched at the conference. The website, that boasts of over 200 members, generated a lot of engaging discussion on how to take it forward so that researchers can stay connected to each other.

The conference, third in the series of such conferences, was successful and participants exchanged notes with each other. A lot of the younger researchers got feedback on their work from senior Indian scientists.

Everyone also agreed that there is still a long way to go for Indian science to make a more powerful impact. They also agreed that initiatives such as ICRN would bring them closer to realizing that.

Chapter 2: Introduction

The Third National Research Conference, organized by Divecha Centre for Climate Change, Indian Institute of Science, Indian Institute of Technology Delhi, Indian Institute of Technology Madras and Centre for Science and Environment, was held at IISc Bangalore on November 3-4, 2012.

Over 90 researchers/scientists from all over South Asia presented talks and posters on their ongoing research areas. Of the 90, 25 were India's top senior scientists affiliated to reputed research institutions such as Indian Institute of Tropical Meteorology, Pune, National Aerospace Laboratories, Bangalore, National Remote Sensing Centre, Hyderabad, Indian Institute of Technology, Gandhinagar, Indian Institute of Technology, Mumbai, Physical Research Laboratory, Ahmedabad, Tata Institute of Social Sciences, Mumbai, Indian Institute of Management, Bangalore, and Central Research Institute for Dryland Agriculture, Hyderabad, among several others. The others included PhD students from different universities and institutions such as Delhi University, Jawaharlal Nehru University, Centre for Environmental Planning and Technology, Benares Hindu University, Ashoka Trust for Research in Ecology and Environment, Indian Institute of Forest Management, Central University of Tamil Nadu and Ravenshaw University, Cuttack, among many others. (For detailed list of presenters with their affiliations see Annexure I).

The talks were broadly divided into four themes: climate science/impacts, mitigation, adaptation and climate politics/policy, which ran simultaneously in parallel sessions in the morning and the afternoon over two days.

There were 18 presentations on climate science/impacts, nine presentations on climate change mitigation, 20 presentations in climate change adaptation and six presentations in the climate politics/policy sessions. In addition to these, 17 posters were presented in the science/impacts category, 13 in mitigation category and eight in the adaptation and policy/politics category. Three awards were also given to junior scholars in the three poster categories. (For detailed list of presentations see 'Agenda' in Annexure II).

2.1 Goals of the conference

The conference was the third in the series of such conferences. The first conference was organized in March 2010 and the second conference was held in November 2011. The aim of the series of conferences is to enhance capacity for climate research and action in India by:

a. Developing an arena for promoting interaction among researchers, analysts and practitioners from across the country

b. Enhancing understanding of the current state of activities and research capabilities in the country and thereby identifying key lacunae

c. Deepening and broadening engagement on the climate issue with a particular focus on smaller academic institutions, NGOs and younger scholars

d. Strengthening a sense of 'community' among researchers

e. Exploring ways to more effectively link climate research and action programmes

Chapter 3: Sessions in detail

3.1 Introductory Session

The opening session of the conference included Sunita Narain and Chandra Bhushan of Centre for Science and Environment, P Balaram and G Bala of Indian Institute of Science and Ambuj Sagar of IIT Delhi. In her opening remarks, Sunita Narain outlined the purpose of the conference, which is to build a vibrant scientific research community. She emphasized on the importance of science, which determines the outcome of policies and actions that countries take on climate change. She iterated that the issue of climate change is intensely political and therefore the role of the Indian scientist is crucial in determining the paths for the future and that we should not merely depend on global science. It is imperative that Indian scientists do their own research in this context.

P Balaram, director of IISc, in his welcome speech, outlined that it is important to understand climate skeptics in the field of climate science. In India, it is much easier to discuss policy than science and climate science is still nascent, he said. Data collection assumes significance, and in India, very little data is collected. He stressed the need for students and faculty to take up measurements and analyses with caution.

G Bala then spoke of the current research trends in climate change. He highlighted five major areas that have been gaining attention in the scientific community and journals. These include carbon budget, earth system modeling, climate change projections, changes in cryosphere, and geo-engineering.

On carbon budget, he mentioned how much of carbon is going to the ocean and land and the importance of results from data collection by thousands of scientist who synthesize huge data. He presented the Decadal Budget study from Global Climate Programme observations (CO_2now.org) that update the climate budget yearly.

The study showed 88 per cent of carbon emissions from fossil fuels and cements; 12 per cent from deforestation and land use change. Nature has its way of balancing the CO_2 increase with ~50 per cent in the atmosphere and the rest is stored in the oceans and land. The fraction of CO_2 in the atmosphere remains the same as carbon uptake from land and oceans stabilize the concentration in the atmosphere. This uptake has been increasing with time.

On earth system modeling, he emphasized its importance to understand projections and asserted that science has moved beyond Physical Climate System (Carbon/Nitrogen Cycle etc) studies. He said modeling and projections are important for a future outlook and aids better policy actions and broader societal concerns.

On climate change projections he said that the CMIP5 model provides Global Scale Coarse resolution data and uses 64 models from 32 modeling centres. It is a useful dataset to understand robust responses in the climate change system and equally important data for impact studies as 260 publications so far have used the data in one year for their studies. It was also pointed out that the range of projections from these models is very large, and the complexities lie in this uncertainty.

On Cryosphere changes, he mentioned that the area and volume of Arctic sea ice has decreased by 49 and 76 per cent since 1979 and in a few years it is likely to be ice-free. The projection for glacier Himalayan melt from CMIP5 showed that the worse scenario would be after 150-200 years where all the Hindu Kush Himalaya glaciers would melt. At present half a metre of water melts each year.

On the science of geo-engineering, he said that in order to tackle changes in climate change in case of failure in emission controls and negotiations, focus has been given to "Block the amount of Sunlight (Solar Radiation Management)". This would mitigate warming conditions, as 2 per cent of sunlight if reflected back to space would reduce doubling of atmospheric CO_2. Reduction of sunlight and reflection is aided by using space sunshades, stratospheric aerosols, marine cloud whitening, whitening the roofs and lightning the colour of crop leaves.

He summed up by encouraging the gathering to look forward to the IPCC AR5 WG1 Report, which would be out in 2013 with updated assessments of atmosphere, oceans, glaciers and sea ice changes, projections based on ESMs, geo-engineering along with an Atlas of regional

Panel at the opening session

projections. He also laid emphasis on rigorous regional level analyses to be undertaken to better understand future projections.

Ambuj Sagar who spoke on capacity building for meeting the climate challenges pointed out the need for a bigger network on climate change, and to engage more people to respond to the issues of climate change. There is a dearth of capacity building in India and many meetings are held, but they are driven by opinion, not evidence. The ICRN conference according to him is about more people and more institutions and more topics for a better coverage to understand what is going on in the country and what gaps exist. It is an opportunity for connecting young scholars to present their research, get feedback to improve their work and interact with each other. He also said that such national conferences would have a greater impact, and these should be coupled with regional workshops.

From the science aspect, Chandra Bhushan gave an overview of the politics of climate change and the state of climate change negotiations. He brought out the fact that with seven different negotiating tracks and a large number of regional groupings, the nature of negotiations has become very complicated. He also outlined the world's expectations of the Doha climate conference.

3.2 Science/Impacts of Climate Change

The sessions on science/impacts were spread over two days. There were three presentation sessions, and one poster session. Presented below are the highlights of the presentations in each of the sessions:

3.2.1 SESSION I

SPEAKERS

Sabin TP: CORDEX-South Asia

TN Venkatesh: Glacier retreat in the Himalayas: Observations and Numerical Simulations

Vimal Mishra: From Mean to Extremes: What do CMIP5 Projections tell us about climate change in India

K Rajendran: Simulated changes in Indian monsoon

Smriti Basnett: Monitoring seasonal snow cover in Sikkim Himalaya

Gaddam Vinay Kumar: Monitoring of Glacial Mass Balance in Baspa Basin, Himachal Pradesh

Sabin TP: Sabin spoke about CORDEX, South Asia, which is an initiative towards producing dynamic regional downscaling of models. It also includes archival, management, retrieval of data products. Many workshops are conducted for capacity building, he added. Explaining the work on CORDEX at IITM, Pune, he said that eight different GCM's are run to produce historical run (1950-2005) and future projections (2005-2100). Most of the simulations are over and some are ongoing. Data would be available on webpage of IITM soon. Discussing a specific technical aspect, he said an important scientific conclusion to a comparative study between zoom v no zoom experiments brought out that zooming improves the simulated precipitation over land as well as improves the simulation of some of the important features of South Asian monsoon.

TN Venkatesh: Referring to glaciers as the markers of climate change, Venkatesh said that some of the Himalayan glaciers are retreating, while some in the Karakoram range are advancing. The conclusion that glacial advance indicates no global warming is incorrect according to him, since the number of glaciers is still small. In his study, Venkatesh proposed a one-dimensional model of glaciers. In his study, the motion (advance or retreat) of glacial ice under gravity was modeled in terms of dynamical (length of the glacier, slope of the terrain) and thermodynamical (equilibrium line-net snowfall) parameters. The model was able to explain the retreat of glaciers in terms of these parameters. He added that the model could be used to study the effects of climate change on glacial retreat if a good estimate of climate impacts on net snowfall could be estimated.

Vimal Mishra: According to Mishra, statistical downscaling and bias correction are robust tools to downscale simulated model data to study regional

Climate change is intensely political and Indian research must feed into the process: Sunita Narain, Director-General, Centre for Science and Environment

effects. The conclusions emerging out of his ongoing study include indications that the monsoon will be shifted, and the maximum variability in precipitation will be seen in September. June-July will show maximum variability in temperature and in general, there will be an increase in hot extreme events and extreme precipitation events. He added that comparative studies between statistical techniques and dynamical downscaling are going on and that it is a topic of active research, but Mishra clarified that globally, CMIP5 models are able to capture the rainy and dry regions quite well.

K Rajendran: According to Rajendran, past climate projections are still a problem in CMIP5 models. While a high-resolution model—of 180 to 200km—is able to capture important features of tropical climate and it performs well even over Indian region in contrast to most models, the problem is getting good boundary conditions. Models showed systematic reduction in rainfall over the west coast, it is important to get rainfall over projection both land and ocean correct in the context of monsoon.

Smriti Basnett: Her study analysed snow cover over two basins on inter-annual, seasonal and monthly time scales. She found that Sikkim gets maximum snow in February. There is a continuous snow precipitation even during summer months in this region unlike western Himalayas. The main contribution of snow rate comes from western disturbances than from the Southwest monsoon.

Gaddam Vinay Kumar: In the satellite image analysis 0 degree isotherms are used to show the retreat of glaciers. A detailed mass balance is important to obtain these isotherms, according to Kumar. He also said that the mean annual loss of 0.87 km^2 was seen during 1962-2009, and there is a possibility of scarcity of water due to glacial mass loss. This may have severe social impacts, he warned.

3.2.2 SESSION II

SPEAKERS

Sanjeev Kumar: Nitrogen cycling in Marine and Freshwater Environments

Pradeep Majumdar: Understanding hydrological impacts and uncertainties on river basin scale

N Devaraju: Equilibrium sensitivity of global terrestrial ecosystem: Carbon to elevated nitrogen deposition in community land model 4.0

Sanjeev Kumar: Kumar started with a brief introduction of Nitrogen Cycle and its role in climate and environmental change. Kumar talked about nitrogen cycle, removal and deposition of nitrogen and carbon dioxide take-up process and data analysis using mass spectrometer under fixed temperature and salinity conditions. He also summarized the chlorophyll concentration in the results.

Experiments were first conducted using (different isotopes) of nutrients to check for biological pump in Arabian Sea, near Mangalore. It was checked if phytoplankton can intake the inorganic carbon in the same way even after the increase in seawater temperature due to climate change. Experiments were also conducted by varying temperature and salinity under experimental conductions and results were discussed.

The result was the intake of inorganic carbon was reduced when temperature got increased and salinity decreased. The second part of presentation was to discuss environmental change in the coastal areas of Kerala (estuaries), the effect on backwaters due to anthropogenic activities. Due to the anthropogenic activities, the intake of ammonia and nitrogen increased in those backwaters.

Pradeep Majumdar: He explained the change in precipitation patterns, regional changes in water resources, downscaling of statistical models, A1B scenario and various issues on river water quality, irrigation, water quality simulation and models development at regional level and management of water resources in future. Majumdar started with the brief explanation of climate change and its impacts, increase in temperature (warming), change in precipitation and rise in sea levels and added that these affect hydrology indirectly.

To predict the precipitation, water availability and irrigation requirements, GCMs were used earlier. But there are problems related to scale and uncertainty while dealing with GCMs. GCMs are not efficient in fields of hydrology like evapotranspiration. He said the models were made and checked. Three levels of uncertainties were discussed and results obtained by downscaling.

N Devaraju: Devaraju explained that nitrogen deposition is increasing overtime and their increase is being modeled and added that the influence of nitrogen on concentration-carbon feedback is of greater importance. In his study, a different formula was introduced to find TEC (Total Ecosystem Carbon) sensitivity. N-deposition in future may not be able to compensate warming, he concluded.

An ongoing session on science and impacts

3.2.3 SESSION III

SPEAKERS

Chandra Sekhar Jha: National Carbon Programme

Suchita Srinivasan: Impact of Rainfall and Temperature on Yields of Rice and Millets at the District Level

Rajiv Kumar Chaturvedi: How much Carbon does Indian Forests Hold – A DGVM-based Analysis

Angshuman Modak: Sensitivity of the Global Hydrological Cycle to the Meridional Distribution of Stratospheric Aerosols

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Chandra Sekhar Jha: Jha spoke about the Green India Mission as envisaged under the National Action Plan on Climate Change and the census on natural resources that takes place every five years. He also said that there is need for a country forest map. So far, 113 vegetation types have been mapped and validated using more than 100 ground data points.

Under the National Carbon Programme, forest fire information is given out within 15 minutes, and the 12th Five Year Plan would focus on ocean and atmosphere. Currently, there are five sensor-based towers established in the national ecosystem. The idea is to address the complete phenology of deciduous forests for the first time in India.

Suchita Srinivasan: Asserting that governments should rethink agricultural policy, Srinivasan said increase in temperature affects agricultural yield. She also pointed out that existing policies don't focus on decline in millet production. The emphasis of her study was mainly on the differences between rice and millet on a broader range and not on individual varieties.

Rajiv Chaturvedi: In his study, Chaturvedi showed that land covered by the forests in India is decreasing contrary to established results. He highlighted the effects of climate change on forests, while outlining the mitigation potential of forests.

Angshuman Modak: Modak's ongoing study was done to investigate the effect of meridional distribution of sulfate aerosols into the stratosphere on surface temperature and precipitation change. The study found an ideal distribution, which mitigated both temperature and precipitation.

Forest Ecosystem in India : Carbon Source or Sink

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ABSTRACT

It's a much debated question as to how much carbon does Indian forests hold and whether Indian forests are a net source or sink of carbon? Literature estimates suggest that total carbon stock in Indian forests vary from 6245 million tones of carbon (mtC) to 10,054 mtC, of which an estimated 2026 mtC to 4381 mtC comes from the biomass component and 3552 mtC to 7181 mtC comes from Soil. Review of published studies suggests mean of 3386 ± 989 mtC in biomass and a mean of 5,000 ± 1464 mtC in soils. Carbon stock projections from three carbon pools i.e. biomass, soil and litter are obtained from 11 CMIP5 general circulation models and are analyzed for the Indian forests for the RCP scenarios 4.5, and 8.5 over the 20th century. A mean of 11 GCMs suggests Indian forests to be a source of 1.8 to 2.2 GtC under the RCP scenarios 4.5 to RCP scenario 8.5 respectively.

INTRODUCTION

- Climate projections using Representative Concentration Pathways (RCPs) under the Coupled Model Inter-comparison Project 5 (CMIP5).
- In contrast to the SRES scenarios, RCPs represent pathways of radiative forcing, not detailed socioeconomic narratives or scenarios.
- There are four RCP scenarios: RCP 2.6, RCP 4.5, RCP 6.0 and RCP 8.5 – these scenarios are formulated such that they represent the full range of stabilization, mitigation and baseline emission scenarios available in the literature.
- The naming convention reflects socio-economic pathways that reach a specific radiative forcing by the year 2100.

OBJECTIVES

1) **To investigate how much carbon stock does Indian forests hold? - and whether Indian forests are currently a sink or source of carbon.**
2) **To project carbon stock changes in Indian forests under the new RCP climate change scenarios based on CMIP5 climate change projections.**

METHODOLOGY

- Data downloaded for **Soil Carbon**, **Biomass Carbon** and **Litter Carbon** from the **CMIP5 data portal**.
- **11 models** listed in **Table 2** are considered for this study, as the value of all the three carbon pools were available for these models only.

  Total carbon = Soil carbon + Biomass carbon + Litter carbon.
- As data from all the models is at different resolution, data for each model is regrided to the resolution of **0.5 * 0.5 degrees** using bilinear interpolation.
- Out of all the RCP scenarios (described in **Table 1**) only **RCP 4.5** and **RCP 8.5** are considered, as all the listed 11 models do not provide data for RCP 2.6 and RCP 6.0.
- Carbon flux is calculated with respect to the base line of **1961-1990**.

INFORMATION

Table 1 : Description of all the Representative Concentration Pathways.

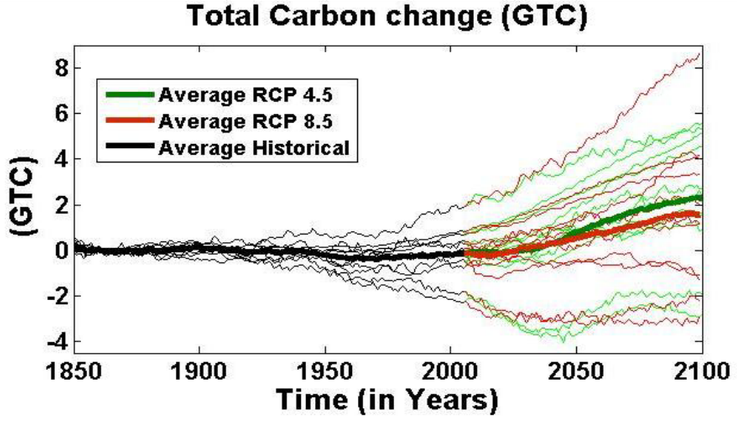
RCP	Description	Developed by
RCP 2.6	Its radiative forcing level first reaches a value around 3.1 W/m2 mid-century, returning to 2.6 W/m2 by 2100. Under this scenario greenhouse gas emissions and emissions of air pollutants are reduced substantially over time	IMAGE modeling team of the Netherlands Environmental Assessment Agency (Van Vuuren et al., 2007).
RCP 4.5	It is a stabilization scenario where total radiative forcing is stabilized before 2100 by employing a range of technologies and strategies for reducing greenhouse gas emissions.	MiniCAM modeling team at the Pacific Northwest National Laboratory's Joint Global Change Research Institute (JGCRI) (Wise et al., 2009)
RCP 6.0	It is a stabilization scenario where total radiative forcing is stabilized after 2100 without overshoot by employing a range of technologies and strategies for reducing greenhouse gas emissions.	AIM modeling team at the National Institute for Environmental Studies (NIES), Japan (Fujino et al., 2006) and (Hijioka et al., 2008)
RCP 8.5	The RCP 8.5 is characterized by increasing greenhouse gas emissions over time representative for scenarios in the literature leading to high greenhouse gas concentration levels.	MESSAGE modeling team and the IIASA Integrated Assessment Framework at the International Institute for Applies Systems Analysis (IIASA), Austria; (Riahi et al., 2007)

Table 2 : List of 11 models from which the data for Soil, Biomass and Litter carbon are obtained.

Modeling Center (or group)	Model	Latitude (in degrees)	Longitude (in degrees)
Beijing Climate Centre, China Meteorological Administration	bcc-csm1-1-m	1.11	1.12
Beijing Normal University, College of Global Change and Earth System Science	bnu-esm	2.76	2.81
Institut Pierre-Simon Laplace, France	IPSL-CM5A-LR	1.89	3.75
Institut Pierre-Simon Laplace, France	IPSL-CM5A-MR	1.89	3.75
Institut Pierre-Simon Laplace, France	ipsl-cm5b-lr	1.89	3.75
Japan Agency for Marine-Earth Science and Technology, The University of Tokyo), and National Institute for Environmental Studies	miroc-esm	2.76	2.81
Japan Agency for Marine-Earth Science and Technology, The University of Tokyo), and National Institute for Environmental Studies	MIROC-ESM-CHEM	2.76	2.81
Max Planck Institute for Meteorology	MPI-ESM-LR	1.84	1.87
Max Planck Institute for Meteorology	MPI-ESM-MR	1.84	1.87
Norwegian Climate Centre	NorESM1-M	1.89	2.50
Norwegian Climate Centre	NorESM1-ME	1.89	2.50

RESULT

Figure 1 : Total carbon change with respect to the baseline 1961-1990. Thin lines represent the carbon change of individual 11 models and the broad line represents the mean of the 11 models listed in Table 2. Black color represents Historical (1850-2005), Green color represents RCP 4.5 (2006-2099) and Red color represents RCP 8.5 (2006-2099).



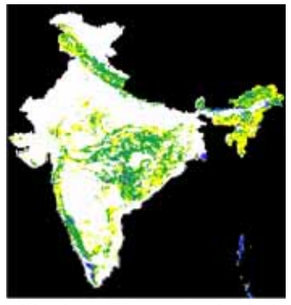


Figure 2 : FSI classification of forested grids in India. 4.3% of grid points (blue) were classified as "very dense forests", 54.9% (green) as "moderately dense forest" and 40.7% (yellow) as "open forests".

CONCLUSION

- There is not much variance in the historical projections (1850-2005). Whereas, the variation increases in the future projections (2006-2099), i.e, RCP 4.5 and RCP 8.5.
- The projections of the models IPSL-CM5A-LR, IPSL-CM5A-MR, MIROC-ESM-CHEM, miroc-esm and bnu-esm are very close to the ensemble projection for both the scenarios RCP 4.5 and RCP 8.5.
- Pre historical data is available and plotted, but the analysis is done from 1961.
- The variation in the projections for RCP 4.5 and RCP 8.5 increases around the year 2050.
- A mean of 11 GCMs suggests Indian forests to be a source of 1.8 GtC under the RCP scenarios 4.5 with the range of 5.8 GtC to -3.2 GtC.
- A mean of 11 GCMs suggests Indian forests to be a source of 2.2 GtC under the RCP scenarios 8.5 with the range of 8.8 GtC to -3.2 GtC.

REFERENCES

1. Ravindranath, N.H., Somashekhar, B.S. and Gadgil, M., Carbon flows in Indian forests. Clim. Change, 1997, **35**, 297–320.
2. Chaturvedi, R.K., Joshi J., Jayaraman M., Bala G., Ravindranath N.H., Multi-model climate change projections for India under Representative Concentration Pathways. Current science, 2012.
3. Hibbard, K.A., D.P. Van Vurren and J. Edmonds., A primer on the Representative Concentration Pathways (RCPs) and the coordination between the climate and integrated assessment modeling communities., *CLIVAR Exchanges*, 2011, **16**, 12-15
4. Chaturvedi R.K., et al. Impact of climate change on Indian forests: a dynamic vegetation modeling approach. Springer , 2010.

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Monitoring Glacier Changes in Parbati Basin, Himachal Pradesh, India

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Introduction:

In the present study, loss in glaciated area of 67 glaciers of Parbati basin has estimated. Major power plants are proposed on Parbati and Beas rivers. It would be useful to continuously monitor these glaciers to understand changes due to climate.

Study area

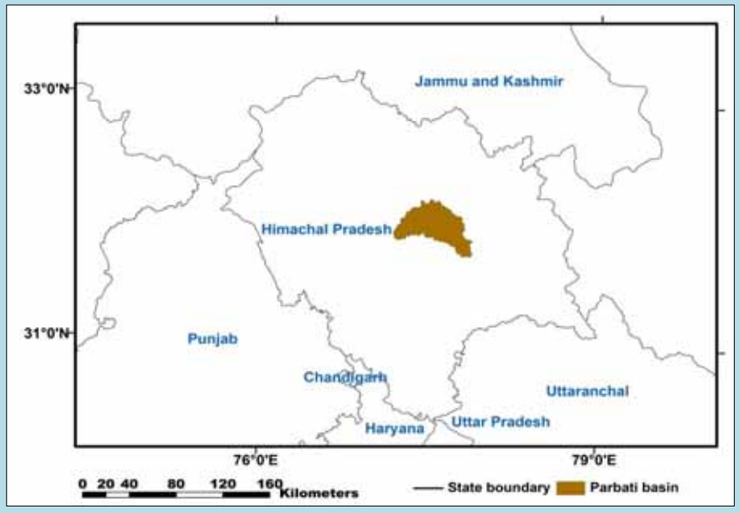

Figure 1: Location map of Parbati basin

The total area of Parbati basin is about 1754.12 sq. km. Altitudinal range of the basin is 1118 to 6196 m.a.s.l.

Data used

Landsat 5 TM - 31 Aug 1998 and 13 Aug 2009 imageries were used . Imageries were downloaded from the USGS archive (http://glovis.usgs.org). ASTER GDEM used as source of elevation.

