Vol.3 Issue 3, September - December, 2018

DIVECHA CENTRE FOR CLIMATE CHANGE

Newsletter of the

DIVECHA CENTRE FOR CLIMATE CHANGE

Infosys prize 2018

Air pollution and health

Intercollegiate climate science quiz 2018

The 14th Jeremy Grantham lecture

Climate science quiz at Kochi, Kerala

Indian Institute of Science
Bengaluru
www.iisc.ac.in

CONTENTS

From the Chair

News and Events:

1. Infosys prize 2018
2. Air pollution and health
3. Intercollegiate climate science quiz 2018
4. National Consultation on disease burden from air pollution
5. The IPCC 1.5 ^{0}C report meet
6. Climate science awareness program in Kochi, Kerala
7. The 14th Jeremy Grantham lecture
8. Science and training workshop on climate change
9. The Indian Technical and Economic Cooperation program
10. Contributions of air pollution to climate change
11. Workshop on climate change

Research Highlights:

12. How will reduction in air pollution affect Indian monsoon?
13. Water-food-energy Nexus

Editors: S. K. Satheesh, J. Srinivasan and K. Krishnamoorthy

Contact: Chair, Divecha Centre for Climate Change,
Indian Institute of Science, Bengaluru-560012.
Tel: +91-80-22933070
Email: chair.dccc@iisc.ac.in
www.dccc.iisc.ac.in

FROM THE CHAIR

Greetings!

During the one decade since it was established, the Divecha Centre for Climate Change has carved out its unique identity as a centre, entwining science and policy for sustainable development to enable societies to face challenges posed by global environmental and climate change and to identify potential solutions. The Centre has remained vibrant and has made several significant advancement in this direction. The notable accomplishments include:

• Establishment of the South Asia regional office of the international long-term science-cum-policy programme "Future Earth" at the Centre. This provides an umbrella program for climate scientists and social scientists to come together and exchange the knowledge for sustainable development under changing climate.

• Influencing policy making at national and regional scales through active dialogue between scientists, policy-makers and the general public, by providing advanced training to students and young professionals and creating awareness among policy makers in emerging domains of energy and water security. A programme involving the Members of the Parliament (MPs) and the State Legislative Assemblies (MLAs) has been initiated, on important issues related to climate change policy, with a view to influencing the government policies on climate change, mitigation and adaptation. The first of this series was organized on "Himalayan Glaciers and Water Security of the Indo-Gangetic Plains". In a similar way, the Centre has plans to cover other relevant topics such as "Air Quality and Health", which is an issue of interest to the "MAIRS" international project office which has been formulated at the Centre.

• Addressing the impact of climate change on our precious biodiversity. It is going to be a challenge to India to fulfil its commitment to halt its biodiversity loss by 2030, as our biodiversity is not yet fully documented. There is a need to generate a comprehensive biodiversity database using high-resolution satellite data as well as through in situ efforts by network of volunteers from schools and colleges across the country. It is also essential to establish biodiversity study parks across different eco-zones and land-use types in order to understand the evolution of floral and faunal biodiversity in response to different stresses including climate change. The centre supports and would continue to support maintaining biodiversity study parks in natural forests.

• Establishment of the "Water Solutions Lab" has been an important accomplishment of the Centre. According to the IPCC, there is a high degree of certainty on the impact of climate change on food security, resulting from changes in the onset and amount of precipitation as well as its temporal and spatial distribution due to increase in temperature. The changes in Indian monsoon rainfall, influenced by human activities, have a detrimental effect on agriculture. The demand for water, energy and food is increasing due to rising population, rapid urbanization and changes in land-use. Because of the complex linkages between water, energy and food, it is important to engage with diverse decision-makers in government, the private sector, industry and civil society. An understanding of the complex water-energy-food nexus is central to sustainable development, is being pursued as part of these programs.

In summary, the Centre is synergizing physical sciences and social sciences to define new roads for sustainable development under changing climate.

S. K. Satheesh

INFOSYS PRIZE 2018

(Left to Right) Infosys co-founder Mr. Narayana Murthy, Prof. Navakanta Bhat, Nano Science IISc., Prof. S.K. Satheesh, Divecha Centre for Climate Change, IISc., and Infosys Science Foundation president Mr. K. Dinesh.

On 13th November 2018, Infosys Science Foundation announced that Prof. S.K. Satheesh has been selected for the Infosys prize 2018 for his pioneering scientific work in the field of climate change.

The work of Prof. Satheesh has highlighted the role of light absorbing soot particles on earth's climate. Soot is an aerosol, which is a by product of incomplete combustion of firewood, diesel or agricultural