Methodology

1. Glaciers were delineated by visual interpretation and boundaries digitized in ArcGIS 9.2.
2. Digitized boundaries were used to estimate the loss in area of glaciers.
3. "SWIR / Blue", "SWIR / Green" and "SWIR / Red" ratios were analysed to extract debris cover of glaciers.
4. Further investigations were also carried out to understand effect of size and area altitude distribution on the rate of retreat.

Results and Discussion

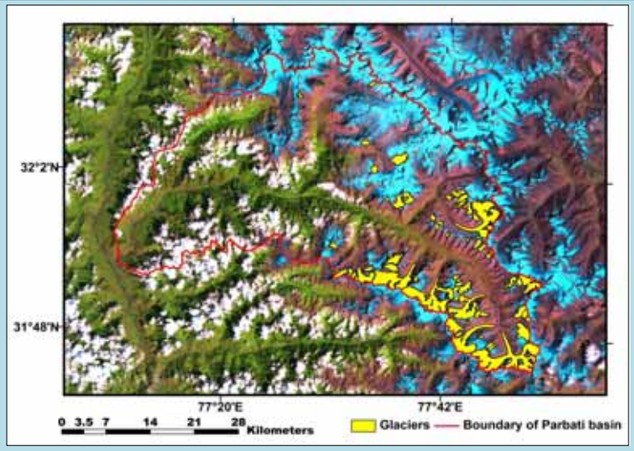

Figure 2: Glaciers of Parbati basin

The total areal extent for 1998 was 154.32 ± 9 sq. km. The total glaciated area for 2009 was 148.90 ± 9 sq. km. Total loss in glaciated area was estimated 5.41 ± 0.2 sq. km or ~3.5 % from 1998 to 2009. Glaciers have been receding at the rate of ~0.49 sq. km a^{-1} or ~0.31 % a^{-1}. This rate is less than the previously estimated rate ~0.5% a^{-1} for 1962 to 2004 for 90 glaciers with the help of topographic maps (Bolch et al, Science, 2012). Estimated loss in area for Parbati glacier is shown in figure 3.

Figure 3: Loss in area of Parbati glacier

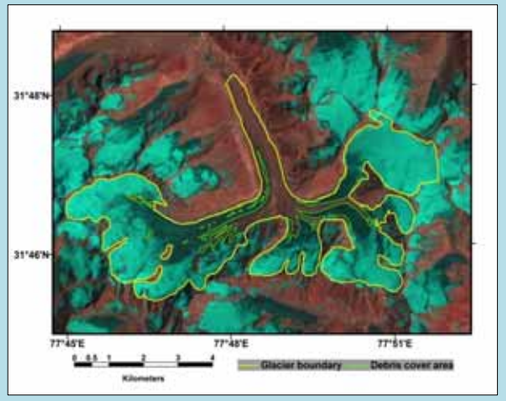

Figure 4: Debris cover of Parbati glacier

The total debris cover for 1998 was ~13.82 sq km (8.9 %). For 2009, total debris cover area was ~17.37 sq km (11.65 %). About ~6 sq km of new area got debris covered between 1998 and 2009.

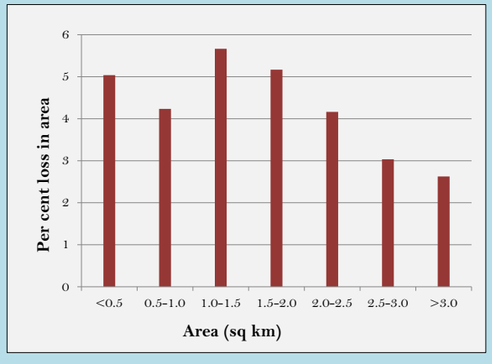

Figure 5: Loss in area of clean glaciers (debris cover <5%)

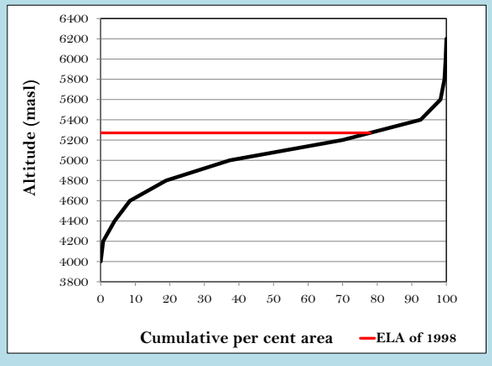

Figure 6: Cumulative area altitude distribution of glaciers

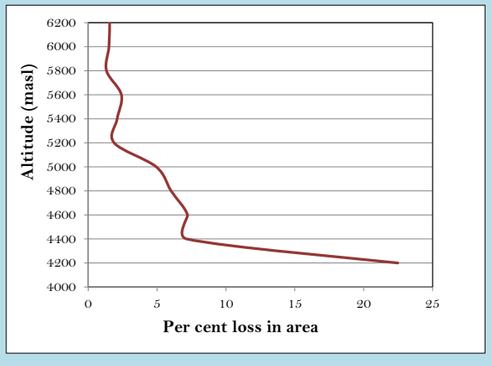

Figure 7. Loss in area at various altitudes

Conclusions

1. Glaciers of Parbati basin have retreated at the rate of ~0.31 % a^{-1} from 1998 to 2009.
2. Smaller glaciers are retreating faster than the larger glaciers.
3. Area loss is high at lower altitudes.
4. Debris cover has increased by ~6 sq km between 1998 and 2009.

Assessing Imprints of Large Scale Phenomena on Climate Extremes in India

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Large scale forcings: ENSO, QBO and AISMR

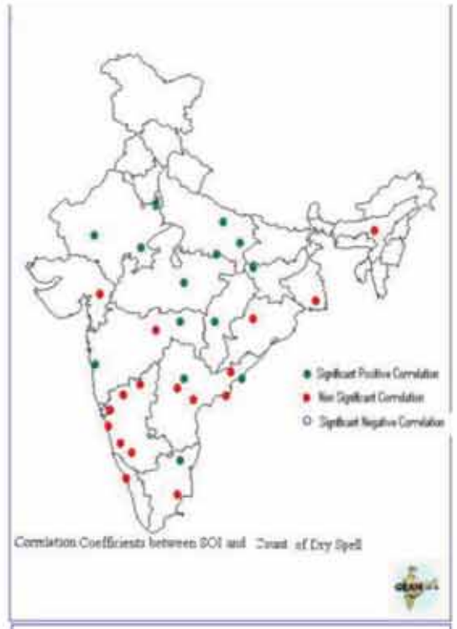
Indices: SOI, Zonal Wind Index and area average of rainfall

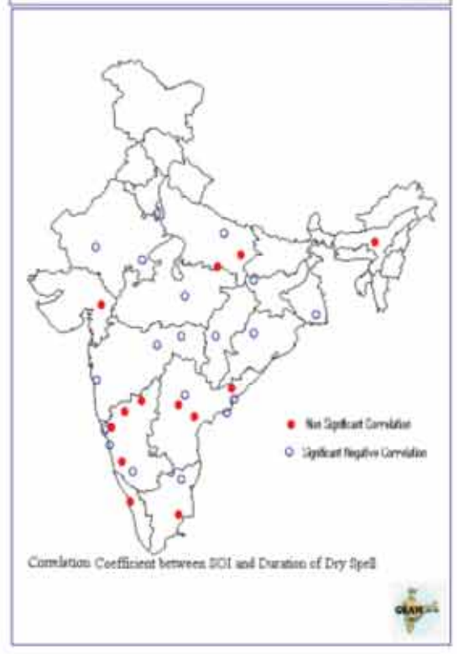
Climate extremes: wet and dry spells and cyclone crossing Indian coastline

ENSO is positively associated with annual count of dry spells but it is restricted only to the north and the interior where rainfall amount is less and negatively correlated with mean duration with more universal effect. It is significantly correlated with the number of depressions crossing the Indian coast.

QBO is negatively correlated with the duration of dry spell.

AISMR is strongly associated with depressions crossing Indian coastline





Present-day climate and future projections for North East India (NEI)

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- **Objective** -The changes in climatic parameters of **temperature** and **precipitation** in NEI are studied in depth. NEI is home to rich flora and eco-biodiversity.
- **Methodology**-
  1. Prevailing **climatic conditions** in the region are analyzed by the observations at the regional meteorological stations in NEI for the years 1971-2005.
  2. Climatic changes have been **validated** using **Regional Climate Model version 3** (RegCM3) to study model performance in the region.
  3. **Extreme temperature events** of daily maximum and minimum temperature have been analyzed on the basis of IMD gridded datasets.
  4. **Projections** to future years on the basis of RegCM3 simulations have studied and discussed with special emphasis to extreme cold and warm temperature events.
- **Conclusion** –
  1. RegCM3 is able to **simulate the trends** in annual mean temperature correctly for 1971-2005. But, **rainfall overestimation** is simulated.
  2. Occurrence of **warm nights in summer months** was more frequent than that of warm days.
  3. Simulations to future years indicate **rise in annual mean temperature** and **annual rainfall**.

ROLE OF BIOAEROSOLS IN CLIMATE CHANGE OVER INDO-GANGETIC PLAIN

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Background

• Bioaerosols are a group of organic aerosols ranging (10 nm-100 μm) are airborne particles or large molecules that are either alive, carry living organisms or are released from living organisms (e.g., bacteria, fungi, virus, pollen, cell debris and bio-films).

• Bioaerosols are Bioaerosol has two significant implications: health hazard and climate change.
• A substantial body of work in progress on the importance of bioaerosol as ice nuclei (IN) and cloud condensation nuclei (CCN) and implicating them in alteration of cloud coverage and hence the global climate.

• Bioaerosols has potential role: -
- in altering the chemistry of the atmosphere via microbiological degradation,
- in modifying the chemical composition of other organic compounds upon collision or contact and hence inducing changes in the IN and CCN ability of organics in atmosphere
- in driving the chemistry (including photochemistry) at environmental interfaces such as air/snow interface.

Objectives

Indo-gangetic plain (21°45 to 31°0 N lat. and 74°15 to 91°30 E long.), covers an area of ~650,000 km^2, roughly 21% of the total area of India. The indo gangetic plains are home to 40% of India's population, being comprised of the states of Punjab, Haryana, Uttar Pradesh (UP), Bihar and West Bengal and experiencing drastic change in the climate in last few decades.

Hence, biological characterization of aerosol is of paramount importance which are neglected in India so far.
- Measurements of ambient particulate matter (PM_{10} and $PM_{2.5}$)
- Biological characterization of aerosols

Methodology

• Sampling was carried out at Agra. In Agra sampling site was Dayalbagh, a suburban site which is 10 km away from the industrial sector of the city where due to agricultural practices vegetation predominates.

• $PM_{2.5}$ and PM_{10} samples were collected at the sampling site by Polltech Sampler using filter paper as collecting surface.

• **Biological characterization:** Aqueous extract of filter was used for fungal and bacterial estimation. The concentration of fungal and bacterial spores in the air is expressed as number of spores m^{-3} air.

- **Fungal culture** – Culturable concentrations of fungi collected on impactors are determined or quantified using SDA media. In order to assess the ability of fast growth of aero fungi, fungi were incubated at 27° C in the SDA media. Fungal spores were identified morphologically under a light microscope using oil immersion at a magnification of 1000x.

- **Bacterial culture** – Bacteria is isolated using Waksman's dilution technique and different concentrations are cultured on nutrient Agar medium. The incubated plates are kept at 30°± 2°C for 1 day. As the colony appears on the medium, it is recultured until pure cultures are obtained. Bacterial spores are identified morphologically under a light microscope using oil immersion at a magnification of 1000x.

• **Meteorological parameters:** were measured along with the sampling

Results and conclusion

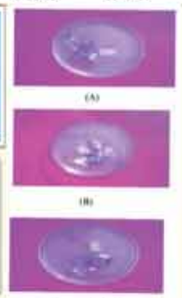
Table: Average, standard deviation and range of concentration (μg m^{-3}) of PM_{10} and $PM_{2.5}$.

Parameters	Mean	Standard deviation	Range	
			Minimum	Maximum
PM_{10}	220.3	86.1	91.7	333.3
$PM_{2.5}$	132.7	37.7	66.7	175.0

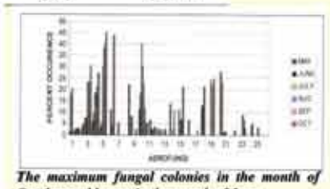
Table: Mean and standard deviation of concentration (cfu m^{-3}) of airborne fungi and bacteria in PM_{10} and $PM_{2.5}$.

Parameters	Mean	Standard deviation	Range	
			Minimum	Maximum
Total microbial count				
PM_{10}	486.9	214.4	125.0	725.2
$PM_{2.5}$	392.8	215.9	125.0	725.2
Fungal counts				
PM_{10}	83.3	15.8	62.5	104.2
$PM_{2.5}$	83.3	17.0	62.5	104.2
Bacterial count				
PM_{10}	403.6	198.6	62.5	625.0
$PM_{2.5}$	309.5	198.9	62.5	625.0

Fungi



Aspergillus



The maximum fungal colonies in the month of October and lowest in the month of June.

Bacteria in sample

Bacteria in blank

Acknowledgement: Financial assistance from the DST, New Delhi is gratefully acknowledged. Assistance from the research students are appreciated.

Table: Correlation matrix in $PM_{2.5}$ and PM_{10}

	$PM_{2.5}$	Bacteria	Fungi	TMC	Tem	RH	WS	WD
$PM_{2.5}$	1.0							
Bacteria	0.14	1.0						
Fungi	-0.27	0.24	1.0					
TMC	0.12	0.99	0.31	1.0				
Temp.	-0.15	-0.27	0.4	-0.23	1.0			
RH	-0.19	0.09	0.74	0.17	-0.17	1.0		
WS	0.16	-0.11	-0.20	-0.13	-0.31	-0.16	1.0	
WD	0.44	0.26	-0.27	0.22	-0.37	-0.29	-0.54	1.0

	PM10	Bacteria	Fungi	TMC	Tem	RH	WS	WD
PM_{10}	1.0							
Bacteria	0.76	1.0						
Fungi	-0.34	-0.44	1.0					
TMC	0.76	0.99	-0.37	1.0				
Temp.	0.48	0.86	-0.19	0.87	1.0			
RH	-0.6	-0.65	0.69	-0.61	-0.55	1.0		
WS	0.1	-0.32	0.27	-0.31	-0.44	-0.13	1.0	
WD	-0.18	0.39	-0.25	0.38	0.55	-0.33	-0.42	1.0

Highlights

❖The concentration of PM_{10} and $PM_{2.5}$ are measured in ambient air at a suburban site in Agra, India.
❖ The level of PM_{10} and $PM_{2.5}$ are much higher than recommended value for suburban region by NAAQS (National Ambient Air Quality Standards) in India.
❖ Agra is one of the polluted cities in India since last one decade and its air quality is not improved yet.
❖ Biological components in aerosol are determined for bacteria and fungi. Bacterial and fungal colonies in PM_{10} and $PM_{2.5}$ are in the typical range 100-1000 cfu m^{-3} (cfu = colony forming unit).
❖ Bacterial concentrations are higher than fungal concentrations. Most of the bacteria are white in colour and gram + ve bacteria contribute 75% while gram - ve contributes 25% only.
❖ A total seven types of fungi are identified in aerosol samples in this region during study period. *Aspergillus niger* species are dominant.
❖ Meteorological parameters play important role in growth and presence of micro-organisms in the air.

The Changing Climate of Ahmedabad City: A Scientific Perspective Based on Multivariate Analysis

Anurag Kandya, Yashika Agarwalla, Kamaljit Ray

GLOBAL BACKGROUND

Globally, urbanization has altered the surface heat flux and the emission flux which has significantly affected the micro and macro climatic trends. Urban Heat Island phenomenon, altered precipitation cycles, and the extended green house gas effect are one of the few artificially induced global environmental hazards.

DATA USED AND RESEARCH METHODOLOGY

DBT, WBT, Wind Speed and RH of Ahmedabad city which were available for a period of 37 years (1969-2006) at a frequency of every 3 hours were analyzed using the Mann-Kendall Trend Test for the various hours of the day. Frequency analysis of the Bioclimatic indices (Thom Discomfort Index, Siple and Passel 'Cooling Index') were done for multiple time scales.

PRESENT STUDY

In the background of the fast rate of urbanization witnessed in Ahmedabad viz. high population growth (110 million by 2035), high vehicular growth rate (8% CAGR) and major developmental plans on the anvil (GIFT City, IT Parks), the present study attempts to quantify the changing climatic trends in the city.

RESULTS AND DISCUSSIONS

Mann-Kendall Trend Test Analysis of the Dry Bulb Temperatures during 1969-2006

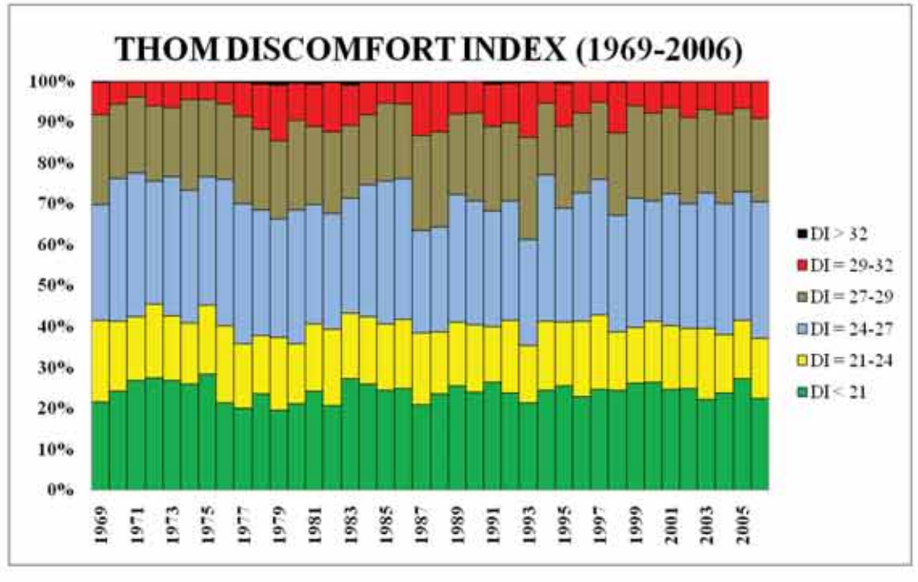
Months	12:00 AM	3:00 AM	6:00 AM	9:00 AM	12:00 PM	15:00 PM	18:00 PM	21:00 PM	Min	Max
January	U	U	N	N	N	D	N	N	U	D
February	U	U	U	U	U	N	N	N	U	U
March	U	U	N	N	N	D	D	N	U	N
April	U	U	D	D	D	D	D	N	U	D
May	U	U	U	N	D	D	N	U	U	D
June	U	U	U	U	U	U	U	U	U	U
July	U	U	N	N	N	N	U	U	U	N
August	U	U	U	U	N	U	U	U	U	N
September	U	U	U	N	N	U	U	U	U	N
October	N	N	N	D	D	D	D	N	N	D
November	U	U	N	N	N	D	D	N	N	N
December	U	U	N	N	N	D	D	D	N	N

U: Upward Trend | N: No Trend | D: Decreasing Trend

Prominent increase in the minimum temperatures

Increase in thermal discomfort

Narrowing of the DTR.



Rainfall and Temperature Characteristics of Four Indian Cities

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➢ Objective

- Current climate and future projections of four cities and corresponding meteorological subdivisions and homogeneous zones in India have been analyzed in this study.
- The cities include **Howrah, Kochi, Madurai** and **Vishakhapatnam** and their corresponding meteorological subdivisions are **Gangetic west Bengal, Kerala, Tamil Nadu** and **Coastal Andhra Pradesh**. The respective homogeneous zones are **North East, West coast** and **East coast**.

➢ Methodology

- IMD gridded data set is used to study the **annual mean temperature** (1969-2005) and southwest monsoon **precipitation** (1951-2010) over four cities and their respective subdivisions and homogeneous zones.
- IPCC models output are compared against the observed values of annual mean temperature and southwest monsoon precipitation to validate the models. **MIROC 3.2 (medres)** model simulates temperature and precipitation close to the IMD observed values.
- **Extreme temperature events** of daily maximum and minimum temperature have been analyzed on the basis of IMD gridded datasets.
- This study is further extended to **future years** with time slices of 2015-2024, 2015-2034, 2015-2044 and 2071-2099 based on output from **NCAR_CCSM3** and discussed with special emphasis to extreme cold and warm temperature events.

➢ Conclusion

- Similar trends in annual mean temperature and southwest monsoon precipitation during current period in the four cities and their corresponding subdivisions and homogeneous zones
- MIROC 3.2 is able to **simulate the trends** in annual mean temperature correctly for 1969-2000. But, **rainfall** is **overestimated** at Madurai and Vishakhapatnam and **underestimated** at Howrah and Kochi.
- **Warm days** and **Warm nights** **show increasing trends** and **Cold days** and **Cold nights** **show decreasing trends** except for Howrah where cold days significantly increase during 1969-2005.
- Future years indicate rainfall and temperature **rise** in all the four cities and their respective subdivisions and homogenous zones.
- There is indication of **rise in warm events** and **fall in cold events** in three cities such as Kochi, Madurai and Vishakhapatnam. In Howrah, there is no trend in extreme temperature events.

Seasonal variations of surface ozone and its precursors over Kannur

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Introduction

Surface ozone is one of the secondary air pollutants whose high concentration is harmful for humans and plants. Ozone absorbs IR radiation emitted by the surface of the earth and thus is classified as one of the green house gases in the troposphere. It does not have direct natural sources, but it is produced in the atmosphere mainly due to its precursors emitted by the increased human activities.

Kannur (11.9^{0}N, 75.4^{0}E, 5m asl), a rural location confined between the costal belt of Arabian sea and Western Ghats in Kerala state.

Observational site and surroundings

Results and Discussion

We have been observed a significant seasonal variation for O_3 and NO_x mixing ratios at this site. The daily average diurnal variation of O_3 shows a maximum mixing ratio in the late afternoon at all seasons due to its enhanced production by the photolysis of NO_2 and minimum during early morning over a period of two year from November 2009 to December 2011.

The average seasonal variations of O_3 mixing ratios are observed to be maximum during winter and minimum during monsoon period. During winter season, long range transport of air mass contributed to the observed high O_3 mixing ratios at this location. While in summer, in spite of higher solar flux, O_3 concentration is low at this site. This may be due to the cloud cover and the higher abundance of humidity due to its proximity with the Arabian Sea.

The organics detected in vapour phase containing traces of alkanes, alkenes, aldehydes and organic acids present in the ambient air at this site amounts to higher concentrations of VOCs which can lead to the production of O_3 through VOC-NO_x cycle.

The correlation between O_3 and meteorological parameters indicate the influence of seasonal changes on O_3 production. Investigations were further extended to explore the week day weekend variations in O_3 mixing ratio at an urban site reveals the enhancement of O_3.

Regional temperature variability in the Western Ghats

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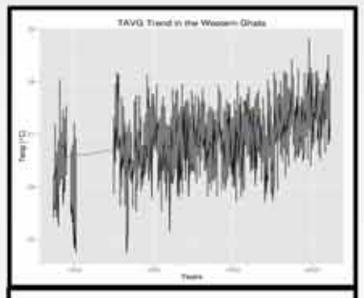
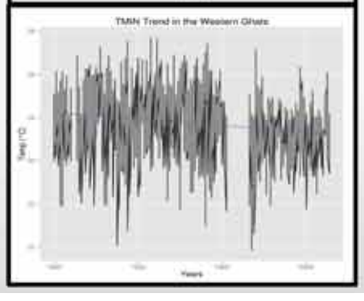
Introduction

- Scale variant mode and impact of climate change necessitates local to regional level assessment
- Surface air temperature records provide invaluable information for those assessments but having limitations in using it in local or regional scale
- Present study assesses the long term temperature variability in the Western Ghats region

Methodology and Results

- Data collection, selection, homogenization and trend analysis
- Significant positive trend in regional average TAVG, TMAX and negative trend in TMIN with site specific variability





Conclusion

- The variability needs to be explored further looking at the local and the ongoing landscapes level changes
- The level of uncertainity has to be evaluated along with Kriging based interpolation to know about the spatial variability and directionality

"Trends in the Rainfall Pattern over India"

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1. Introduction

While occurrences of water bodies across the country depend upon physiographic settings and rainfall conditions, the recharging of the water bodies depends mostly on rainfall which is a highly variable parameter. In the context of climate change, Indian summer monsoon also is changing. The Indian summer monsoon (June to September) rainfall is very crucial for the economic development, disaster management, hydrological planning for the country. Earlier, constructed all India rainfall series was based on 306 uniformly distributed stations ***(Parthasarathy et al., 1994)***. To understand the climatology in a better way, the construction of a homogeneous rainfall data series was the first step in this study.

2. Construction of Homogenous Data Series

To prepare a homogenous rainfall time series, we have selected 1476 rain gauge stations having maximum data availability during the period 1901-2003. We have considered 458 districts for the present analysis. Each of these 458 districts of the country has two or more representing stations. First of all, the district rainfall is calculated as the arithmetic average of rainfall data of stations in the district. Thus, the rainfall data series was constructed as spatially and temporally homogeneous. Rainfall for the meteorological subdivisions (36) was calculated as the area weighted rainfall of the districts within the meteorological sub divisions.

3. Results

3.1. Overall pattern of Rainfall in country

Mean (1901-2003) rainfall of July is 286.5 mm, which is the highest and contributes 24.2 % of annual rainfall (1182.8 mm) while August rainfall is slightly lower and it contributes 21.2% of annual rainfall. June and September rainfall are almost similar and they contributes 13.8 % and 14.2 % of annual rainfall respectively. The mean south-west monsoon rainfall (877.2 mm) contributes 74.2 % of annual rainfall (1182.8 mm). Contribution of pre-monsoon rainfall and post-monsoon rainfall in annual rainfall is mostly the same (11%).

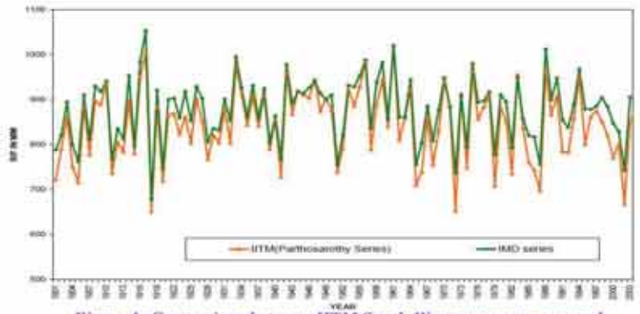

Figure 1: Comparison between IITM South-West monsoons seasonal Rainfall series and the new IMD series

3.2. Epochal patterns of Indian monsoon Rainfall

Decades	Mean Per cent departure from normal	Freq. of Deficient year	Freq. of Excess year
1901-10	-2.2	3	0
1911-20	-2.5	4	3
1921-30	-0.3	1	0
1931-40	1.7	1	1
1941-50	3.3	1	1
1951-60	2.5	1	3
1961-70	-0.1	2	1
1971-80	-0.8	3	1
1981-90	-0.3	2	2
1991-00	0.6	0	1
2001-03	-5.9	1	0

Table 1: Decadal mean (% departure from normal), frequency of drought and flood years

Figure 2: The 31 year moving averages of all India south-west monsoon

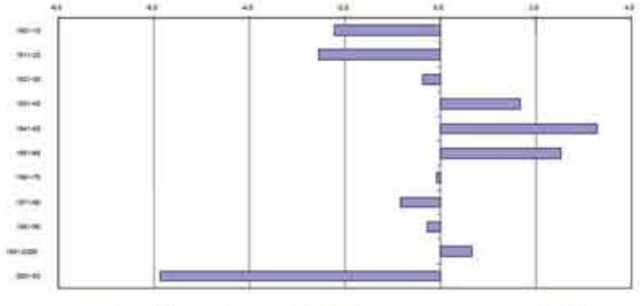

Figure 3:Decadal means of all India summer monsoon rainfall

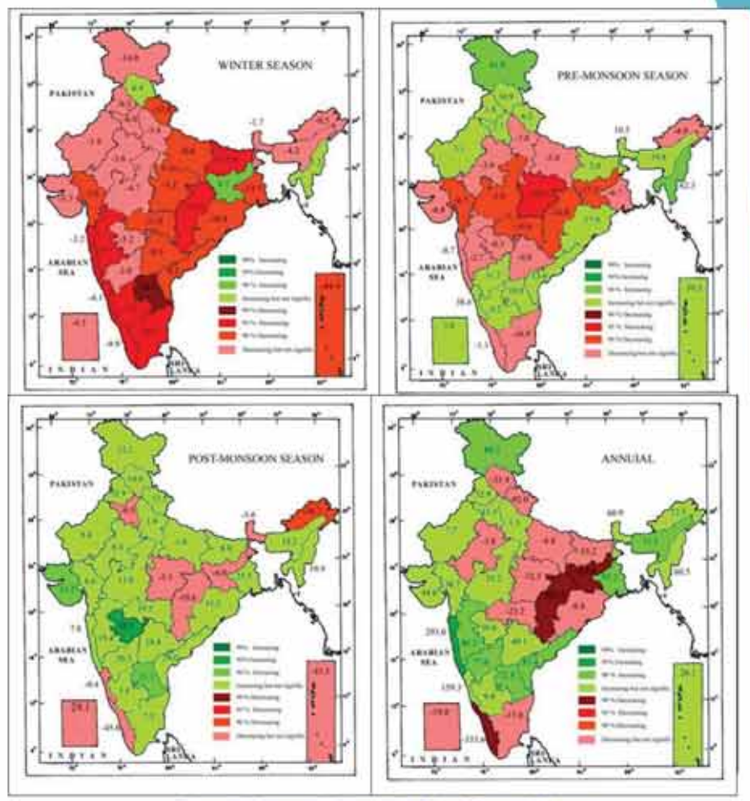

Figure 4: Increase/Decrease in Rainfall over 100 years

4. Conclusion

It has been found that the contribution of June, July and September rainfall to annual rainfall is decreasing for few sub-divisions while contribution of August rainfall is increasing in few other subdivisions. June rainfall is getting importance as its contribution to annual rainfall is increasing in almost 19 sub-divisions while decreasing in the remaining 17 subdivisions.

References

1. Parthasarathy, B., Munot A and Kothawale D R.,(1994).All-India monthly and seasonal rainfall series 1887-1993; *Theoretical and Applied Climatology* **49** 217-224.
2. Pant, G.B. & Rupa Kumar, K., (1997). *Climates of South Asia*. John Wiley & Sons, Chichester, 320 pp.

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Spatio-temporal characteristics of rainfall in the Malaprabha River Basin

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Introduction

Climate change → Changes in the water budget → Needs basin level analysis

Study area

Malaprabha River Basin in North Karnataka

Objective

- Understand the spatial variation and temporal trends in the rainfall

Methodology

- MK test for trend analysis
- SQMK test to identify the beginning of monotonic trends

Data used

- Rainfall data from 11 stations
- Stream flow data
- ENSO and EQUINO indices

Period : 1971-2003

Observations and Discussions

- Large spatial variation in rainfall:
  1800 mm (upper catchment) → < 500mm (command area)
- Temporal variation in rainfall: Decreasing trend in the upper catchment
- A decreasing trend in the stream flow since 1980-85 → Positively correlated with the decreasing trend in the upper catchment rainfall
- Positive correlation between 5year moving average of the stream flow, upper catchment rainfall, and the ENSO and EQUINO indices

A model-based investigation of the relative significance of CO2-fertilization, climate change and nitrogen deposition on Net Primary Productivity and ecosystem carbon storage.

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OBJECTIVE

• The objective of this study is to examine the vegetation responses to elevated CO2 levels, climate change and atmospheric-nitrogen deposition during the 20th century.

METHODOLOGY

•A global climate model, Community Atmosphere Model (version 5.1), coupled to the Community Land Model at 2-degree resolution is used to quantify the responses.

• The model is forced by historical nitrogen deposition data, CO2 concentration scenarios and associated changes in climate for the period 1850-2000.

EXPERIMENTS

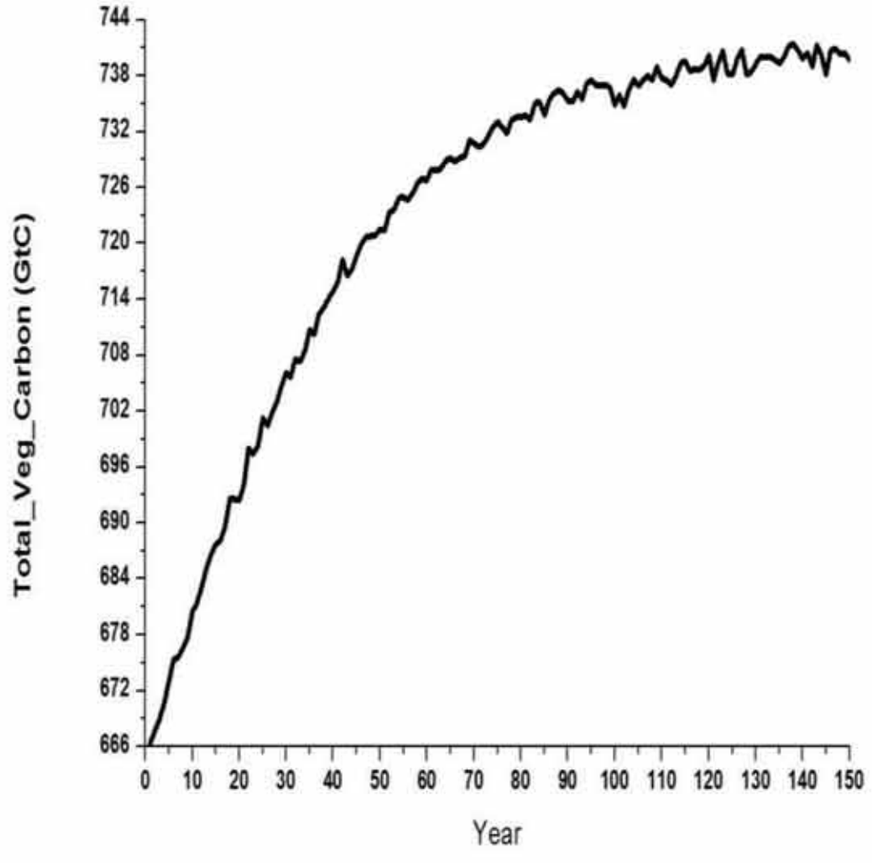
•Well spun up pre industrial state of the model climate.

•Seven 150 year simulations

(1)Control Run

(2) Historical run

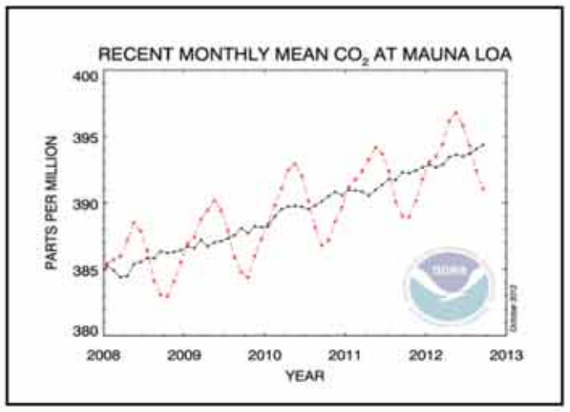
(3) 5 other experiments with varying boundary conditions (CO2 concentration, SST, Nitrogen deposition data)

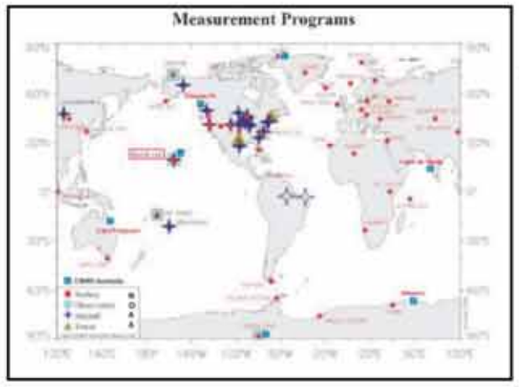


Diurnal & Seasonal variation of mixing ratio and carbon isotopic ratio of air CO_2 over an urban station in India

By TANIA GUHA & PROSENJIT GHOSH
IISc

Background information





Steady rise in CO_2 concentration leads to global warming

Atmospheric CO_2 monitoring stations throughout the world

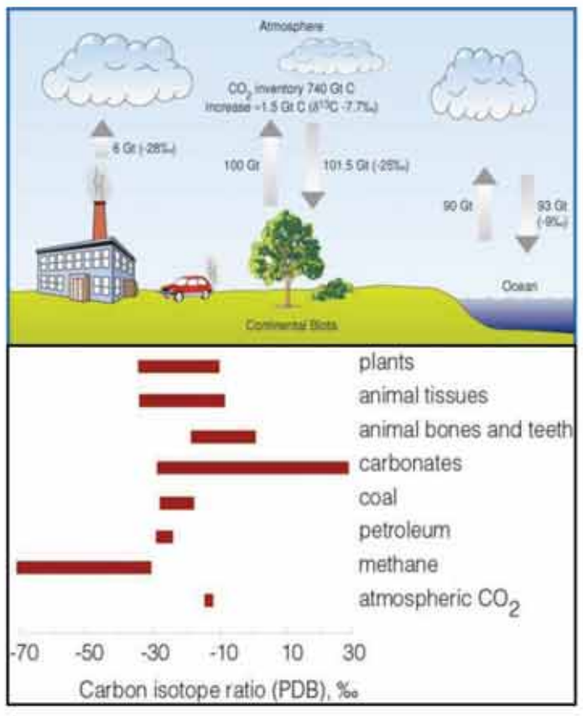
Bangalore- urban station in India for atmospheric CO_2 monitoring

Air CO_2 extraction and measurement

Air CO_2 Sampler

Extraction protocol.

Measurement of isotopic ratios



Seasonal variation of air CO_2 observed at Bangalore

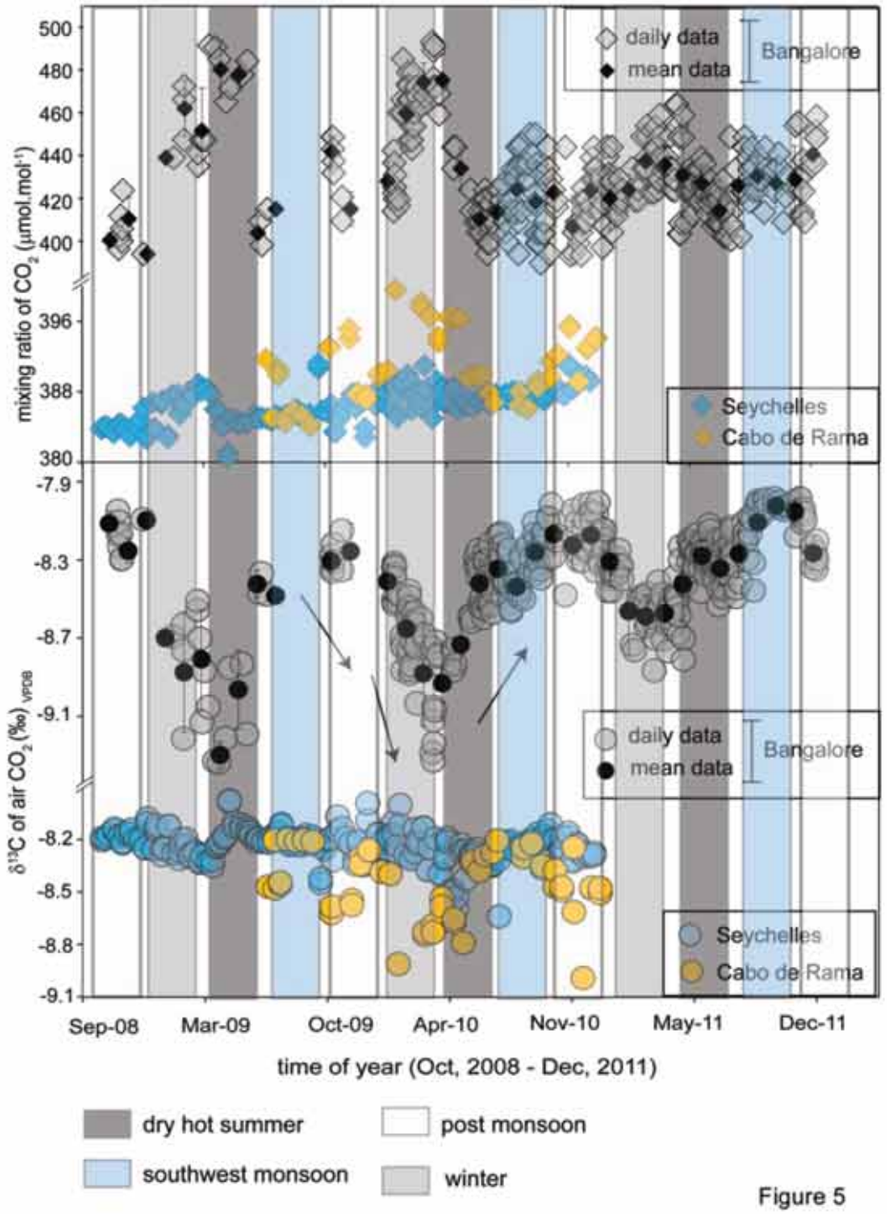


Figure 5

Comparison Of Climate Response To Two SRM Techniques

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MOTIVATION

To perform a comparative study of the climate response to two space based SRM techniques involving stratospheric aerosols and sun reflectors.

METHOD

•In this study we used a Community Atmosphere Model (CAM3.1) coupled to the Community Land Model (CLM3.0) and a slab ocean model(SOM) developed by NCAR to perform

• Geoengineered simulation with sulphate aerosol **(Geo-Sulphate)**

• Geoengineered simulation with reduction of solar constant **(Geo-Solar) .**

PRELIMINARY FINDING

We observed a warming of 0.6 K in the stratosphere in the **Geo-Sulphate** simulation whereas a cooling of 0.4 K in the **Geo-Solar** simulation.

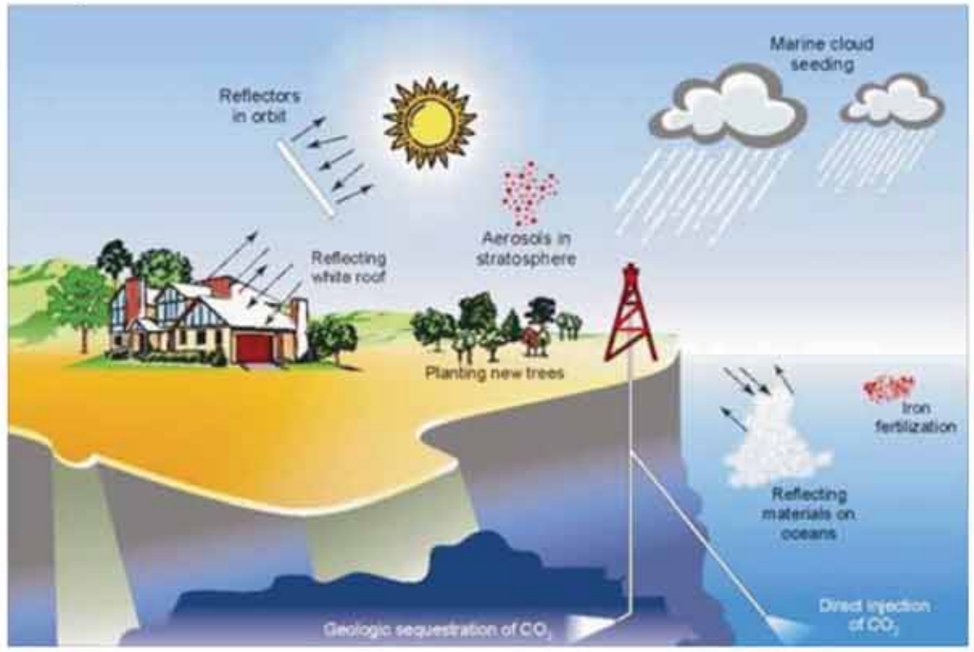

Fig1:Schematic representation of various geo-engineering proposals G.Bala Current Science 2009

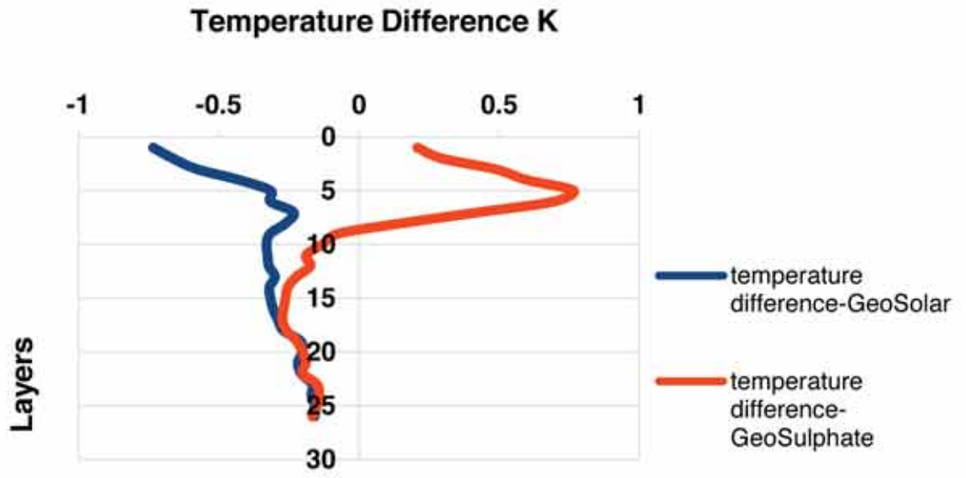

Fig 2: Temperature Difference Profile

Climate Change and Agricultural Productivity: A Case Study of Maize in India

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Abstract

The issues of climate change gained its momentum only in the latter part of the twentieth century, when the world started witnessing global warming. It has been addressed as the greatest and widest market failure ever occurred to mankind that has resulted due to externalities. Though all the consequences of such a change are yet to be fully understood, three main issues can be addressed in this regard. They are the impacts on agriculture, sea level rise, and the increase in number of frequency of extreme events, resulting in a serious threat to mankind. In our study we have concentrated only on the impact of climate change on agriculture. We have further narrowed down our study to the impact of climate change in India by studying the case of maize, a very sensitive crop to climate.

In India, agriculture mostly depends on the mercy of monsoons and the environment. Several factors directly connect the change in climate and agricultural productivity such as average increase in temperature, change in rainfall amounts and patterns, rising atmosphere concentration of carbon dioxide, change in climate variation and extreme events etc. These factors have their direct and indirect effects on crops, soils, livestock and pests.

With the help of metrological and agricultural data the paper tries to give the aggregate picture of the change in climate in the past five decades in India. Various climate indicators have been examined using traditional (indexing and percentage change) and modern (spectral) methods. Cross spectral analysis is also carried out between climatic variables (temperature and precipitation) and maize yield (partial productivity), in order to understand the inter-relationship between them.

Our traditional analysis suggests Kerala is one of the states which has been quite stable in the past five decades with respect to climatic conditions. On the other hand Jammu and Kashmir is one among the worst affected State in India with respect to the increasing trend in temperature and decreasing trend in precipitation. A comparison of maize yield revealed that Jammu and Kashmir has been affected more than Andhra Pradesh, which was blessed by increase in precipitation and decrease in temperature. The results provide a strong support to our hypothesis that climate change does have a vital role to play in agricultural yield.

The spectral analysis results indicated that there are much cyclical or short term fluctuations in terms of temperature than in precipitation in India with an increasing spectral density curve. This is quiet uncommon in economic series. We also find that there is a significant long run relationship among yield and climatic variables, depicting the dependency of yield of maize on climatic variables.

In brief, our study suggests a strong long-run relationship, between climate change and yield. Since our study has mostly concentrated on temperature and precipitation, therefore, further in-depth analysis is required and a multivariate framework is needed for a much better understanding of the issue at hand. The need for similar analysis for other crops is also very urgent to initiate a comprehensive public policy to tackle the impact of climate change in food production in India.

The Traditional Method

$$I_i = \text{Maxi} - \text{Xi} / \text{Maxi} - \text{Mini}$$

$$1/6 \sum \text{Ii}$$

Ranks of State by Climate Index

State(s)	Rankings					
	1950s	1960s	1970s	1980s	1990s	2000
Andhra Pradesh	8	7	4	8	7	5
Arunachal Pradesh	14	12	12	13	16	13
Assam	6	2	5	5	6	6
Bihar	5	8	3	10	11	9
Delhi	12	15	7	12	13	11
Gujarat	8	11	3	9	9	8
Haryana	11	13	6	12	14	10
Himachal Pradesh	16	17	12	15	19	14
Jammu & Kashmir	17	18	15	16	20	15
Karnataka	8	6	8	9	12	7
Kerala	2	1	2	3	3	1
Madhya Pradesh	3	9	9	7	3	6
Maharashtra	4	10	1	4	3	4
Manipur	11	7	11	11	15	12
Meghyalaya	1	5	3	6	2	1
Mizoram	1	3	3	2	1	3
Nagaland	13	11	13	13	17	13
Orissa	7	5	4	7	5	7
Punjab	9	15	5	11	13	10
Rajasthan	9	11	3	11	10	8
Sikkim	15	16	14	14	18	14
Tamil Nadu	10	5	9	12	11	7
Tripura	1	4	7	1	1	2
Uttar Pradesh	5	14	10	6	8	8
West Bengal	3	10	3	8	4	7

Source: www.indiawaterportal.com.

Percentage Change of Temperature and Precipitation by States and Union Territories

States	%change in 60s over 50s		%change in 70s over 60s		%change in 80s over 70s		%change in 90s over 80s		%change in 2000s over 90s		%change in 2000s over 80s	
	T	P	T	P	T	P	T	P	T	P	T	P
A.P	2.35	5.5	-1.06	18.2	3.16	-13.2	-1.87	1.16	24.1	3.71	-1	30.5
Ar P	3.53	-14.6	-5.98	30.5	1.87	-3.3	-0.05	0.78	5.3	2.01	-9.3	2.7
Asm	3.86	-3.1	-3.88	24.9	1.27	-18.2	-0.26	0.95	14.3	1.79	-7.9	4.3
Bhr	2.84	-10.4	-1.76	23.9	0.56	-13.9	-0.59	1.8	7.8	2.81	-35.7	-33.7
Dli	3.45	-22.9	0.28	-3.8	1.24	7.6	-2.02	0.8	22.7	3.75	-17.5	-19.3
Guj	1.86	-32.6	0.3	85.2	1.64	-25.6	-1.05	0.88	15.1	3.67	-31.4	-26.6
Hry	3.64	-37.4	0.16	6.4	-0.67	38	-1.25	2.13	-0.5	3.99	-22.4	-29
H.P	5.83	-36.1	0.07	-25.4	-2.65	117.5	-0.1	3.91	-8.2	7.01	-40.9	-43.8
J&K	6.57	-42.4	4.45	-23.7	-3.45	87.6	1.27	3.32	12.3	12.46	-50.8	-54.4
Kts	2.24	-16.3	-0.77	7.2	1.62	5	-0.79	0.73	-21.4	3.03	51.9	-2.4
Krl	1.89	19.6	1.88	-0.4	0.18	-8	2.83	-0.02	-8.2	2.94	15.6	16.2
M.P	1.93	21.3	-0.08	8.9	1.38	-20.6	-1.31	1.95	46.5	3.68	-43.3	-12.8
Mha	1.26	13.9	-0.29	21.3	2.25	-22.7	-2.73	1.8	24.8	2.23	-28.1	-4.1
Map	2.2	-0.1	-1.6	-2.6	1.66	2.5	-1.12	0.3	0.1	1.4	-6.5	-6.7
Meg	3.03	-3.8	-3.42	51.5	1.23	-36.7	-1.14	2.29	76.8	1.86	-4.9	6.1
Miz	0.03	-3.6	0.73	21.8	1.23	-21.9	-0.2	-1.57	13.7	0.16	-7.5	-3.6
Nld	4.53	-8.6	-4.5	10.9	2.12	-4.3	-0.46	0.78	5.8	2.27	-12.5	-10.2
Ors	2.16	23.6	-1.16	3.5	1.05	10	-1.39	2.02	22.3	2.65	-33.2	15
Pb	4.14	-56	0.2	7.1	-1.45	118.7	-1.7	2.99	-12.4	4.11	-37	-43.1
Rj	2.58	-19.1	0.44	47.2	0.97	-31.5	-1.09	2.23	41.6	5.39	-35.2	-25.1
Skm	2.11	-10.7	-1.73	8	1.56	11.7	0.76	-0.43	3.6	2.22	-18	-8.4
T. N	0.82	20.9	-0.26	3.2	1.24	-19.5	1.31	-0.23	14.1	2.91	17.4	34.9
Tri	0.42	7.7	-0.47	-12.9	0.61	7.6	0.45	-1.13	-3.6	-0.14	-0.1	-2.8
U.P	2.91	8.6	-1.18	7.3	0.03	11.4	-0.37	1.91	-14.4	3.27	-37	-30
W.B	1.66	-4.2	-1.37	16.2	0.01	-8.7	0.31	0.72	34.1	1.31	-35.1	-11.5

Source: www. indiawaterportal.com.

Note: T= Temperature; P=Precipitation; A.P= Andhra Pradesh; Ar. P= Arunachal Pradesh; Asom Assam; Bhr=Bihar and Jharkhand ; Dli= Delhi; Guj= Gujarat; Hry= Haryana; H.P= Himachal Pradesh; J&K= Jammu and Kashmir; Knr= Karnataka; Krl= Kerala; Map= Manipur; Meg= Meghalaya; Miz= Mizoram; Nld= Nagaland; M.P= Madhya Pradesh and Chattisgarh; Mha= Maharashtra; Pb=Punjab; Rj= Rajasthan; T.N= Tamil Nadu; UP= Uttar Pradesh and Uttarakhand; and W.B= West Bengal.

Ranks of State by Area, Production and yield (Triennium Average, 2001-03)

State(s)	Area (% of total)	Ranking	Production (% of total)	Ranking	Yield (q/ha)	Ranking
Andhra Pradesh	8.29	5	14.06	1	32.21	1
Madhya Pradesh	12.94	3	13.12	2	19.32	5
Rajasthan	15.40	1	11.46	3	14.01	9
Karnataka	9.15	4	10.50	4	22.62	2
Uttar Pradesh	13.11	2	9.60	5	13.68	10
Bihar	7.27	6	8.95	6	22.25	3
Gujarat	6.89	7	6.51	7	18.06	7
Maharashtra	5.35	8	5.42	8	19.25	6
Himachal Pradesh	4.44	10	5.13	9	22.02	4
Jammu and Kashmir	4.84	9	3.98	10	15.73	8

Source: Chauhan et al., 2007.

Percentage Change in Area, Production and Yield by States Producing Maize

State	%change in 60s over 50s			%change in 70s over 60s			%change in 80s over 70s			%change in 90s over 80s			%change in 2000s over 90s			%change in 2000s over 80s		
	A	P	Y	A	P	Y	A	P	Y	A	P	Y	A	P	Y	A	P	Y
A.P	-0.7	4.9	-5.4	10.4	67.6	111.0	2.5.2	110.8	68.3	-1.3	-1.1	-1.7	70.6	144.9	43.5	54.8	417.1	1132.1
Asm	-20.2	-3.1	-1.1	-12.9	11.7	28.3	85.2	9.8	8	-8.8	-3.7	5.4	-1.9	13.2	15.5	-5.7	12.31	16.8
Bh	-46.9	68.7	46.7	33.4	134.8	81.3	-12.5	-41	-13.4	7.1	78.1	35.3	-1.3	-23.9	44	-15.8	96.8	274
H.P	39.6	39.6	39.6	39.6	39.6	39.6	19.7	-11.2	-19.8	18.9	52.8	27.8	-4.6	4.4	11.7	4.4	93.1.8	142.8
J&K	-54.9	38.4	233.5	61.3	108.1	-29	2.15	34.7	31.8	8.2	-8.7	-14.5	10.9	18	8.5	-33.8	548.4	403.8
Kats	-34.2	80	75.2	478.2	2180	294.4	148.9	83.5	-25.6	66	67.4	5.3	167.9	238.7	26.4	2687.1	4260.2	583.7
M.P	-48.7	54.5	129.7	28.7	113.5	67.5	-34.9	-2.2	8.4	26.8	85.3	35.5	-4.3	8.6	-43.1	-47.8	1007.3	171.4
Mh	-30.7	39.6	96.6	51.4	55.2	39.6	-17.8	-30	15.8	10.2	170.4	-11.3	-4.8	-11	-37.7	-34.8	448.7	307.3
Ori	-34.4	-30.8	20.6	228.4	158.8	100.5	158	101.9	17.7	42.8	18.9	20.3	-23.1	68.7	2.3	-40.1	430	273.4
Pb	-42.7	228.7	158.2	-58	-30.2	2.2	-52.4	-50.8	1.1	-30.7	-44	17.4	-39	28.8	88.8	-89.4	14.8	418.7
Rj	-21.2	466.3	223.3	24	78.3	42.4	19.9	-15.5	28.9	9.2	85.9	51.9	-1.4	-22.1	-25	26.1	1084.1	290.7
T.N.	30	39	33.9	17.8	155	83	41	37.2	-2.7	40.3	108.6	48.9	196.4	239.4	7.7	725	1397.3	95.8
U.P	-47	73.9	68.2	38.1	59	15.3	-17.4	-74.7	-6.8	-11	58.8	19	-18.1	6	23.1	-35.9	59.5	133.6
W.B	-38.8	51.6	84.2	-8.9	2.3	12.4	3.34	15.6	12.1	22.85	46.8	18.5	-45.4	8.2	98	-74	134.8	389.4

Source: Agricultural Census of India (Various issues)

Note: A= Area, P= Production, Y= Yield; A.P= Andhra Pradesh; Asm= Assam; Bh=Bihar and Jharkhand; H.P= Himachal Pradesh; J&K= Jammu and Kashmir; Knr= Karnataka; M.P= Madhya Pradesh and Chattisgarh; Mha= Maharashtra and Gujarat; Pb=Punjab and Haryana; Rj= Rajasthan; T.N= Tamil Nadu; U.P= Uttar Pradesh and Uttarakhand; and W.B= West Bengal

Coherency of Climate and Yield by States

Frequency	Yield - Temperature	Yield - Precipitation
All Frequencies	Andhra Pradesh, Tamil Nadu	Madhya Pradesh, All India
0-0.09	Andhra Pradesh, Madhya Pradesh, Uttar Pradesh, Jammu and Kashmir, Karnataka, Tamil Nadu, Haryana and Punjab,	Madhya Pradesh, Uttar Pradesh, Orissa, All India
0.1-0.19	Orissa	Madhya Pradesh, Jammu and Kashmir, Rajasthan, Bihar, Gujarat and Maharashtra
0.2-0.29	Gujarat and Maharashtra, Karnataka, Tamil Nadu	Gujarat and Maharashtra, Haryana and Punjab, Madhya Pradesh
0.3-0.39	Andhra Pradesh, Tamil Nadu, Rajasthan	Madhya Pradesh, Uttar Pradesh, Karnataka, Rajasthan,
0.4-0.5	Andhra Pradesh, Madhya Pradesh, Haryana and Punjab, Uttar Pradesh	Madhya Pradesh, Karnataka

Source: www.indiawaterportal.com and Agricultural Census of India (Various issues).

Phase Summary of Yield and Precipitation

State(s)	No of observations	Phase Mean(ph)	Coherence	Significant.
Andhra P	26	0.41	0.16	NSig
Assam	26	-0.4	0.08	NSig
Bihar	26	-0.07	0.14	NSig
Gujarat & Maharashtra	26	0.99	0.17	NSig
Haryana & Punjab	26	0.70	0.24	NSig
HP	26	-0.66	0.25	NSig
J&K	26	0.25	0.03	NSig
Karnataka	26	0.53	0.33	Sig
MP	26	-0.08	0.96	Sig
Orissa	26	-0.76	0.15	NSig
Rajasthan	26	1.18	0.50	Sig
TN	26	-0.07	0.14	NSig
UP	26	-0.11	0.07	NSig
WB	26	0.23	0.25	NSig
All India	26	0.35	0.19	NSig

Note: Sig= Significant and Nsig= Non-significant
Source: www.indiawaterportal.com and Agricultural Census of India (Various issues)

Phase Summary of Yield and Temperature

State(s)	No of observations	Average phase (ph)	Coherence	Significant
Andhra P	26	-0.04	0.14	NSig
Assam	26	-0.04	0.09	NSig
Bihar	26	1.00	0.05	NSig
Gujarat & Maharashtra	26	-0.31	0.44	Sig
Haryana & Punjab	26	0.3	0.28	NSig
HP	26	0.30	0.03	NSig
J&K	26	-0.93	0.15	NSig
Karnataka	26	-0.42	0.25	NSig
MP	26	0.01	0.41	Sig
Orissa	26	0.25	0.20	NSig
Rajasthan	26	-0.04	0.21	NSig
TN	26	0.05	0.35	Sig
UP	26	1.01	0.15	NSig
WB	26	-0.60	0.15	NSig
All India	26	-1.09	0.12	NSig

Note: Sig= Significant and Nsig= Non-significant
Source: www.indiawaterportal.com and Agricultural Census of India (Various issues)

Coherency Summary-significance

Frequency	Yield - Temperature	Yield - Precipitation
All Frequencies	Andhra Pradesh, Rajasthan, Tamil Nadu, West Bengal	Karnataka, Rajasthan, Madhya Pradesh
0-0.09	Andhra Pradesh, Bihar, Haryana and Punjab, Jammu and Kashmir, Tamil Nadu, West Bengal	Assam, Bihar, Haryana and Punjab, Himachal Pradesh, Jammu and Kashmir, Karnataka, Madhya Pradesh, Orissa, Uttar Pradesh
0.1-0.19	Himachal Pradesh, Jammu and Kashmir, Orissa, Rajasthan, West Bengal	Bihar, Gujarat and Maharashtra, Jammu and Kashmir, Madhya Pradesh, Rajasthan, Tamil Nadu
0.2-0.29	Andhra Pradesh, Karnataka, Orissa, Rajasthan, Tamil Nadu, West Bengal	Gujarat and Maharashtra, Haryana and Punjab, Madhya Pradesh, Rajasthan
0.3-0.39	Andhra Pradesh, Assam, Haryana and Punjab, Rajasthan, Tamil Nadu, West Bengal	Karnataka, Madhya Pradesh, Rajasthan
0.4-0.5	Andhra Pradesh, Assam, Madhya Pradesh, Uttar Pradesh, West Bengal	Madhya Pradesh, Karnataka

Source: www.indiawaterportal.com and Agricultural Census of India (Various issues).

Long Run Relationship Between Yield and Temperature By State

State(s)	Average Phase (ph)	Coherence	Significant
Andhra P	1.04	0.62	Sig
Assam	0.19	0.09	NSig
Bihar	0.33	0.30	Sig
Gujarat & Maharashtra	1.26	0.23	NSig
Haryana & Punjab	1.72	0.30	Sig
HP	-0.59	0.05	NSig
J&K	0.49	0.62	Sig
Karnataka	-1.58	0.43	Sig
MP	0.94	0.56	Sig
Orissa	1.34	0.17	NSig
Rajasthan	0.45	0.06	NSig
TN	0.12	0.57	Sig
UP	1.90	0.18	NSig
WB*	0.01	0.96	Sig
All India*	-1.45	0.30	Sig

Source: www.indiawaterportal.com and Agricultural Census of India (Various issues
Note 1. (*) denotes Nonlinear trends, all other are linear trend
2. Sig= Significant and Nsig= Non-significant

Long Run Relationship Between Yield and Precipitation By State

State(s)	Average Phase (ph)	Coherence	Significant
Andhra P	0.82	0.12	NSig
Assam	-1.22	0.22	NSig
Bihar*	-0.99	0.30	Sig
Gujarat & Maharashtra	-1.77	0.22	NSig
Haryana & Punjab*	-0.77	0.30	Sig
HP*	2.48	0.55	Sig
J&K	-0.15	0.30	Sig
Karnataka	1.49	0.08	NSig
MP	-0.03	0.95	Sig
Orissa	-1.33	0.38	Sig
Rajasthan	-0.88	0.03	NSig
TN	-0.94	0.13	NSig
UP	-1.27	0.45	Sig
WB	0.09	0.30	Sig
All India	2.41	0.11	NSig

Source: www.indiawaterportal.com and Agricultural Census of India (Various issues)
Note 1. (*) denotes Nonlinear trends, all other are linear trend
2. Sig= Significant and Nsig= Non-significant

Vegetation dynamics in sub tropical temperate vegetation in Himachal Pradesh using Spatially Explicit Individual Based(SEIB) - DGVM

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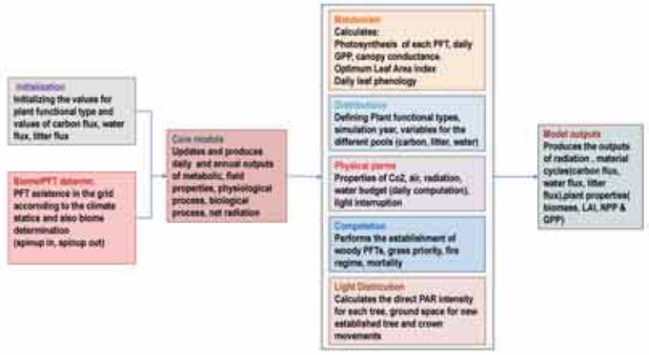
- A dynamic global vegetation model (DGVM) is a computer program that simulates shifts in potential vegetation and its associated biogeochemical and hydrological cycles as a response to shifts in climate.
- SEIB : Spatially Explicit Individual Based Simulator (*Sato, Itoh, & Kohyama : JAMSTEC, NIES and Hokkaido Univ)*
- Current DGVMs rely on two dimensional representation of radiation model
- 3D light interception in SEIB
- Better photosynthesis model, improving upon Farquhar method (which is a unpredictable and quite linear)
- Outputs of SEIB connects well with field parameters and better validation
- Scope to account high amount of variation in vegetation dynamics
- Hence best suited for Tropical – Temperate vegetation scenarios of Indian subcontinent
- Components of dynamic global vegetation model are: Physics, physiology and Ecological dynamics

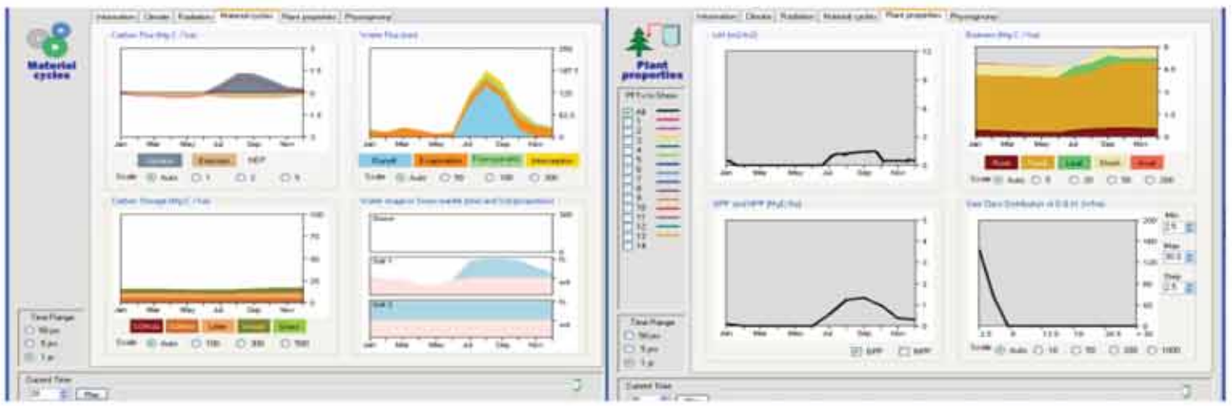
Objective : Develop understating on operation of a DGVM and initial analysis of vegetation simulation at fine scale.

Climate data (NCEP/NCAR)

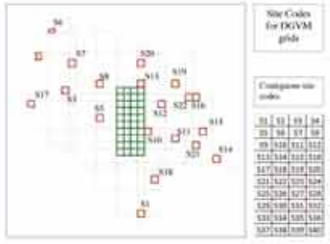
Components of SEIB – Functional design



Material flows and plant properties outputs from SEIB



Total sites simulated and corresponding 10kmX10km grids for contiguous transect and discrete sites



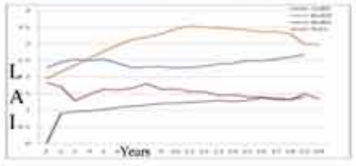
Results of current experiment

Transition of Biomes

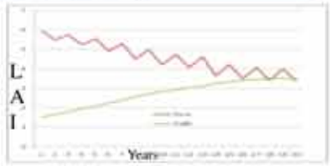
Leaf Area Index – Annual pattern

Variation in Biomass for a biome category

Patterns of Leaf Area Changes



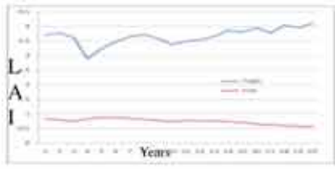
S5 - Boreal Evergreen Forest/Woodland



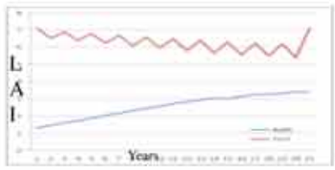
S10 - Moist Savannah

Plant Functional Types observed

Temperate broad-leaved evergreen (TeBE)
Temperate broad-leaved summer green (TeBS)
Boreal needle-leaved evergreen (BoNE)
Boreal broad-leaved summer green (BoBS)
Temperate herbaceous(C3) (TeH)
Tropical herbaceous(C4) (TrH)



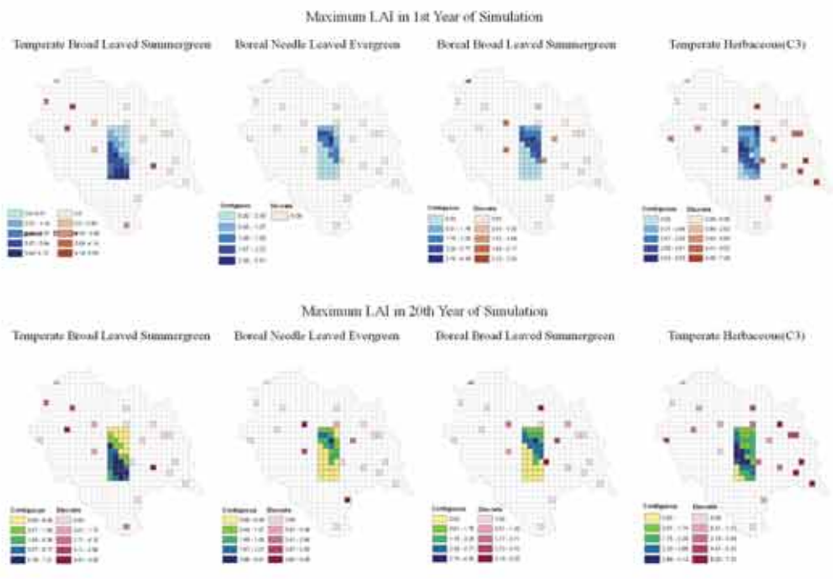
S1 - Temperate Deciduous Forest



S17 - Moist Savannah

S14 - Arctic Alpine Tundra

Maximum LAI achieved by sites over period of twenty years based on NCAR reanalyzed climate data



- Characteristic transition of biomes is observed in few sites. Even in two decades model response seems promising (at least two in each region)
- Savannahs seem to get populated by tree population even in BAU scenario
- Biomass patterns at this initial stage confirm with published quantities
- Boreal systems can show low biomass which needs further focus
- Warm systems (deciduous and savannah) continuously put on trunk biomass (can be good sinks)

Perception Analysis of Climate Related Impacts Faced by Agricultural Communities Using Fuzzy Cognitive Mapping Approach

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1. Background

- Strong scientific evidence of climate change impacts on communities is apparent.
- The objective is to create knowledge on the impacts of climate change on agricultural systems by understanding the perception of stakeholders so that planned adaptation interventions can be made in lieu of climate related impacts.
- This paper documents perception of agricultural communities in Gujarat on climate related impacts using a Fuzzy Cognitive Mapping (FCM) approach.
- The outcome of the FCM approach is in a form of networks, as understood by the agricultural community.
- Documenting these cause-effect networks enabled us to understand the major impacts caused due to climate change on agricultural communities.

2. Methodology

- The spatial focus of investigation is six villages of the Junagadh district of Gujarat (Moti Dhanej, Khorasa, Kadaya, Ghumkuti, Nani Dhanej and Galoda) where agriculture is the predominant livelihood.
- In the initial phase of the study group interviewees was carried out in each of the six villages. A total of 34 participants contributed to the five group interviews.
- The FCM approach leads to Fuzzy Cognitive Maps (FCMs) which are graphical and mathematical representations of variables and their connections forming causal relations in a given system in the form of directed networks.
- For our analysis we use a partial multi-step FCM approach adapted from Özesmi and Özesmi (2004), which includes the following steps :
  a. Determining if the sample size is adequate.
  b. Drawing of cognitive maps.
  c. Coding the cognitive maps into adjacency matrices
  d. Augmenting individual cognitive maps and then adding them together to form stakeholder social cognitive maps.
  e. Analyzing the structure of individual and social cognitive maps using graph theoretical indices.
  f. Analyzing the differences and similarities in variables among stakeholder groups.
  g. Condensing complex cognitive maps into simpler maps for comparison purposes.
- The *hypothesis proposed* here is that, *it is important to understand stakeholder's perception of climate and weather impacts as communities cannot adapt or will not interfere in a detrimental cause-effect relationship if they don't "see" the relation*, which has also been proposed by Reckien et al (2010).
- Different groups of agricultural landowners were approached in the six villages of Junagadh district asking them to reflect on the question: What are the impacts on your livelihood due to increase in winter temperature?

3. Results

- Fuzzy Cognitive Maps are based on fuzzy logic and this tools helps in mapping perception of people. The figure below is an example of a Fuzzy Cognitive Map made based on the perception of a stakeholder community

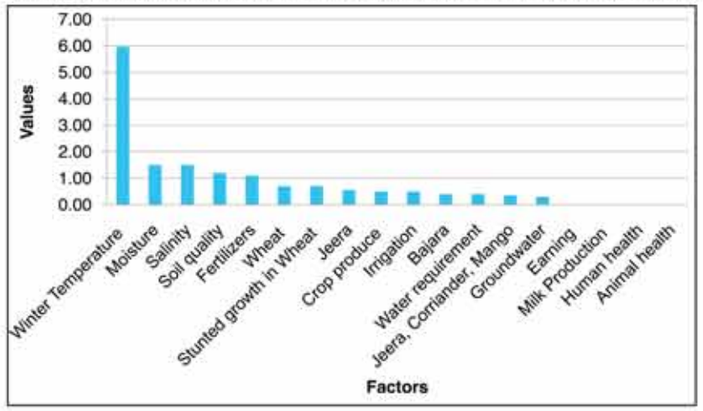
3.1. Coding cognitive maps into matrices, the tables below shows the aggregate matrix of the six stakeholder groups interviewed

0	Winter temperature	7	Stunted growth in Wheat	13	Soil quality
1	Increase in Winter Temperature	8	Soil Moisture	14	Ferlilizer
2	Crop produce	9	Water requirement	15	Earning
3	Bajara	10	Irrigation	16	Milk Production
4	Jeera	11	Groundwater	17	Human health
5	Jeera, Corriander, Mango	12	Salinity	18	Animal health
6	Wheat				

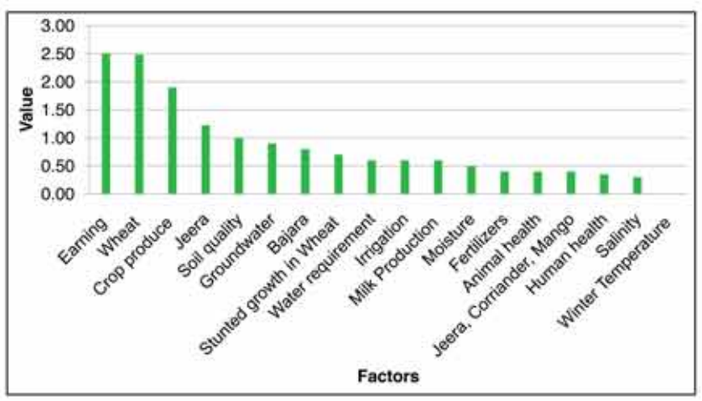
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	0.0	-0.4	0.8	-0.5	-0.4	-0.5	0.7	-0.5	0.6	0.0	0.0	0.0	0.0	0.4	0.0	-0.6	0.4	-0.2
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0
3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0
5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0
7	0.0	-0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	-0.6	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.3	0.0	0.0	0.0	0.0	0.0	0.0
12	0.0	-0.6	0.0	-0.2	0.0	-0.2	0.0	0.0	0.0	0.0	0.0	0.0	-0.3	0.0	0.0	0.0	0.0	-0.2
13	0.0	0.2	0.0	0.5	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	-0.3	0.0	0.0	0.0	0.0	0.0
15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

3.2. Indices calculated

- Out-degree is an indicator that enable to detect those variables with strong influence on others



- In-degree is an indicator that enable to detect those variables that are impacted much by others



3.3. Statistical Analysis of Individual Maps

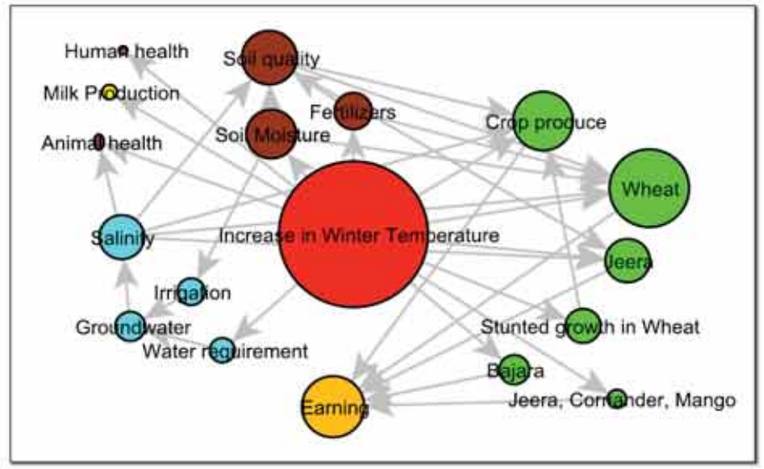
- The network statistics for each map is averaged over all maps, shown in the following tables.
- As a result of aggregation we get one map representing its collective understanding.

Individual Maps	Landowners
Size of Maps	
Av[factors/map]	7.8
MIN number of factors	5.0
MAX number of factors	11.0
DIFF (MAX, MIN)	6.0
Density	
Av[(connections/factor) per map]	1.25
Av. Density [C/N(N-1)]	0.024
Complexity - Influence diversity	
Av. [(receivers/factors) per map]	0.27
Av. [(emitters/factors) per map]	0.14
Av. [receivers/emitters]	1.94

Cognitive Interpretive Diagram	Landowners
Size of Maps	
Number of maps aggregated	5.0
Number of factors in CID	18.0
New factor/map in average	3.6
Density of map	
Number of connection in CID	34.0
New connections/maps in average	6.8
Av. [C/N(N-1)] in CID	0.11
Complexity - Influence diversity	
Number of receivers in CID	4.0
New receivers/maps in average	0.8
Number of emitters in CID	1.0
New emitter/maps	0.2
Receivers/emitters in CID	4.0

3.4. Cognitive Interpretive Diagrams (CID)

- CID of agricultural landowners interviewed in Junagadh district



- The factors of the maps have been grouped into 8 different issue areas and given a distinctive colour coding:
  - climate parameters: red
  - water problems: blue
  - human health: light pink
  - agriculture related problems: green
  - changes in income: golden yellow
  - land resources: brown
  - animal health: purple
  - milk production: yellow
- From the CID we can understand the most important direct impact due to increased winter temperature is on reduced crop productivity, including wheat , jeera and reduced moisture levels in soils.
- Other major indirect impacts are reduced earning, increase in salinity due increase in groundwater extraction because of increased water requirements.
- Salinity which is a indirect impact of increased winter temperature affects soil quality which has indirect impacts on wheat and other crops productivity.

4. Conclusions

- Drawing impacts nets gives insight into the perceived affectedness and seriousness of impacts.
- The main concern for all groups interviewed was the increase in winter temperature reduced crop productivity especially wheat productivity and consequently reduced earnings. Other concerns have been groundwater extraction causing an increase in salinity due increased water requirements.

Poster session and lunch underway during the Third National Research Conference on Climate Change

3.3 Mitigation

The sessions on mitigation were spread over two days. There were two presentation sessions, and one poster session. Presented below are the highlights of the presentations in each of the sessions:

3.3.1 SESSION I

SPEAKERS

Surender Kumar: Substitute or Complement? Assessing Renewable and Non-renewable Energy in OECD Countries

Yogesh Tiwari: Greenhouse Gas Measurements in India

N H Ravindranath: Climate Change and Forests

Shiv Someshwar: Adaptation/Mitigation: Local/Global: Sustainability Challenges for REDD+ in Central Kalimantan

Chetan Krishna: Evaluation of India's Wind Energy Potential

Surendar Kumar: Kumar highlighted that large cuts in carbon emissions are required for mitigation, and that it is necessary for a carbon free economy. In recent times, the share of renewable energy has increased by 4-8 per cent. After calculating the productive inefficiency for each sector it was found that the mineral and mining sectors are most energy inefficient.

Yogesh Tiwari: According to Tiwari, there are very little measurements of greenhouse gases (GHGs) in India. Referring to electricity production in India, using coal-burning process, he said that such processes increase GHGs in the atmosphere and hence it is important to set up GHG monitoring stations in India. Currently, they can be found in Pune, Singhabad, Delhi and Nainital. These stations have collected data, which is in the processing state at present.

N H Ravindranath: According to Ravindranath, deforestation and land use change constitute 50 per cent of carbon dioxide in atmosphere. While forests have a large potential to mitigate climate change, the fact is forests are very vulnerable and will be impacted by climate change.

He highlighted that the aims of the Green India Mission are to mitigate climate change by enhancing environmental services (such as carbon sink) and assess it, and adaptation of vulnerable species and improvement of hydrological cycle. Referring to research and knowledge gaps, he said that carbon dynamics in different land use sectors should be estimated, carbon dioxide sequestration modeled and that stock, changes and flux need more attention.

Shiv Someshwar: Kalimantan refers to the Indonesian portion of the island of Borneo. It has 85 per cent land and 3.5 per cent of the population compared to Karnataka. It is a low level economy and much social divergence is seen there. People there feel fire is the best way to clear land. And fire plays a critical role in carbon emissions. Up to 40 per cent reduction is possible there, Someshwar said.

Dr G Bala of IISc Bangalore highlighted five research areas that have been gaining attention: carbon budget, earth system modelling, climate change projections, changes in cryosphere and geo-engineering

Chetan Krishna: One of the goals of the National Action Plan on Climate Change is 15 per cent of energy should be from renewable sources. India has 4250 GW wind energy potential. He said that Northern India needs to explore the option of wind energy more than south India. Pointing out the limitations, Krishna said that the initial cost for wind turbines is greater than that of conventional fossil fuel generators per MW installed.

Then there is noise that is produced by the rotor blades. He also added that the power generated by wind is very much variable because it depends on many climatic factors. Therefore, proper forecast ranging from one to two days are needed so that thermal power plants are used according to the windmills' power.

3.3.2 SESSION II

SPEAKERS

Harini Nagendra Greening Cities: Urbanization and Climate Change in India

Tejal Kanitkar: Low Carbon Pathways Under Climate Constraints

Divya Pandey: Carbon Footprints of Rice Cultivation Under Different Tillage Practices in Rice-Wheat System

Hippu Salk Kristle Nathan: Can India go Nuclear Energy Free—the Pathways and Aftermaths

Harini Nagendra: Nagendra pointed out the increasing urbanisation trend that is emerging in Indian cities. She gave the example of how Bangalore had transitioned from a garden city to concrete city. She said the trees in Bangalore were rich in species but in low density. It has resulted in more suspended particulate matter (SPM), and the SPM is within in limits in areas where the tree-density is high. There is even a temperature difference of 3-5° between stretches of roads with trees and without trees.

Tejal Kanitkar: Kanitkar pointed out that carbon budget does not prescribe trajectories of growth; it just puts a limit on the total emissions. Of 638 GtC, India's entitlement is 103 GtC—and only 68GtC is available. She compared the emission trajectories for China and India for the years 2010 to 2100 and the total energy generation for US and India and found that lower the carbon space, the higher the costs. She concluded that the financial burden is higher for India as compared to the US.

Divya Pandey: Pandey's study found that conventional agricultural practices leave the smallest carbon footprint. She studied rich-wheat cultivation under conventional tillage and no tillage conditions.

Hippu Salk Kristle Nathan: Referring to nuclear energy as clean energy, Nathan said that erroneous projections had been made about nuclear energy in the past. Projections made in 1970 were by 2010 the share of nuclear would be 80-90 per cent in the total energy generation, but actually it was only 14 per cent. Claiming nuclear installed capacity has gone down, he added that nuclear energy is an option, not a requirement. He also said that the cost has not declined for nuclear but has increased and that renewable energy is the answer to nuclear uncertainty.

An Assessment of Electrification of India's Remote Villages

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Background

A fifth to a fourth of more than one lakh remote villages, where grid-extension is infeasible, are covered under Remote Village Electrification (RVE) program of Ministry of New and Renewable Energy. This study aims to understand RVE and assess its effectiveness

Questions

- What is the scope of RVE program? What is 'Remote'?
- Who are the stakeholders in RVE? What are their roles?
- How RVE is financed? What is it's budget?
- What RVE projects have been implemented & how?
- What is the effectiveness of the RVE program?

Method

- Review Government Policy Documents
- Collect Data on budget and progress so far
- Verify through primary level assessment

→

- Understand 'remote', RVE, and stakeholders
- Types , sizes of projects & claimed progress
- Understand ground realities and gaps

→

- Indicators based Approach
- Distinguish b/w: DESIRED Objectives | ACTUAL affairs
- Distinguish b/w: Decentralized generation | Solar HLSs
- Macro and Micro level: Technical, Economic

Expected Outcomes

- Get relative positions of States in implementation progress
- Get exact financial and implementation mechanisms
- Know the *temporariness* of 'temporary' Solar HLSs
- Find factors of success & failure for different types of projects
- Policy implications for non-remote, un-electrified villages

Performance Study of rooftop photovoltaic panels

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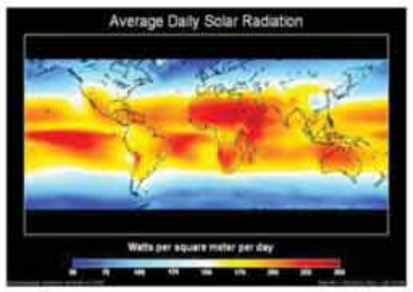
Divecha Centre for Climate Change,
Indian Institute of Science, Bangalore—560012.

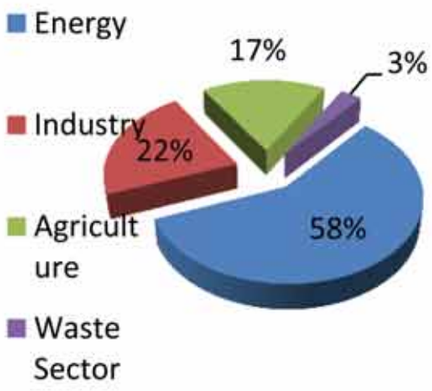
AIM

- Use of grid tie rooftop solar PV to generate electricity to mitigate greenhouse gases.
- Use of sun tracker to improve performance of solar PV power output.

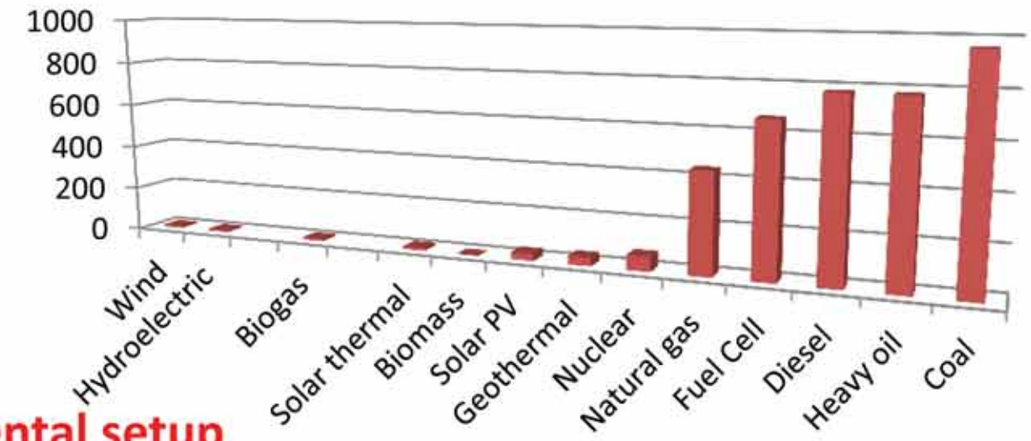
Motivation



- Earth's surface receives on an average 170W/m2 horizontal solar insolation per day.
- Major source of GHG emission is from Energy sector and specifically by generation of electricity.



g CO2 /kWhe

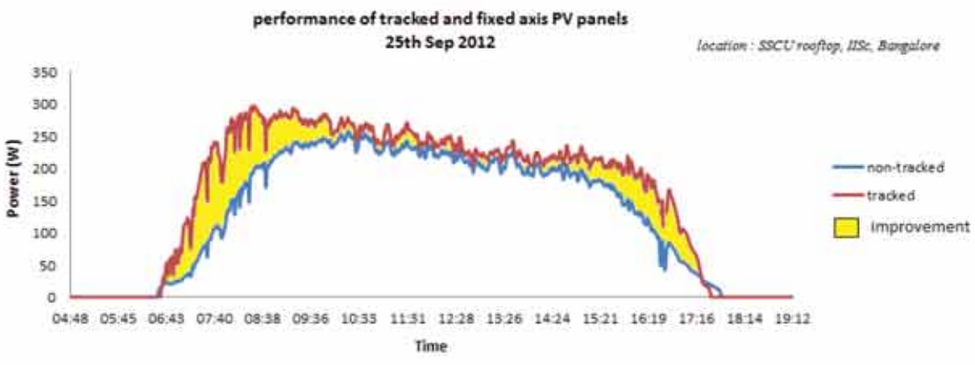


Experimental setup

- We have setup two modules , each(230Wp x 2) , one of them is connected to the sun tracker device and the other is fixed with a tilt of 15^0 to horizontal due south to receive maximum radiation .
- Total capacity of the plant is 920Wp .

Results

- On an average our panels are generating 2.8 kWh per day.
- In August month alone, we have generated around 84.35 kWh, with 3054 Wh/sq.m insolation
- This has cut down emission of 65-85 kg of CO2.
- In the entire life-cycle of this PV plant, Carbon emission savings is appx 25 tones.



Assessment of preparedness of Indian Business Houses in addressing present and emerging Climate regulations, Voluntary Codes and commitments (Domestic & International)

Amit Maheshwari, PGDFM 2011-13
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Indian Institute of Forest Management, Bhopal

Introduction

The main objective of research was to obtain first hand and authentic information about Climate Change impacts on companies and their planning perspective accordingly

The focus of research was *Climate Change Mitigation* and not Climate Change Adaptation

UNFCCC defines mitigation in context of climate change, as a human intervention *to reduce the sources or increase the sink* of green house gases

Stages in Research

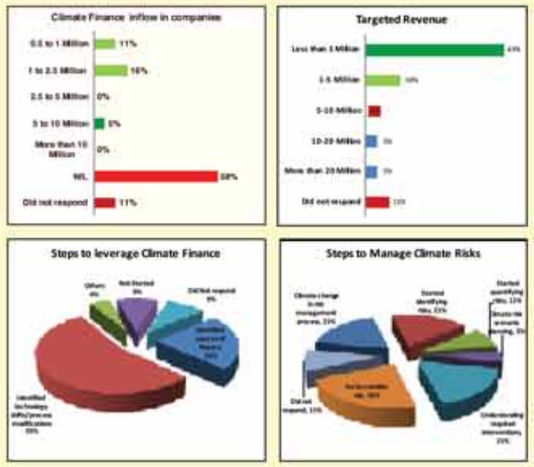
1. Reviewing of activities of industries at global level and policies and regulations of various countries in world.
2. Designing of questionnaire
3. Endorsement from *NEERI & EU India Chamber of Commerce*
4. Prepare a target list of companies and develop senior level management contacts through e mails, phone and meeting in person
5. Follow up with the companies to provide them assistance and get the responses
6. Analysis of responses and drafting of survey report

Research Methodology

- Descriptive Research design was followed with the inclusion of Survey
- Non Probability & Convenient sampling from
  - *PAT* Designated Consumer list
  - *CDP* India list
- Structured Close Ended questionnaire with 20 questions divided in two parts
  - Part A focused senior decision makers & dealt with Climate Finance opportunities present in market
  - Part B comprise 16 questions on various aspects of Climate Change Mitigation
  - There were some open ended questions too to get an in depth understanding of companies activities

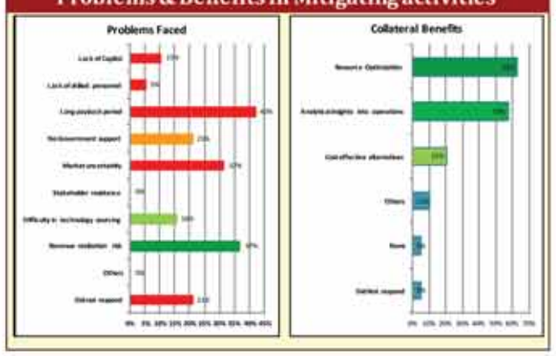
Preparedness of Companies for available Funds & Mechanisms

Climate Finance

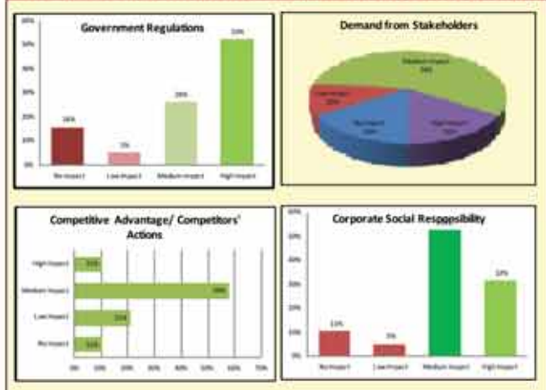


Climate Change Awareness

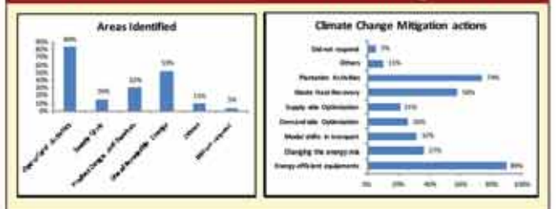
Problems & Benefits in Mitigating activities



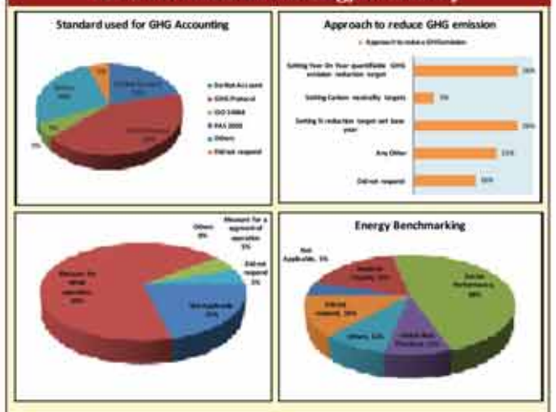
Drivers responsible for Climate Change Mitigation



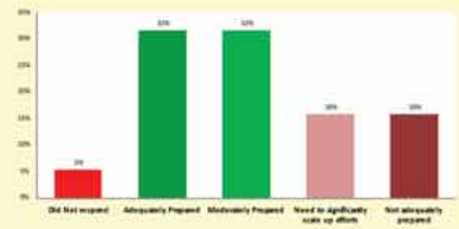
Areas & Actions identified for Mitigation



Green House Gas & Energy Efficiency



Preparedness of Companies



Some Individual Cases

1. ACC ltd follows CSI & WBCSD guidelines to reduce carbon footprints and achieve sustainability in their business
2. NALCO has started a pilot project on Carbon sequestration to reduce their carbon footprint
3. JK Papers are engaged with farmers in huge scale plantation to compensate for their GHGs emissions.
4. Bombay Dyeing follows PCB guidelines to reduce their green house gas emissions
5. NALCO also benchmark its energy usage against standards set by its technology providers

Conclusion

From the findings it can be concluded that:

1. Companies require a well planned implementation of technology & process shifts which they have identified to leverage climate finance opportunities
2. Though maximum Indian companies are aware of Climate Change and also tracking it but there is a lack of urgency to realize its impact on business and work accordingly
3. There is need of stakeholders to become active and force companies to become eco friendly
4. Most of the companies have identified the areas to work upon for climate change mitigation which will result in net positive outcome in near future
5. Government regulation being strongest driver and various market mechanisms offered by government will help companies to link climate change mitigation with business strategy rather than social responsibility

List of companies responded

GMR	Reliance Industries Limited, Textile Division
Nagarjuna Group	JK Paper Ltd
NALCO	UltraTech Cement Ltd
Bombay Dyeing	PPN Power Generating Company Private Limited
SKF India Ltd.	JK Cement Works, Rajasthan
OCL India Ltd.	Hitech Power & Steel Ltd.
ACC Limited, Thane	Cummins India Limited
Malwa Industries Ltd	Albert David Limited
Bajaj Auto	Claris Lifesciences Ltd
Shree Cement Limited	

Pathways to GHG Emissions Reduction in the Indian Cement Industry: A Clustering Based Approach

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- Indian cement industry : **~7% of GHG emissions** | **Four-fold** growth in production by 2050
- Industry classified into clusters to identify - **targeted , cost effective and value creating interventions**
- k-means clustering used to classify the plants using attributes: Kiln Type, Grinder Type, Kiln Size, Product Mix, Normalized Capacity and Energy Intensity (GJ/ T)
- Emissions Pathway generated for a reference plant – BAU vs. active interventions. Financing Requirements and Revenue generating opportunities evaluated.
- SEC figures for cluster centroids - 4.24 GJ/T to 3.38 GJ/T, nearly a 25% variation
- **135 MT CO2eq** reduction potential by 2050. **10 Billion USD** in NPV. Total investment required = **37 Billion USD**
  - Alternative fuels offer most cost effective solution to GHG ↓
  - Clinker substitution is most expensive. Poor performing cluster would require financial assistance
  - NPV +ve even without carbon prices.
- Implications for Stakeholders:
  - Government: **Coal requirement ↓ 45 MT, RDF co-processing => 9MT of MSW being used up beneficially,**
  - Industry: **↓ reliance on coal linkages provided by PSU coal companies, targeted interventions => better compliance**
  - Investors: **High IRR of ~ 33%, No technology risks with identified interventions, No implementation hiccups barring a few regulatory clearances**

Assessment of Carbon Mitigation Potential of Bioenergy Alternatives

CH Sreenivas, Anand B Rao

Department of Chemical Engineering, IIT Bombay, Mumbai, Maharashtra, India

Objective: Comparative assessment of carbon mitigation potential of Bioenergy alternatives in India

- Need for the study
- Framework for the study
- Assumptions
- Methodology for the assessment
- Expected outcome

- Comprehensive Mitigation Assessment Process (COMAP)
- Period:2010-2030
- Marginal abatement Cost curve

Cost of energy (produced or saved) of Bioenergy technology options are compared with their fossil based counterparts to estimate the incremental cost (IC). The IC for carbon mitigation for each of the selected Bioenergy technology (in Rs. /kWh or Rs. /GJ) is estimated using the carbon emission (tC/kWh or tC/GJ) reduction obtained by substituting fossil fuel alternatives.

Effective Energy Conservation Strategies & Techniques in Industries Towards Cleaner Environment

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- **Introduction**

- The industries implementing cost control initiatives in other areas of their enterprise can successfully extend that business intelligence to electricity utilization and conservation activities
- Reducing T & D losses from 34% to 17-18% as compared to 7% in China is another focus of the present study for implementation

- **Purpose of the Paper**

- Optimum utilization of existing assets
- Improving efficiency in production systems & reduction in distribution losses
- Promoting R&D, transfer and use of technologies and practices for environmentally sound energy systems, including new and renewable energy sources
- Improving energy infrastructure
- Promoting of energy efficiency and emission standards

- **Design Methodology**

- Various types of questionnaire have been supplied to different task groups namely industrialists, MIDC officials, MSEB officials and their feedback is obtained.
- In Amravati city area more than 100 respondents have been contacted and their feedback related to study is analyzed

Results / Implications

- It has been estimated that nearly 30,000 MW could be saved through the implementation of energy conservation programs
- Most of India's megawatt potential can be captured at substantially lower costs compared to the cost of capacity additions, which currently stands at over US$1 million per MW.
- The need of the time is to implement suitable strategies and techniques of effective energy conservation in industries at all levels

‘Changing’ roof water spouts in Ladakh - What stories of ‘Change’ do they tell us?

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Q Are they a way of adapting to a changing climate, or a reflection of changing socio-economic changes, or an adaptation to demographic changes?

Map of J & K with LoC (Pakistan - India) & LAC (China-India)

Leh district at 45110 Sq Km is the largest in the country , Located between 32 - 36N and 75 - 80E.
Comprises of Leh town and 11 3 villages, Population 147,104 (2011 census).
Leh has a **cold desert climate** with long, harsh winters from October to early March, the temperature can range from −28 C (-18.4F) in winter to 33 C (91.4F) in summer[2] The city gets occasional snowfall during winter. The weather in the remaining months is generally fine and warm during the day. Average annual precipitation is only 90 mm (3½ inches).

Leh district map

1. Climate Change Analysis over the last 35 years

Temperature : Max temp for peak summer month shows rising trend of nearly 0.5 deg C, rise of nearly 1deg C for all winter months,
Precipitation : Clear declining trend in precipitation (reduction in snow fall) from Nov to March. - 70% of the annual precipitation mostly in the form of snow
Summer there is a slight decreasing trend - 30% of the annual precipitation is in the form of rain
Baseline survey results from Leh: 80% of the respondents in Leh felt that summers and winters were becoming warmer
50% felt that rainfall was increasing, 30% did not know whereas only 20% felt it was decreasing, 75% felt that snowfall was decreasing

2. Other Changes – Modernisation, Aspirations, Migration, Cash economy

3. Demographics

	2001	2011
Total	**117,232**	**147,104**
Male	64,306	92,907
Female	52,926	54,197
Rural	**88,593**	**83,901**
M	46,534	44,605
F	42,059	39,296
Urban	**28,639**	**63,203**
M	17,772	48,302
F	10,867	14,901

Summary
•Close to 30,000 increase in a decade,
•Out of which only 1,300 is roughly in the female population
•Urban male population increase sof over 30,000 a close to 3 times increase.

4. Questions for further research

a) Though snowfall is reducing, does higher winter temperatures and shorter winters mean increase snowmelt is posing new problems to traditional roofs

b) Why is there a discrepancy between weather data on summer precipitation (rainfall) and people’s perception of the same

c) How does one explain the new found elaborate details of roof water spouts – availability of certain industrial materials, exposure to the outside world, changing demographics and climatic factors whose exact manifestation needs further detailed investigation

The potential for grid-tied solar rooftop PV systems in India

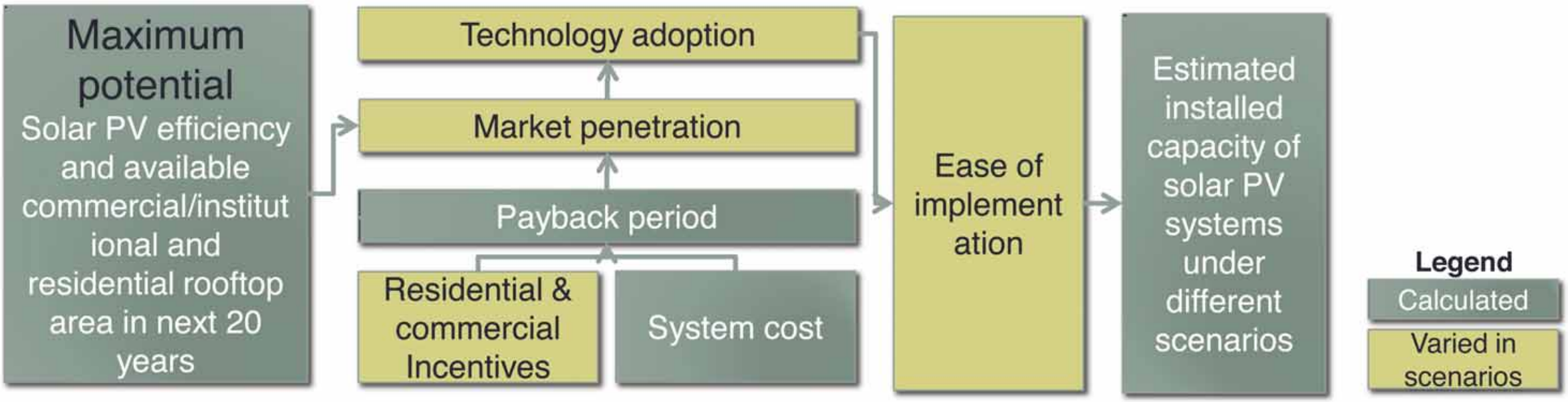
National Institute of Advanced Studies, Bangalore

Narasimhan, G., Gupta, I., Nathan, H.S.K., Sen Gupta, D., Ahuja, D.

Background

The Jawaharlal Nehru National Solar Mission forms one of the key planks of India's strategy on climate change. Indian policy has hitherto focused on grid-connected utility scale systems and rural off-grid systems. This poster describes a framework that can be applied to estimate the potential for grid-tied rooftop systems.

Methodology



Main Results and Conclusions

Model results suggest that while rooftop PV systems offer the potential for generation in the tens of gigawatts close to urban centers of demand with reductions in transmission and distribution (T&D) losses, uptake will be greatly hampered in the absence of suitable incentives and easily implementable grid connection protocols. The model should be further refined to isolate the impact of particular economic incentives and policy measures on uptake of such systems.

Dr G Bala of IISc Bangalore and Dr Sudhir Chella Rajan of IIT Madras (right) at the Third National Research Conference on Climate Change

3.4 Climate Policy/Politics

One session on climate policy/politics was held on the first day of the conference. The posters on the subject were clubbed with the adaptation session. Highlights of the policy/politics session are presented below:

3.4.1 SESSION I

Speakers

A Damodaran: Climate Financing and Challenges of Climate Action Plan: Implementation at the Panchayat Level

T Jayaraman: Equity, Carbon budgets and Durban Platform

Saju T S: Depressions and Droughts: Rethinking 'Scale' in the Climate Change Discourses

A Damodaran: According to Damodaran, state action plans mostly focus on variability, vulnerability scenarios, adaptation, mitigation scenarios and policy tools. On adaptation he said that credit flows are not happening. It's basically the same old problem but climate asks for quicker responses. Devolution of finances is a grey area. "Even if you get money, are you empowered in the real sense?" he asked. He added that real empowerment would happen when control over natural resources are completely in the hands of the locals. Giving an example of the Karnataka state action plan, he said that while the plan looks good, the method of implementation is not innovative—it follows the same old model.

T Jayaraman: Giving an overview of the status of climate change negotiations, Jayaraman said there is no mention of differentiation or equity in the Durban Platform text and it has a one-sided emphasis on mitigation. He also said that the intent of Durban Platform will be read differently by different countries and suggested that in the context of adaptation that eventually India will have to do, it make sense to sign up earlier to a climate agreement, but any global agreement must retain the elements of the Bali Action Plan, including technology transfer, finance and adaptation.

Saju T S: Saju traced the history of climate change discourse and focused on the scale issue. Typically, climate change is projected to be a global issue, but one that does not inform or informed by the everyday processes of adaptation. He suggested the concept of place instead of scale be used where place is not a thing but a way of seeing and focusing, more like an 'entry' point to the climate change discourse.

3.5 Adaptation Sessions:

The sessions on adaptation were spread over two days. There were three presentation sessions, and one poster session. Presented below are the highlights of the presentations in each of the sessions:

3.5.1 SESSION I

Speakers

B Venkateswarlu: Current Research Initiatives on Climate Change and Agriculture by ICAR

Shamima Aktar: ICT and Community Climate Care Centres for Knowledge Management and Adaptation in Rural Bangladesh

Ranjana UK Piyadasa: Climate Change Adaptation Strategies through Rural Water Management Practices for Agriculture Practices: Case Study in Sri Lanka

Tenzing Ingty: Response of Agro-Pastoral Indigenous Communities in the Alpine Eastern Himalayas to the Cascading Effects of Climate Change

B Venkateswarlu: Before talking about current research initiatives, Venkateswarlu took his audience through the impacts of climate change that have been observed through modelling. For instance, he said that wheat is likely to be negatively impacted in rabi due to terminal heat stress, which will also impact commercial poultry. Then, he moved on to NICRA, the project components of which include strategic research, technology demonstration, sponsored research and capacity building. He gave out the details of each of the components in his presentation. Updating on the research outputs so far, he gave examples such as there has been significant increase in semi arid areas in Madhya Pradesh and Bihar, and that dryness is overall increasing in the country. He also presented a snapshot of the key interventions and outcomes related to agriculture in the country—initiatives such as convergence through NREGA for drought proofing, community seed banks etc.

Shamima Aktar: The main idea behind Aktar's study was to assess the credibility of information and communication technology to reduce climate change vulnerability. She narrated how the cyclone Sidr in 2007 killed people and inundated agricultural land and added that while information is aplenty, there needs to be ways and means for the information to reach people. And it is here that ICT can help, along with strengthening the disaster management programme in Bangladesh.

Ranjana UK Piyadasa: Piyadasa took his audience through the history of water management practices in Sri Lanka and said that irrigation technology existed even in 500 BC. Sri Lanka is covered with a network of thousands of manmade ancient lakes and ponds, called tanks, and almost all of them show a high degree of sophistication in their construction and design. Piyadasa's study was conducted to identify current water availability for irrigation and agricultural sustainability by the ancient traditional cascade water management system in the dry zone of Sri Lanka. He concluded that the traditional system has helped rural communities adapt to the impacts of climate change and transformed their lives and farming patterns.

Tenzing Ingty: Talking about the impacts of climate change on the Himalayas, Ingty explained how agro-pastoral communities adapt in the eastern Himalayas. His study focused on the Dzumsa community and confirmed certain climate change indicators. He brought out that traditional knowledge forms important sources of information. In fact, traditional people have much to offer to the discourse of climate change and how counter the impacts, he said.

3.5.2 SESSION II

Speakers

P K Viswanathan: Developing Vulnerability Indices for Detecting Climate Change Impacts on Agriculture and Rural Livelihoods in India: An Exploratory Analysis of Maharashtra

Jagmohan Sharma: Indicator-based Methodology for Characterizing Vulnerability of Forest Ecosystems for Adaptation to Climate Change

Mamata Swain: Weather Based Crop Insurance Scheme: For Adaptation to Climate Change in Odisha

Rakesh Dalal: Feasibility Assessment of Solar Pumping for Draw-Down Agriculture in Dimbhe Region

Prasun Das: Vulnerability and Adaptation to Natural Disasters: Evidences from Rural Odisha, India

P K Vishwanathan: Viswanathan opened his presentation talking about agriculture, which is a source of 15 per cent greenhouse gases. It would be more if indirect emissions are also included. Going over on the impacts of climate change on agriculture, he said demographic vulnerability and agricultural variability of crop pattern are important indicators.

Jagmohan Sharma: Sharma introduced the scope of his study and followed it up by explaining the methodology, criteria and indicators. Referring to the forest sector, he said the steps entailed identifying the criteria that show the vulnerability of forest ecosystem; ranking them to their capacity to determine the

vulnerability; documenting the hypothesis; aggregating common sectors; weighing indicators; and making the final decision. Key considerations include that tropical forest in densely populated southeast Asia is in danger of climate change.

Mamata Swain: Weather based crop insurance scheme should be in favour of marginal farmers so that they can use them in drought condition or other similar circumstances where crop loss occurs. Her presentation touched upon why Odisha is vulnerable to climate change, how climate change affects agriculture and the problems related to micro-insurance. She said that while people are not aware of crop insurance schemes, there are other deterrents such as high risk from purchase and high transaction fee.

Rakesh Dalal: Dalal's study looked at checking the efficiency of existing diesel pumps in the Dimbhe region, the emissions arising thereof, and exploring the option of using solar pumps, which he said was feasible to explore as an alternative to the existing irrigation pumps.

Prasun Das: In order to explore the vulnerability that farmers face, Das chose Kalahandi area in Odisha for his study. He found that if farmers apprehend food insecurity, they try and increase their income through livestock, which has helped reduce the burden to an extent. The source of livelihood according to him has been changing over the years, and some villagers are more affected by drought compared to others.

3.5.3 SESSION III

Speakers

Anand Patwardhan: Agenda for Research in Climate Change Adaptation

E Vivekanandan: Climate Change and Marine Ecosystem Sustainability

Avantika Singh: Gendering Climate Change – An Insight from Gorakhpur and Jalaun District of Uttar Pradesh

S.Janakarajan: Challenges and Prospects for Adaptation: Climate Change and Disaster Risk Reduction in Coastal Tamil Nadu

Anubhab Pattanayak: Characterizing Sensitivity of Farming Communities to a Changing Climate

Anand Patwardhan: Patwardhan deliberated on the need and direction of adaptation research. He began with the treatment of the subject in IPCC reports and said that adaptation may not be just considered as an offshoot of climate change research but also without it. Adaptation research has significance because enough mitigation is not possible and the risk distribution is different among the people and systems impacted. Adaptation research also addresses development agenda. Initially adaptation was viewed by IPCC as mechanistic response, which is there is impact and you adjust to it. However, in the third and fourth assessment reports, adaptation was dealt in more detail and adaptive capacity found focus. Now there is a more process view of adaptation, integrating it with society and its capacity to deal with impacts. On vulnerability, he said its origins need to be understood—whether it is originating from climate change or from our policies and sources within systems. On adaptation, he said that the area needs a lot of interdisciplinary knowledge and should therefore be projected as an interdisciplinary research area.

E Vivekanandan: Marine ecosystems are important as productive systems and biodiversity rich areas. Oceans influence climate. Human interventions in coastal areas include overfishing, habitat degradation, pollution and now climate change. Carbon dioxide dissolving in oceans results in acidification and hypo-oxygenation of oceans (reduction in availability of dissolved oxygen). Warming, observed in Indian Ocean zone, is moving north toward India. In this regard, ecosystem would need management assistance through governance and policy changes. Biological changes like elevated rates of growth and decay of phytoplankton is already altering the base of food web. Oil sardines, absent in eastern coast until 1976, have now spread through the coast of India. Changes in species composition is happening and as climatic thresholds are exceeded more number of species will find it difficult to cope, Vivekanandan warned.

Avantika Singh: In the definition of adaptation there is impact approach and there is vulnerability approach. Gender is a concept that is not defined by your being male or female but it is defined by society. The West sees females as a typical south Asian woman capable of nothing and seeking help. In the study area of Gorakhpur and Jalaon, Singh found that climate change is impacting women more than men. However, social kin ties have improved. Low status of women is due to several reasons like lack of decision-making power.

S Janakarajan: Janakarajan discussed the vulnerabilities in coastal Tamil Nadu and what adaptation actions are possible. Adaptation is a justice issue. Coasts are high in population due to industry and because of which they under more threatened (pollution). Vulnerability of delta ecosystem and adaptation thereat pose huge challenge. Vulnerability in the Nagapattinam district has increased due to damming of the Cauvery river and fresh water not reaching delta

region, thus hampering the livelihood of people depending on such brackish water. Adaptation challenges here are also due to inadequate/improper governance and poor advocacy. Present vulnerability will exacerbate under climate change, he warned. Also, there are limits to adaptation since there are constraints. Costs of adaptation are high. Constraint analysis is necessary by studying inhibiting factors before adaptation is attempted, said Janakarajan.

Anubhav Pattanayak: Indian climate is highly sensitive to climate change and it is likely to be significantly impacted by 2020. Socioeconomic impact would be huge. Pattanayak's study probed whether farmers, big and small, are likely to be impacted equally. Linking climate with income was the approach of the study. The measure that connects the two is net revenue per hectare. The study found with temperature increase the income falls. With passage of time with climate change this differential of fall in income is going to be higher. Income decrease is seen in all farmer categories, however, marginal and large farmers lose out most while small and medium farmers show more resilience. Implication for marginal farmers for such fall in income is poverty trap.

3.6. Concluding Session

Prominent scientists and the organizing committee of the Indian Climate Research Network shared the dais at the concluding session of the Third National Research Conference on Climate Change.

CBS Dutt of Indian Space Research Organisation spoke of ISRO's climate change research programme and of the increased observations through satellites and marine campaigns. For now, the focus is on basic research and impacts, for example, rainfall over India is non-acidic, and black carbon is decreasing. Trends in all these are going to be explored in more detail. He also added that twenty-six agro-met stations had been established thus far, and he invited everyone to add to the environmental data records.

GS Bhat, chairperson of the Centre for Atmospheric and Oceanic Sciences, then asked the audience whether we under variations in monsoon at present. He said a roadmap for monsoon research is required. It is crucial because it involves major linkages between hydrometeorology, aerosol and clouds and oceanography-atmosphere and ocean come together.

Sunita Narain then addressed the gathering and reiterated the importance of science backing policy. She stressed that climate change is real and that it is happening, but negotiations had failed the people and the planet. She then explained why equity must be a pre-requisite for any global agreement on climate change and clarified that India has never asked for the right to pollute—it has always demanded its right to development. She pointed out that science and research assume even more importance given the current state of affairs—the world will be a more risky and vulnerable place, there are tough negotiations ahead since the world will not give up on already occupied place, and there are tough economics ahead since the world has to find out energy and growth options that are both sustainable and affordable.

The concluding session also saw the launch of the Indian Climate Research Network website (www.icrn.in).

Poster award distribution at the concluding session

Living with floods and loss of land in the hamlets in Sundarban islands, India

Mohan Kumar Bera

PhD student, Tata Institute of Social Sciences, Mumbai

1. Abstract

The impact of rising sea level in Sundarban region has been experienced by the extensive land erosion and land encroachment by the rivers and sea. The rapid land erosion reduces the size of the island which forces people to leave the area. It is the embankments which have been shifted towards the villages and the rivers and sea capture the hamlets close to the embankments. Once a large area encroached by the rivers and sea, people become refugee and move towards safer locations as per their convenience and capability to purchase the land. The migration from affected village to non-affected villages is dependent on livelihood strategies among the villagers.

2. Introduction

There is an important relationship between livelihoods and climate change which has influenced by the global environmental degradation. The global south becomes vulnerable to losses and destruction due to combining outcome of existing social vulnerabilities and degrading climatic conditions. The combining outcomes also influence the patterns of migration. The aim of the paper is to see the people's experience of climate change in fragile areas in Sundarban and the trends of migration due to climate change.

3. Purpose

Sundraban region is prone to disasters due to sea surge and cyclone. The disaster phenomena are also closely linked with breaching river embankment which causes saline water floods in the village. So, the river embankment is one of the main concern for protecting the saline water flood in the region which protect saline water flooding and save lives and livelihoods. The rapid land erosion reduces 251.961sq km land since 1969-2001 and two islands have submerged which causes large numbers of landless and homeless villagers (Hazra, 2002).

Acknowledgement

Prof. Subodh M Wagle, Tata Institute of Social Sciences, Mumbai and Dr. Terry Cannon, Institute of Development Studies

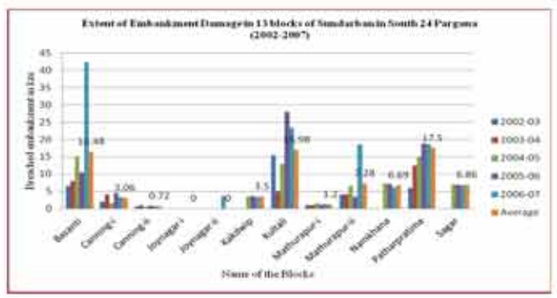
4. Methodology

G-Plot GP of Patharpratima and Ghoramara & Dhablat GP of Sagar Block of Western Sundarban have been selected for conducting research on the basis of losses of physical area due to rapid land erosion. The realistic ethnography approach of qualitative research methodology has been followed which includes interaction and non-participant observation for concentrating day to day activities of the people. Field notes have been taken to capture the data in the field.

Decreasing Population, Census of India

Name of Villages	Population 1961	Population 1971	Population 1981	Population 1991
Bishalakshipur	*25*	*	*	*
Khasimara	*367*	*123*	*	*
Ghoramara	*3047*	*4163*	*4336*	*4972*
Lohachara	*628*	*374*	*220*	*
Gobordhanpur	*939*	*1414*	*1551*	*1589*
Shibbur	*3431*	*3722*	*4887*	*6632*

* Uninhabited area



5. Loss of food production due to loss of land

Loss of land causes permanent loss of agricultural production which causes crisis of food in the flood affected villages.

6. Impact of loss of land on fishery

The commercial pisciculture activities of the villagers affected due to rapid land erosion and river encroachment.

7. Impact of loss of land on physical assets

The rapid land erosion and river encroachment destroyed physical assets of the affected villagers which includes individual house, school building, road, community hall, market place, government buildings.

8. Impact of loss of land on source of income

The loss of production of land reduces the work opportunity into the village and increases the numbers of land less farmers who creates pressure on existing labour market in the village. As a result surplus labourers either go out for earning money or involves into non agricultural activities.

9. Loss of livelihood and impacts on the trend of migration

Case: *Hari Babu got married in chandanpiri, Namkhana. First they bought land in Chandanpiri, Later they bought land Daspur, G-Plot which is close to his father-in-law house. When his younger brother got married in, Namkhana and they took one Bigha of land as dowry. Presently elder shifted at Daspur, Third brother shifted at Chandanpiri and younger brother shifted in Namkhana. They do not have agricultural land in Gobordhanpur, but they produce food grains in Daspur and Namkhana and supply to them. As the Gobordhanpur is highly vulnerable to breaching embankment, there are huge opportunities of daily wage work in the village and they get their livelihood.*

10. Displacement, migration and livelihoods

Displaced people were given land to stay safely at *Colony* which is far from conventional source of livelihood. The villagers in the *Colony* have changed their source of income and adopted available source of livelihood. But, the displaced people are unable to recover from their crisis.

11. Conclusion

The rapid land erosion affects on sources of livelihood which forces villagers to move away from the hamlets. But, they are influenced by the livelihoods. Though government has provided rehabilitation, they stay at vulnerable location for getting their livelihoods. As the land erosion is a continuous phenomena, villagers find their own ways of recovery which provide better solution than *Colony*.

References:

Hazra et al (2002). Sea Level and associated changes in the Sundarbans. Science and Culture. Vol 68, no 9-12, 2002, p 309-321

Govt of India, Census of India, India, 1961, 1971, 1981, 1991

Further Information

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Exploring Climate Change Adaptation (CCA) responses of a resilient socio-ecological system in the buffer villages of Singalila National Park (SNP), Darjeeling

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Academy for Conservation Science and Sustainability Studies
Ashoka Trust for Research in Ecology and the Environment (ATREE)

Introduction/Background

The present study is one component of a project whose long-term goal is to develop and pilot a regional model for the integration of climate change information into risk reduction planning, and—more broadly—into rural development planning at the landscape scale

The resilience of social-ecological systems in the face of real but uncertain global climate change is critical if communities, particularly in the developing world, are to adapt to meet future challenges. In awake of this CCA thinking is still relatively undeveloped in the light of the impacts of climate change on managing resources and livelihoods, especially in the context of Darjeeling Himalaya.

Thus, there is an urgent need for new information and perspectives in policy formulation, to address the gradually increasing stresses expected from climate change as we diverge from historical climate conditions.

Objectives

I. To strengthen climate resilience of socio-ecological systems in Darjeeling Himalaya by generating, analysing and disseminating new information on long-term climate awareness

II. To take fully into account community's perceptions, aspirations and constraints, while bringing CCA processes of a socio-ecological landscape within institutional and policy spaces

Gorkhay at 2265m, is a forest village in the buffer zones of SNP. Climate change is likely to have profound influence on these communities resulting in altered pattern of resource utilization and livelihood strategies.

Study Area

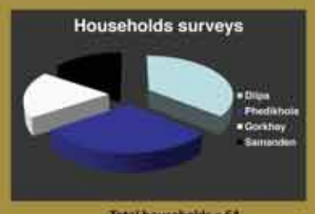
Map source: Critical Ecosystem Partnership Fund (CEPF) priority conservation sites, Darjeeling and Sikkim

Research methods

- Ethnographic perceptism survey using semi-structured questionnaire set households and individual (key respondents) level
- Focus group discussions at community level
- Out of a total of 19 villages, 4 villages selected with different management regime

- Sample size: 1/3rd of the total households
- Selective random sampling

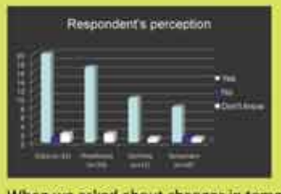
Preliminary results and findings



Total households = 64

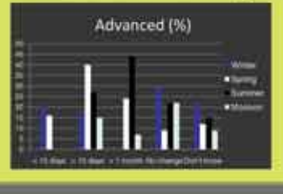
Perception of changes in local climate

When asked how they perceived changes in local climate over the last 5 to 10 years compared to how it was more than 10 years ago



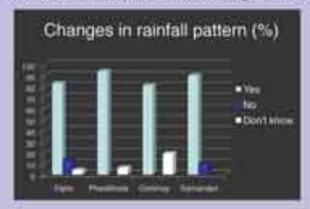
When we asked about changes in temperature pattern in the last 10-15 years?

When asked about changes in the onset of different seasons?

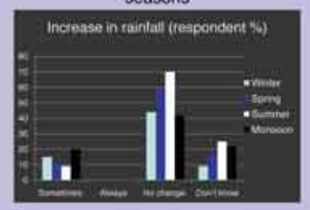


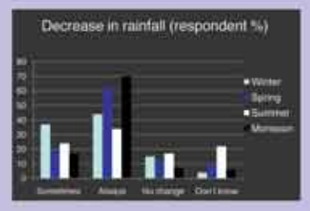
Perception of changes in precipitation

When asked if they perceived changes in rainfall



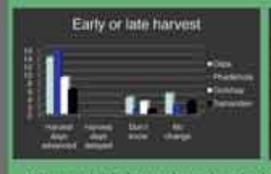
When asked about changes in rainfall with respect to different seasons

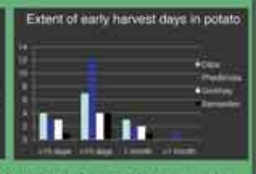




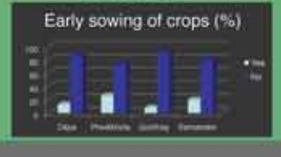
Agro-ecosystem responses

When asked about perceived changes in cropping cycles





When asked about altered agriculture practices or changes to the crop calendar

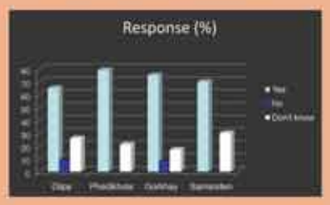


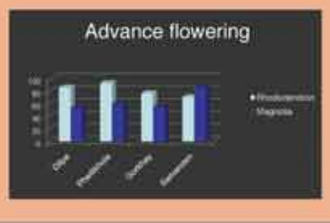
Testimonies

- "These days the rainfall is irregular...with intervals of very high and intense downpour followed by dry sunny spells"
- "I can now easily cross Palmajua khola (local stream) in peak monsoon months of June-July which was kind of impossible during the same period 10-15 years back"
- "I don't know how to put it...may be it is because of bad karma, but it feels as if the sky is closer to the earth and everything is warmer"

Influence on local biodiversity

When asked about changes in phenology (tree, bush, undergrowth)





Socio-ecological highlights of Singalila landscape

Conclusion

The preliminary results suggests climate change is having profound influence on local climate, agro-ecosystems, surrounding biodiversity and local livelihoods. There are already signs of communities adapting to these changes but at present it is difficult to comprehend the level of stress and the coping mechanisms acquired by the communities.

These preliminary findings are from four villages. The study will eventually cover 19 villages in the landscape, from where we hope to discern a pattern in terms of change and responses.

Acknowledgements

- Communities of Dilpa, Phedikhola, Gorkhay and Samanden
- West Bengal Forest Department
- Rinzi Sherpa (Field Assistant)
- Tenzing Sherpa, Arjun Rai, Samuel Thomas, Pem Tshering Dukpa
- Pemba Sherpa
- START/CDKN- providing field support

Climate Change in the Indian Media: Coverage of COP 15 Conference in Regional Press

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1 Background

• In spite of their high vulnerability to Climate Change (CC), few Indians are aware of the terms "climate change" or "global warming" (Leiserowitz & Thaker, 2012).

• Mass media, particularly regional/vernacular press, play an important role in increasing CC awareness in the rural and semi-urban locales.

•COP 15 is a big hook for journalists who would otherwise have less expertise and/or interest in CC communication to focus on CC news.

•The most read daily in Andhra Pradesh is *Eenadu* (Vernacular) and the most read English daily is *Deccan Chronicle* (DC) with a readership of about 60 and 8 lakhs respectively.

RQ: How did *Deccan Chronicle (DC)* and *Eenadu* cover CC during COP 15 ?

2 Methods

Scanning of *DC* and *Eenadu* newspapers for the month of December 2009 at state central library in Hyderabad.

Search for terms: climate change, global warming, COP 15, IPCC, Manmohan Singh.

Coding for

1. **Placement** (front page/middle pages/local)
2. **Focus** (global/national/local)
3. **Framing of impacts** (human/nature/business)
4. **Framing of mitigation policies** (legally binding emission for all countries equally without differentiation; cuts only for developed countries; common but differentiated responsibilities)
5. **COP 15 resolution** (supportive/critical)
6. **Who filed news story** (sourced/in-house)
7. **News sources**

3 Results

Emotional framing in *Eenadu: Jantuokam lo Kalakalam* (Chaos in Animal Kingdom), *Bhootaapam Rytulaku Shaapam* (GW : Curse to Farmers); *Dharani ki Droham* (Betrayal of Earth)

1.Placement: News stories often buried in middle pages. But most stories were branded with the COP 15 logo which might help the audience establish continuity.

2.Focus: *Eenadu* and *DC* focused mostly on international impacts and negotiations and few local stories.

3.Overall, few impact stories, often about impacts to distant places. Little coverage of regional impacts.

4.Majority of *Eenadu* stories framed common but differentiated responsibilities,; *DC* focused mainly on cuts only to developed countries.

5.Majority of stories critical of COP 15 process

6.Eenadu only specified "special correspondent" in most stories, *DC* sourced stories from press agencies

7.Jairam Ramesh, NGO's and Indian negotiators were prominent sources.

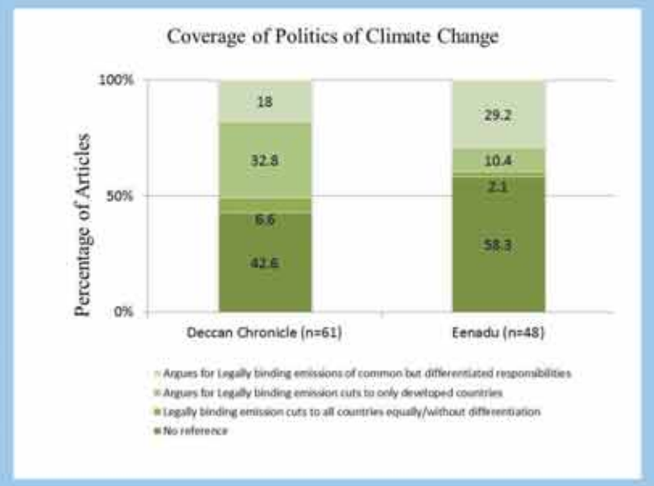
4 Conclusion

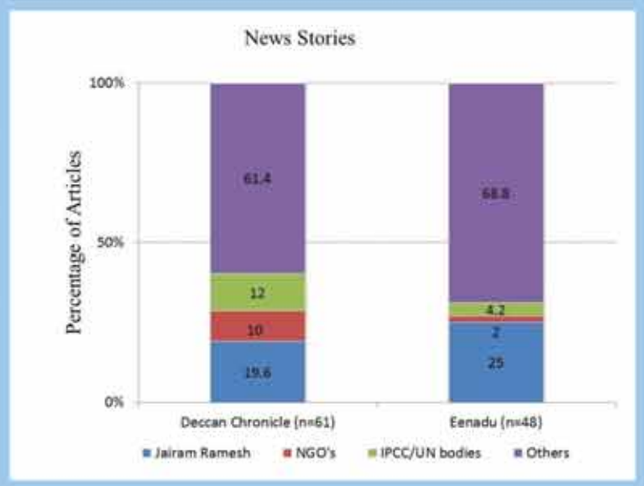
Climate politics trumps climate impact stories. Cause and Effect stories on CC **need more citation** of sources

The coverage of domestic policies and its implications is often on the fringes of the climate change discourse in the Indian press.

More capacity building **workshops** with regional newspaper journalists could help.

Emotive framing seen only in the vernacular, but not in the English daily, perhaps resonates more with rural audiences.





5 Selected References

* Leiserowitz, A. A. & Thaker, J (2012). *Climate Change in the Indian Mind*. Retrieved from http://environment.yale.edu/climate/publications/climate-change-indian-mind/

Shubh Kal - Badlti Jalbayu ke Liye Tayar Hum: A Community Radio Campaign on Climate Change

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Introduction: CRSs in India

CR Movement was started in late 90s of 20th century in India. The Supreme Court of India ruled that airwaves should be free for the public in 1995. The GoI, led by NDA gave permission to academic institutions and KVKs for opening of CRSs in 2002 and GoI, led by UPA gave permission to NGOs in 2006. There are 135 CRSs in the country, where as MIB, GoI has received 1083 applications since 2004. Some of these CRSs run campaign on different themes such as health, education and environment.

Bundelkhand and CRIs in Bundelkhand

Bundelkhand comprises 7 districts of Uttar Pradesh (UP) and 6 districts of Madhya Pradesh (MP) in Central India, one of the most deprived regions of India so far as HDI is concerned. Climatic condition of the region is semi-arid, plagued by acute water scarcity and drought. Nevertheless, the region has its own socio-cultural, political and linguistic identity. There are 2 CRSs in core Bundelkhand region and another 2 adjacent to it. They are Radio Bundelkhand at Orchha (MP), Lalit Lokvani at Alapur (UP), Chanderi ki Awaz at Chanderi (MP) and Radio Dhadkan at Shivpuri (MP).

Radio Bundelkhand (RB) and *Shubh Kal*

RB- the first CRS in the Bundelkhand region was launched by a Delhi based NGO Development Alternative on 23 October 2008. Now it is broadcasting programmes for 8 hours a day on different local issues and concerns.

Shubh Kal - Badlti Jalbayu ke Liye Tayar Hum (Better Tomorrow- We Are Ready for Climate Change) is one of the segments which continued for 1 year. With this background, I tried to explore the following questions:

RQ1: How does a CRS develop content on climate change and broadcast them for creating awareness?

RQ2: How do local people receive it?

Methodology: Ethnographic content analysis of programmes produced and intensive interviews with programme producers and listeners.

Some Findings

Prachi and Rampal, 2 community reporters spoke on the effect of climate change to the community for 1 hour every day, up to 365 days in a year. Both are undergraduates.

Rural Reality Show (RRS) was a programme of the villagers of Bundelkhand to select *Shubh Kal* leaders, who would work as ambassadors to create awareness for adaptation and mitigation of climate change. RB broadcast every episode of RRS live. Villagers listen to live broadcast on radio and cast their votes through SMS to select their *Shubh Kal* leaders. About 800 people from 140 villages participated in RRS. These participants had been assigned to work on five different themes such as kitchen garden, vermicompost, agro forestry, nutrient rich soil and rain water harvesting. All these themes were selected in a participatory way. RB produced programmes broadly relating to these themes.

Conclusion

The campaign reached to people in more than 150 villages. This is a pioneering initiative as far as campaign on climate change in CRS in India is concerned and may be a learning experience for other CRSs too. Radio Bundelkhand networked with other 3 CRSs in the region to accelerate the campaign and it's in process.

Challenges

Government agencies and media houses inform the community on science and technology in a top-down approach. Engaging with the community in such a matter is challenging for CRSs. Especially, lack of scientific language at local level and the limited capacities of programme producers are major challenges.

I am thankful to Radio Bundelkhand team for their support during fieldwork.

Presented at 3rd National Research Conference on Climate Change at Indian Institute of Science, Bangalore on 3-4 November 2012, organized jointly by IISc Bangalore, IIT Delhi, IIT Madras and Centre for Science and Environment, New Delhi

Climate Change and Health Preparedness in India: Protecting Local Communities in Ahmedabad, Gujarat, India from Extreme Heat

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Abstract: Heat waves in Ahmedabad – a top 10 fastest-growing city in India – are becoming increasingly deadly, exacerbated by climate change. The Public Health Foundation of India, Indian Institute of Public Health, Gandhinagar, and Natural Resources Defense Council are working with city officials and the health care sector to protect people from Ahmedabad's rising temperatures. Using qualitative vulnerability assessments, community surveys, and focus-group-based workshops with the municipal government and health care workers, we have identified the most heat-vulnerable populations. Ongoing qualitative and quantitative efforts are focused on developing targeted climate change adaptation strategies to enhance these groups' resilience in the face of extreme heat. Initial results indicate that the following groups are most vulnerable – slum communities, the elderly, newborns, and outdoor workers. Quantitative assessment indicates an excess in total mortality during heat waves, particularly during the 2010 heat wave in Ahmedabad. The project's priority is to reduce heat-related health vulnerabilities and implement an early health warning system for future dangerous heat events. The early health warning system for extreme heat events – the first of its kind in India – is now being developed for a proposed launch before the beginning of Ahmedabad's summer season in 2013.

Background: Extremes of weather have been predicted and observed to be happening with some regularity.

Heat is a major underlying cause of mortality.
- Direct effects include heat stress, heat exhaustion, and heat stroke
- Indirect effects occur when heat is an underlying cause of disease burden

Of all the health effects due to climate change, heat has the single largest contribution and causes the maximum number of deaths, more than all other causes (flood, lightening, tornadoes, hurricanes, cold, and winter storms) combined.

Urban Environments:
- Urban heat island
- Urban microclimates[1]
- Urbanisation

Previous Works: Numerous spells of extreme heat / heat waves have occurred and some have been documented to be associated with massive number of deaths
- France [2]
- Chicago [3]
- Europe [4]
- California [5]

Example of a traditional cooling method: rooftop pottery filled with water to combat urban heat island effect

Noting these evidences, developed and even some developing countries have instituted prevention strategies and preparedness plans to minimize the human costs. These include best practices for city municipalities and workplace health promotion strategies [8, 9].

Existing Scenario in India: The 4X4 report predicts increasing temperatures for India [6]. Ahmedabad also experienced a heatwave in 2010 where hundreds of people died. For the future, projection studies have been done which observe the impact of climate change on summer heat related premature deaths. These studies show an increase of almost two times in the projected mortalities [7].

In absence of due recognition, no similar prevention and preparedness strategies are currently available for India. A discussion of health effects of extreme heat is sadly missing in the national action plan for climate change. In May 2010, Ahmedabad experienced one of the worst heat-waves in recorded history, with maximum temperatures peaking at over 46.8°C. During that heat wave, the city experienced the greatest amount of excess mortality on 22nd May, 2010. Heat waves in Ahmedabad, one of the fastest-growing cities in India, are becoming increasingly deadly and are exacerbated by climate change. We are working with city officials and the health care sector to protect the public from Ahmedabad's rising temperatures.

New cooling technologies used in Ahmedabad to combat the UHI effect: china mosaic roof tiles

Methodology: Using qualitative vulnerability assessments, community surveys, and focus-group-based workshops with the municipal government and health care workers, we have identified the most heat-vulnerable populations.

To explore the relationship between extreme heat on human health in Ahmedabad we conducted a preliminary ecological analysis to ascertain the relationship between daily deaths and temperatures for the year 2010. The year 2010 saw Ahmedabad facing an unprecedented heat wave with maximum deaths recorded on 22 May.

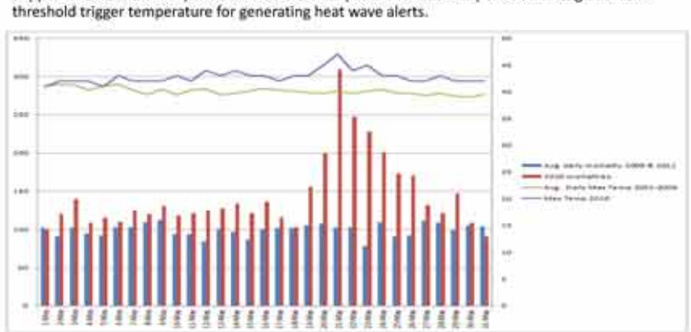
We acquired day wise mortality data disaggregated by sex from the office of the registrar of births and deaths in AMC. The day wise temperature data was obtained from the meteorology department office in Ahmedabad.

Main Findings
Our qualitative work indicates that the following groups are most vulnerable to morbidity and mortality due to heat waves :

- Slum communities
- The elderly
- Newborns, and
- Outdoor workers

Collecting data on heat exposure and behaviors among slum dwellers

Our ongoing quantitative work indicates that excess heat is associated with excess total mortality, particularly during the 2010 heat wave in Ahmedabad. These figures show the relationship between temperature and mortality in 2010. From the data for the summer month of May it is evident that they are linked; as soon as the temperature crosses a threshold (43 degrees for maximum or 36 degrees for mean temperature) the mortality also shows a sudden spurt. It was interesting to see that the peak in excess mortality had already happened before the temperatures reached their peak. This fact is important in recognition of a threshold trigger temperature for generating heat wave alerts.



Using correlations to quantify this relationship, we were able to find moderate to high correlations in the summer months while the same were negative for winter months. For the month of May 2010, when the heat wave was recorded in Ahmedabad, the correlation was the highest at 0.833.

Ongoing Work: The Heat Health Early Warning System for extreme heat events – the first of its kind in India – is now being developed for a proposed launch before the beginning of Ahmedabad's summer season in 2013. With support from the Commissioner of the Ahmedabad Municipal Coorporation, the HHEWS pilot project will be launched in February 2013, with a series of workshops aimed at informing the community of the appropriate steps to take during a high heat event.

One element of the HHEWS will be warnings in English as well as in the local language regarding heat waves and health

In conjunction with the HHEWS pilot launch, NRDC and IIPHG with support from partners at Mt. Sinai School of Medicine and the AMC will release a series of Issue Briefs around Heat Waves and Population Vulnerability. The 4-part series will contain briefs targeted to specific audiences, including:
- Slum Communities
- Construction Workers
- Government Officials
- Workers in the Health Care field

The next step in our quantitative investigation is to conduct a statistical analysis of the threshold for morbidity and mortality attributable to extreme heat. We welcome comments and suggestions for further analysis.

Works Cited:
1. Khosla, R., *The relevance of rooftops: Analyzing the microscale surface energy balance in the Chicago region*. 2010.
2. Vandentorren, S., et al., *Mortality in 13 French cities during the August 2003 heat wave*. American Journal of Public Health, 2004. **94**(9): p. 1518.
3. Curriero, F.C., et al., *Temperature and mortality in 11 cities of the eastern United States*. American Journal of Epidemiology, 2002. **155**(1): p. 80-87.
4. Baccini, M., et al., *Heat effects on mortality in 15 European cities*. Epidemiology, 2008. **19**(5): p. 711.
5. Knowlton, K., et al., *The 2006 California heat wave: impacts on hospitalizations and emergency department visits*. Environmental Health Perspectives, 2009. **117**(1): p. 61.
6. Ministry of Environment and Forests, & Government of India. *Climate Change and India: a 4x4 Assessment*, November 2010. p. 103.
7. Metzger, K.B., K. Ito, and T.D. Matte, *Summer heat and mortality in New York City: how hot is too hot?* Environmental Health Perspectives, 2010. **118**(1): p. 80.
8. Frumkin, H., et al., *Climate change: the public health response*. American Journal of Public Health, 2008. **98**(3): p. 435.
9. Joubert, D., J. Thomsen, and D. Harrison, *Safety in the Heat: A Comprehensive Program for Prevention of Heat Illness Among Workers in Abu Dhabi, United Arab Emirates*. American Journal of Public Health, 2011. **101**(3): p. 395.

Farmers' Perceptions on Drought and Climate Change: Evidence From Western Odisha, India

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POSTER 1: INTRODUCTION

- **Climate Change Impact and Adaptation**

  Climate change is unequivocal, accelerating and beginning to affect vulnerable states. The complex process of climate change affects the vulnerable populations, livelihoods and different sectors through increasing occurrence of climate induced natural disasters (CINDs) like drought, flood, cyclone, desertification, and global warming (IPCC 2007).

- **Understanding Drought Vulnerability and Risk**

  Among these CINDs, drought is considered by many to be the most complex but least understood affecting more people than any other hazard (Hagman 1984). More than half of the world population is susceptible to drought every year (Kogan 1997). It is a slow onset creeping disaster which is gradually increasing in intensity and frequency both spatially and temporally.

- **Rural people's Perceptions for Drought Planning and Mitigation**

  Rural people's perceptions on drought and climate change vulnerability form important tool for devising a rational mitigation strategy to reduce their vulnerability.

POSTER 2: MAJOR OBJECTIVES

- **To analyze the observed impacts of the climate change and recurrent droughts in western Odisha**
- **To analyze the perceptions of the farmers on various aspects of present as well as future vulnerability to drought and climate change in the study region.**
  - **The changes in various climatic factors like rainfall, temperature, drought frequency and intensity during last three decades have been assessed.**
  - **The farmers' experiences on hardships faced, natural and human induced causes of the changes observed have been examined.**
  - **The perceptions on changes/trend in various vulnerability factors such as water availability, soil quality, early warning system, deforestation, social safety nets, institutional support system, degradation of wild life habitat, loss of wetland and water bodies, and damage to plant species etc. have been scrutinized.**
- **To suggest some policy measures to reduce the extent of drought vulnerability and risk in the study region.**

POSTER 3: METHODOLOGY

- **Multistage Stratified Purposive Sampling Method**

First stage: The Bolangir district is located in western part of Orissa has been deliberately chosen for the study since it is the most vulnerable to drought among all the districts of Orissa.

Second stage: Three blocks were selected on the basis of degree of drought vulnerability which are Saintala (most vulnerable), Patnagarh (moderately vulnerable) and Titlagarh (least vulnerable).

Third Stage: Three villages were selected, one from each of the selected blocks: Samara of Saintala; Mundomhul of Patnagarh; and Bijepur of Titlagarh

Fourth Stage: Sample households (HHs) were chosen from each of the selected villages through Stratified Random Sampling Method covering 12 major livelihood groups, which are (1) Large Farmer (more than 10 acres), (2) Medium Farmer (5.01-10 acres), (3) Small Farmer (2.51-5 acres), (4) Marginal Farmer (up to 2.5 acres), (5) Agricultural Labourer, (6) Non-agricultural Laborer, (7) Forest Resource Dependant, (8) Rural Artisan, (9) Businessman, (10) Service Holder, (11) Livestock Rearer, and (12) Others including Fishing Community, Stone Merchants, and Tailors. A total of 139 sample households were surveyed for the study.

POSTER 4: METHODOLOGY (continued…)

The present and future vulnerability to drought and climate change has been assessed by ranking the vulnerability factors (economic/environmental/social/institutional) with respect to their effects during past, present and future climatic risks in the matrix form using a scale of 1(lowest)to 5(highest). The ranking helped to identify the vulnerability factors that are expected to pose greater threat in future. The average ranking also helped to identify the relative strength of effects of various vulnerability factors that are posing greater threat.

The study region (India → Orissa→ Bolangir)

POSTER 5: NATURE OF DROUGHT VULNERABILIY IN BOLANGIR

- **Drought is a recurring and single most insidious phenomenon in Bolangir district of Orissa. The recurrent drought in the district is mostly responsible for its 'chronic backwardness'.**
- **The increasing frequency of occurrence of the hazard is one of the major factors behind the rising level of drought vulnerability in the region, which is mainly due to "wide variability of rainfall from season to season", not as a result of deficiency of annual rainfall.**
- **One of the prime reasons for increasing drought frequency and vulnerability in study region is the neglect of the traditional water-harvesting structures and low level of irrigation**
- **Disappearance of drought-resistant indigenous crop varieties and loss of bio-diversity are shoring up the level of vulnerability to drought and climate change.**
- **Poor governance, lack of basic infrastructure, wide-spread poverty and illiteracy are the major sources of vulnerability in the region.**

POSTER 6: FARMERS' PERCEPTIONS ON DROUGHT FREQUENCY, DROUGHT INTENSITY AND RAINFALL PATTERN

The average numbers of occurrence of drought per decade in the region has suddenly increased to 5.1 during last decade (1994-2004 from1.7 during previous decade. So the frequency of occurrence of drought tends to increase in the region. As far as the severity of drought is concerned, people faced very severe drought situation during both 2002 and 1996 with rank value of 4.9 each out of 5.

Farmers' perceptions on drought frequency and intensity

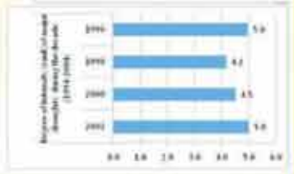
Farmers' perceptions on rainfall pattern in drought years

	Amount/ Sufficiency*					Distribution ##				
Years	2002	2001	2000	1998	1996	2002	2001	2000	1998	1996
Scores	1.0	2.9	1.0	2.5	1.0	1.0	1.0	1.1	1.0	1.0

Notes: * Codes to follow: Very less-1, little less-2 Sufficient-3 (compared with normal rainfall)

Codes to follow: More erratic-1, less erratic-2 (more even)-3, No Change-4(compared with normal rainfall)

Source: Field survey



POSTER 7: PERCEPTIONS ON HARDSHIPS FACED DURING DROUGHT

Though the intensity of the droughts of 2002 and 1996 was similar as found earlier, the extent of hardships caused by these two droughts was much different. Particularly, it was less during the drought of 2002 compared to the drought of 1996 due to increased preparedness. On the other hand, among different kinds of natural disasters faced by the households, it is distinctly drought and temperature increase that happened to affect the sample households significantly.

Farmers' perceptions on hardships faced during disaster period									
	Degree of hardships faced during major droughts in last decade*					Degree of effects of different disasters*			
Years	2002	2001	2000	1998	1996	Drought	Cyclone	Flood	Temperature extreme
Scores	4.3	3.1	3.7	2.8	4.9	4.6	1.4	4.1	4.3

Note: *1 implies nil or negligible level, while 5 refers to maximum level of hardships faced (in a 1 to 5 point scale)
Source: Field survey

POSTER 8: PERCEPTIONS ON NATURAL AND HUMAN INDUCED CAUSES OF DROUGHT

As regards different natural causes of recurrent drought in the study area, majority of 69.5 per cent of households perceived that it is the wide variability of rainfall, not inadequacy, which was the major reason for exacerbating drought situation in their region.

Perceptions on natural causes of recurrent droughts

Major natural causes	% positive response
Only inadequacy of rainfall, not erraticity	6.0
Wide variability of rainfall, not inadequacy	23.6
Both inadequacy and erraticity of rainfall	67.3
Land type is too sloppy that drains out rain	49.4
Location of major lands is such that it neither can be irrigated nor can hold rainfall and soil moisture	12.8
Lack of irrigation facilities due to natural topography of the region	46.3
Lack of irrigation due to inadequate water resources	69.5
Lack of soil moisture or soil is incapable of holding moisture	31.6
Any Other	3.6

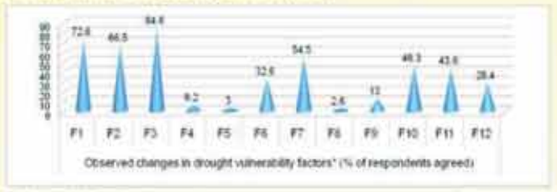
Among human induced causes of drought, 81.7 per cent of respondents expressed their view that the major human induced cause of recurrent drought situation in the region is the lack of irrigation due to negligence of water harvesting structures (WHSs). Though it is possible to increase the irrigation coverage through WHSs in the region due to conducive biophysical and socio-economic factors, the institutional support is not sufficient as per the views of the farmers.

Perceptions on human induced causes of recurrent drought situations

Major human-induced causes	% positive response
Lack of irrigation projects due to inefficient governmental effort though there is a viable option	71.2
Lack of irrigation from WHSs though possible	81.7
Poor irrigation water management at local level	18.3
Poor crop selection	20.6
No early warning was transmitted through responsible authorities at local level	60.9
Early warning was given but too late for which crop planning could not be changed	20.2
Did not believe on early warning though it was given at right time	17.2
Watershed is not developed	52.8
Though watershed was developed, it couldn't be sustained	40.3
Lack of awareness/ignorant about what to do	33.0
Unable to invest on drought mitigation measures due to poor socio-economic status/exploitation by land lord, private money lender or local Zamindar	66.9
Deforestation	53.3
Any other (lack of coordination among people, political negligence etc.)	23.8

POSTER 9: PERCEPTIONS ON CHANGES IN DROUGHT VULNERABILITY FACTORS

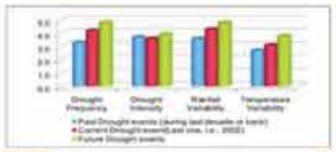
Farmers' perceptions on changes in drought vulnerability factors



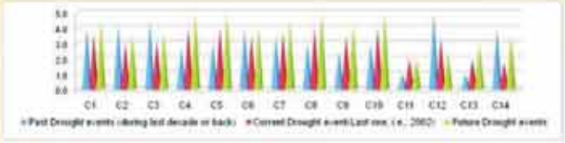
F1: Both rainfall is falling and becoming more erratic.
F2: Night temperature is declining and day temperature is increasing over the years
F3: Irrigation coverage have been stagnated over the years.
F4: Irrigation from WHS is is increasing
F5: Governmental effort for participatory irrigation management has increased
F6: Soil is becoming less fertile and less able to hold moisture
F7: Awareness about the drought management practices has increased
F8: Early warning system has been strengthened
F9: More sustainable treatment of watershed has been observed
F10: Deforestation has increased significantly
F11: Participatory management of common property resources has been emphasized and increased though not significantly
F12: Meaningful long-term strategies have been adopted over the years to address these human induced causal factors

POSTER 10. TREND IN DROUGHT IMPACTS: CLIMATIC FACTORS

The temperature variability, rainfall variability and drought frequency are exhibiting clear increasing trends; while the drought intensity has declined in recent years compared to the same during the past drought episodes, as perceived by the rural households.



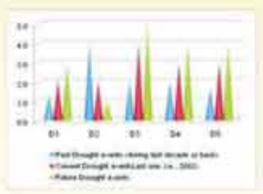
POSTER 11. TREND IN DROUGHT IMPACTS ON AGRICULTURAL ACTIVITIES

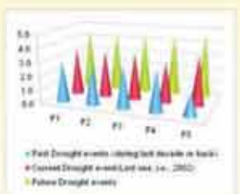


Among different economic impacts of drought related to crop farming, the impacts showing clear increasing trend are drought induced insect infestation and plant diseases, disruption in water supply, unemployment from production decline and increase in food prices. Due to increasing frequency of drought and moisture stress, the resistivity of plants is gradually falling, that in turn, results in increasing risks of frequent pest attack.

- C1 Annual or perennial crop losses
- C2 Damage to crop quality
- C3 Reduced crop productivity
- C4 Insect infestation
- C5 Plant diseases
- C6 Income loss of farmers
- C7 Bankruptcy of farmers
- C8 Unemployment from production decline
- C9 Increase in food prices
- C10 Disruption in water supplies
- C11 Decreased land prices
- C12 Increasing trends of fallow lands
- C13 Purchasing of drinking water
- C14 Sale of farm assets and durables

POSTER 12. TREND IN DROUGHT IMPACTS ON LIVESTOCK, FISHERY ANF FORESTRY

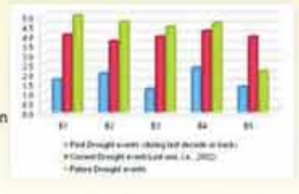




- D1 High cost/unavailability of water for livestock
- D2 High livestock mortality rate
- D3 Breeding delays or decreased pregnancies
- D4 Low prices for livestock products
- D5 Grazing land and fodder availability
- F1 Loss from fishery production
- F2 Damage to fish habitat
- F3 Loss of young fish due to decreased flows
- F4 Loss from timber production
- F5 Less access to non-timber forest produces

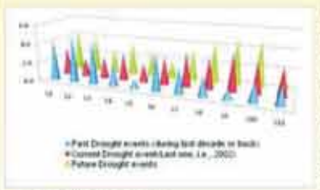
POSTER 13. TREND IN DROUGHT IMPACTS ON ENVIRONMENT

Among other economic impacts, the risks on accounts of grazing land and fodder availability, loss from fishery production damage to fish habitat, loss of young fish due to decreased flows, loss from timber production, and less acces to non-timber forest produces by the poor are expected to increase in future years.



- E1 Reduction and decradation of wild life habitat
- E2 Shortage of feed and drinking water
- E3 Loss of wetland and water bodies
- E4 Damage to plant species
- E5 Deforestation

POSTER 14. TREND IN DROUGHT IMPACTS: INEQUALITY, HEALTH AND QUALITY OF LIFE



- S1 Mental/physical stress
- S2 Reductions in nutrition
- S3 Loss of human life (Due to suicide, starvation)
- S4 Water user conflicts
- S5 Political/management conflicts
- S6 Disruption of cultural belief system
- S7 Public dissatisfaction with governments
- S8 Inequity in distribution of drought relief
- S9 Reduced quality of life
- S10 Migration from rural to urban
- S11 Reduced standard of living

Also the peoples' perceptions on social and institutional fronts do not indicate any better prospects. Among the selected indicators, the water user conflicts, political / management conflicts, reduction in quality of life are exhibiting clear increasing trend.The respondents felt that the conflicts over the irrigation water allocation and distribution would continue to increase due to reduced size of utilizable water resources. The increasing occurrence of political and management conflicts, political nepotism and corruption are expected to further increase the vulnerability of rural poor. The quality of life is perceived to be deteriorated in the coming days due to rising degradation in environmental, social and economic spheres. On all these accounts, the mental and physical stress levels are expected to increase for vulnerable rural poor.

POSTER 15 : FUTURE DIRECTIONS

- This kind of grassroots based studies is important for devising future short term and long term action plans. Most of the climate change studies have highlighted more on the macro or global perspectives of climate change.
- Such an approach may lead to a false perception that climate change is a global issue and individual or local approaches can do nothing to mitigate those. These kinds of local studies will thwart such misconceptions and generate awareness in rural people; so that they will start to contribute their bit in combating climate change apart from helping in making policy decisions.

Chapter 4: Conclusion

In India, there is very little country-specific research available to guide climate policy. And yet India is in the thick of things as far as climate change is concerned. In 2010 therefore, researchers and policy advocates on climate change came together and formed the Indian Climate Research Network (ICRN).

The aim of the network is to ensure that climate change debate reaches a wider audience in the country, bridge the communication gap between the scientific community and those outside it and provide the fledgling research community a platform to come together for discussions and debates on climate change. The third National Research Conference at the Indian Institute of Bangalore showcased the best climate research being carried out in the country—while expanding its scope for the first time to include researchers from South Asia.

According to one of the founding members, the quality of presentations at the conference has definitely improved but there is still a long way to go before reaching international standards. Climate change research obviously is a challenging proposition given the wide set of domains such research encompasses. There are certain issues unique to the Indian context, such as monsoons, Himalayan glaciers and energy poverty. Such issues now constitute the bulk of Indian research. One of the gaps that still exists is the fact that researchers don't work systematically to cover broad domains and it is here that ICRN can make an effective intervention in encouraging such work.

So far, most debates on climate change in India are opinion-based. Therefore, there is a need to generate more research-based data to support the opinion. In international negotiations too, India has been constrained due to the lack of quality research in the country. And it is mostly a political issue in the international platform. It is imperative that science shapes the discourse. And, therefore what must follow is Indian scientists do their own research in this context.

ICRN will continue to implement innovative ways to keep the scientists connected to one another and will possibly introduce theme-based workshops in its successive conferences.

Annexure I: Conclusion

Organized jointly by IISc Bangalore, IIT Delhi, IIT Madras and
Centre for Science and Environment, New Delhi

3rd National Research Conference on Climate Change
Indian Institute of Science, Bangalore
November 3-4, 2012

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DAY 1: NOVEMBER 3, 2012

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SESSION I

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DAY 2: NOVEMBER 4, 2012

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Annexure II: Agenda of the Conference

Organized jointly by IISc Bangalore, IIT Delhi, IIT Madras and
Centre for Science and Environment, New Delhi

3rd National Research Conference on Climate Change
Indian Institute of Science, Bangalore
November 3-4, 2012

DETAILED PROGRAMME

DAY 1: NOVEMBER 3, 2012

REGISTRATION AND TEA (VENUE: FACULTY HALL, IISc) – **08.00 to 09.00**

INTRODUCTION – 09:00 to 09:45

(VENUE: FACULTY HALL, IISc) Chair: P Balaram

P Balaram, Director IISc	Welcome Address	09.00 to 09.10
Ambuj Sagar, IIT Delhi	Capacity Building for Meeting the Climate Challenge	09.10 to 09.20
G Bala, IISc	Current Research Trends in Climate Science	09.20 to 09.30
Chandra Bhushan, CSE	Politics and Climate Change and State of Negotiations	09.30 to 09.45

SESSION I - 10:15 to 12:15

SCIENCE & IMPACTS (VENUE: CAOS AUDITORIUM) Moderator: Krishna Achutarao

Sabin T P	CORDEX-South Asia	10.15 to 10.30
T N Venkatesh	Glacier Retreat in the Himalayas: Observations and Numerical Simulations	10.30 to 10.45
Vimal Mishra	From Mean to Extremes: What do CMIP5 Projections tell us about Climate Change in India?	10.45 to 11.00
K Rajendran	Simulated Changes in Indian Monsoon	11.00 to 11.15
Smriti Basnett	Monitoring Seasonal Snow Cover in Sikkim Himalaya	11.15 to 11.30
Gaddam Vinay Kumar	Monitoring of Glacial Mass Balance in Baspa Basin, Himachal Pradesh	11.30 to 11.45
	Question and Answer Session	11.45 to 12.15

MITIGATION (VENUE: CAOS SEMINAR HALL) Moderator: Ambuj Sagar

Surender Kumar	Substitute or Complement? Assessing Renewable and Non-renewable Energy in OECD Countries	10.15 to 10.30
Yogesh Tiwari	Greenhouse Gas Measurements in India	10.30 to 10.45
N H Ravindranath	Climate Change and Forests	10.45 to 11.00
Shiv Someshwar	Adaptation/Mitigation: Local/Global: Sustainability Challenges for REDD+ in Central Kalimantan	11.00 to 11.15
Chetan Krishna	Evaluation of India's Wind Energy Potential	11.15 to 11.30
	Question and Answer Session	11.30 to 12.15

ADAPTATION (VENUE: CAOS CONFERENCE ROOM) Moderator: Chandra Bhushan

A K Singh	Climate Resilient Agriculture - A Way Forward	10.15 to 10.30
B Venkateswarlu	Current Research Initiatives on Climate Change and Agriculture by ICAR	10.30 to 10.45
Md Mijanur Rahman	Community Based Adaptation: The Experiences of Caritas Bangladesh in Vulnerable Coastal Areas	10.45 to 11.00
Shamima Aktar	ICT and Community Climate Care Centres for Knowledge Management and Adaptation in Rural Bangladesh	11.00 to 11.15
Ranjana U K Piyadasa	Climate Change Adaptation Strategies through Rural Water Management Practices for Agriculture Practices – Case Study in Sri Lanka	11.15 to 11.30
Tenzing Ingty	Response of Agro-Pastoral Indigenous Communities in the Alpine Eastern Himalayas to the Cascading Effects of Climate Change	11.30 to 11.45
	Question and Answer Session	11.45 to 12.15

SESSION II - 12:15 TO 13:00

POSTERS ON ADAPTATION AND POLICY/POLITICS (VENUE: CAOS AUDITORIUM) Moderator: Chandra Bhushan

Nishit Pandya	A Climate Vulnerability and Risk Assessment for Rajkot
Mohan Kumar Bera	Living with Floods and Loss of Land in the Hamlets in Sundarban Islands, India
Gulrez Shah Azhar	Climate Change and Health Preparedness in India: Protecting Local Communities in Ahmedabad from Extreme Heat
Mrutyunjay Swain	Farmer's Perceptions on Drought and Climate Change: Evidence from Odisha, India
Anand Gazmer	Exploring Climate Change Adaptation Responses of a Resilient Socio-Ecological System in the Buffer Villages of Singalila National Park (SNP), Darjeeling
Gargi Chakrabarti	Coastal Ecosystem: A Vanishing Point of Climate Jurisprudence in India
Bidu Bhusan Dash	Shubh Kal - Badalti Jalbayu ke Liye Tayyar Hum: A Community Radio Campaign on Climate Change
Viplav Babu	Climate Change in the Indian Media: Coverage of COP 15 Conference in Regional Press

LUNCH AND POSTER VIEWING (VENUE: CAOS TERRACE) - **13.00 to 14.00**

SESSION III - 14.00 to 16.30

SCIENCE & IMPACTS (VENUE: CAOS AUDITORIUM) Moderator: G Bala

Sanjeev Kumar	Nitrogen Cycling in Marine and Freshwater Environments	14.00 to 14.15
Pradeep Majumdar	Understanding Hydrological Impacts and Uncertainties on River Basin Scale	14.15 to 14.30
Mythri D J	Impact of Climate Change on River Netravathi of Karnataka	14.30 to 14.45
Ajai Kumar Rai	Indonesian Seaway Closure and Pliocene paleoclimatic changes in the Eastern Indian Ocean	14.45 to 15.00
N Devaraju	Equilibrium Sensitivity of Global Terrestrial Ecosystem Carbon to Elevated Nitrogen Deposition in Community Land Model 4.0	15.00 to 15.15
Mukti Sharma	Assessment of Impacts of India-Specific Greenhouse Gas Emission Scenario on Projected Climate Parameters by SCENGEN Model	15.15 to 15.30
	Question and Answer Session	15.30 to 16.30

POLITICS/POLICY (VENUE: CAOS SEMINAR HALL) Moderator: Sunita Narain

A Damodaran	Climate Financing and Challenges of Climate Action Plan: Implementation at the Panchayat Level	14.00 to 14.15
T Jayaraman	Equity, Carbon budgets and Durban Platform	14.15 to 14.30
Purnamita Dasgupta	Integrating Distributional Concerns and Ethics from an Economics Perspective in Climate Change Decisionmaking	14.30 to 14.45
Saju T S	Depressions and Droughts: Rethinking 'Scale' in the Climate Change Discourses	14.45 to 15.00
Pradip Swarnakar	Framing of Indian Climate Change Policy Network: A Critical Evaluation of Government Policies During 2007-2010	15.00 to 15.15
Zakir Hossain Raju	Climate Politics Meet Cinematic Poetics: Climate Change Adaptation in Contemporary Bangladeshi Documentaries	15.15 to 15.30
	Question and Answer Session	15.30 to 16.30

ADAPTATION (VENUE: CAOS CONFERENCE ROOM) Moderator: Sudhir Chella Rajan

P K Viswanathan	Developing Vulnerability Indices for Detecting Climate Change Impacts on Agriculture and Rural Livelihoods in India: An Exploratory Analysis of Maharashtra	14.00 to 14.15
Jagmohan Sharma	Indicator-based Methodology for Characterizing Vulnerability of Forest Ecosystems for Adaptation to Climate Change	14.15 to 14.30
Chandra Sekhar Bahinipati	Metrics for Mainstreaming Adaptation in Agriculture and Water Sectors: Insights from a Farm-Household Level Survey in Tamil Nadu, India	14.30 to 14.45
Mamata Swain	Weather Based Crop Insurance Scheme: For Adaptation to Climate Change in Odisha	14.45 to 15.00

Rakesh Dalal	Feasibility Assessment of Solar Pumping for Draw-Down Agriculture in Dimbhe Region	15.00 to 15.15
Prasun Das	Vulnerability and Adaptation to Natural Disasters: Evidences from Rural Odisha, India	15.15 to 15.30
Namrata Ginoya	Vulnerability Assessment and Resilience Plan Against Climate Variability for Coastal Villages of Kutch	15.30 to 15.45
	Question and Answer Session	15.45 to 16.30

SESSION IV - 16.30 to 17.30

POSTERS ON SCIENCE/IMPACTS (VENUE: CAOS AUDITORIUM) Moderator: G Bala

Ankit Dwivedi	Forest Ecosystem in India: Carbon Source or Sink
Yogesh Karyakarte	Monitoring Glacier Changes in Parbati Basin, Himachal Pradesh, India
Ajay Singh	Assessing Imprints of Large Scale Phenomena on Climate Extremes in India
Ranjit Kumar	Role of Bioaerosols in Climate Change over Indo-Gangetic plain
Anurag Kandya	The Changing Climate of Ahmedabad City: A Scientific Perspective Based On Multivariate Analysis
Neha Sharma	Present-day Climate and Future Projections for North East India
Vaishali Saraswat	Rainfall and Temperature Characteristics of Four Indian Cities
Nishanth T	Seasonal Variations of Surface Ozone and its Precursors over Kannur
Akshay Narayankar	Trends in the Rainfall Pattern over India
Saravanan J	Underlying Facts on Changing Forest Floor Respiration at Kolli hills of Tamil Nadu
Nishadh K A	Regional Temperature Variability in the Western Ghats
Reshmidevi T V	Analysis of the Spatial and Temporal Characteristics of Rainfall in the Malaprabha River Basin
Shreeya Verma	FA Model Based Investigation of the Relative Significance of Carbondioxide Fertilization, Climate Change and Nitrogen Deposition of Net Primary Productivity and Ecosystem Carbon Storage
Tania Guha	Observations on Seasonal Variation of Atmospheric Carbondioxide over Bangalore - Affected by Indian Monsoon and La Nina
Abhishek Nair	Perception Analysis of Climate Related Impacts Faced by Agricultural Communities Using Fuzzy Cognitive Mapping Approach
Subhashree Banerjee	Climate Change and Agricultural Productivity: A Case Study of Maize in India
Sirisha Kalidindi	Mitigation of Global Mean Temperature Change from a Doubling of Carbondioxide Using Solar Radiation Management

TEA AND POSTER VIEWING (VENUE: CAOS TERRACE) - 17.30 ONWARDS

DINNER (VENUE: CAOS TERRACE) - 19:30 to 21:30

DAY 2: NOVEMBER 4, 2012

SESSION I - 10:00 TO 12:00

SCIENCE & IMPACTS (VENUE: CAOS AUDITORIUM) Moderator: G Bala

Chandra Sekhar Jha	National Carbon Programme	10.00 to 10.15
Suchita Srinivasan	Impact of Rainfall and Temperature on Yields of Rice and Millets at the District Level	10.15 to 10.30
Rajiv Kumar Chaturvedi	How much Carbon does Indian Forests Hold – A DGVM-based Analysis	10.30 to 10.45
Angshuman Modak	Sensitivity of the Global Hydrological Cycle to the Meridional Distribution of Stratospheric Aerosols	10.45 to 11.00
Siddhartha Sankar Das	Clay Mineralogical Variations in a Late Quaternary High-resolution Sediment Record from the South-Eastern Arabian Sea: Implications for Palaeoenvironmental Change	11.00 to 11.15
Pallavi Sharma	Study of Heat Stress Indices in Metropolitan Cities in India	11.15 to 11.30
	Question and Answer Session	11.30 to 12.00

MITIGATION (VENUE: CAOS SEMINAR HALL) Moderator: Sudhir Chella Rajan

Harini Nagendra	Greening Cities: Urbanization and Climate Change in India	10.00 to 10.15

Tejal Kanitkar	Low Carbon Pathways Under Climate Constraints	10.15 to 10.30
Divya Pandey	Carbon Footprints of Rice Cultivation Under Different Tillage Practices in Rice-Wheat System	10.30 to 10.45
Hippu Salk Kristle Nathan	Can India go Nuclear Energy Free—the Pathways and Aftermaths	10.45 to 11.00
	Question and Answer Session	11.00 to 12.00

ADAPTATION (VENUE: CAOS CONFERENCE ROOM) Moderator: Chandra Bhushan

Anand Patwardhan	Agenda for Research in Climate Change Adaptation	10.00 to 10.15
E Vivekanandan	Climate Change and Marine Ecosystem Sustainability	10.15 to 10.30
R M Bhagat	Climate Analysis for Sustaining Tea Production in North East India: A Pragmatic Approach	10.30 to 10.45
Avantika Singh	Gendering Climate Change – An Insight from Gorakhpur and Jalaun District of Uttar Pradesh	10.45 to 11.00
Sujit Kumar Mishra	Assessing Institutionalized Capacities to Reduce Vulnerability for Climate Extremes in India	11.00 to 11.15
S.Janakarajan	Challenges and Prospects for Adaptation: Climate Change and Disaster Risk Reduction in Coastal Tamil Nadu	11.15 to 11.30
Anubhab Pattanayak	Characterizing Sensitivity of Farming Communities to a Changing Climate	11.30 to 11.45
	Question and Answer Session	11.45 to 12.00

SESSION II - 12:00 TO 13:00

POSTERS ON MITIGATION (VENUE: CAOS AUDITORIUM) Moderator: Krishna Achutarao

Hippu Salk Kristle Nathan	Assessment of Electrification Projects in India's Remote Villages where Grid-extension is Infeasible
Roshan R Rao	Experiment on Performance of Rooftop Solar Panels
Amit Maheshwari	Preparedness of Indian Companies in Addressing Climate Change Regulations and Voluntary Commitments
Karthik Ganesan	Pathways to GHG Emissions Reduction in the Indian Cement Industry: A Clustering Based Approach
C H Sreenivas	Assessment of Carbon Mitigation Potential of Bioenergy Alternatives
A G Matani	Effective Energy Conservation Strategies and Techniques in Industries Towards Cleaner Environment
Deepak Singh	Future of Electricity Storage Systems in India: Developing a Foresight for Battery Technologies by 2030
Peeyush Sekhsaria	Climatic Performance of Traditional and Recent Vernacular Architecture in Ladakh
Ch Matouleibi	Making of a Green Event: A 'Sustainable' Case Study
Sreedipta Chatterjee	Amino Functionalized Zeolitic Tetrazolate Framework (ZTF) with High Capacity for Storage of Carbondioxide
S Meenakshi Sudarvizhi	Experimental Study on Using Copper Slag and Quarry Dust as Partial Replacement for Cement and Sand in Concrete
Shwetmala	Carbon Emission and Sequestration Potential of India
Narasimhan G	The Potential for Urban Solar Rooftop PV Systems to Mitigate Carbon Emissions

LUNCH (VENUE: CAOS TERRACE) - 13.00 to 14.00

SESSION III - 14:00 TO 16:00

CONCLUDING SESSION (VENUE: CAOS AUDITORIUM) Chair: Kamenio Chattopadhyay

CBS Dutt, ISRO	ISRO-GBP and National Information System for Climate and Environmental Studies	14:00 to 14:15
G S Bhat, CAOS Chairperson	Observation Programmes and Opportunities in India	14:15 to 14: 30
Sudhir Chella Rajan, IIT Madras	Indian Climate Research Network: The Way Ahead	14:30 to 14:45
Sunita Narain, CSE	Politics of Climate Change: The Role of Science	14:30 to 14:45
Kamenio Chattopadhyay, Chairman, Division of Mechanical Sciences, IISc	**Closing Remarks and Poster Award Distribution**	15:30 to 16:00

REIMBURSEMENTS AND HIGH TEA - 16:00 to 18:00

Note: *If you have trouble locating Centre for Atmospheric and Oceanic Sciences (CAOS), please look for Divecha Centre for Climate Change. They are both in the same building.*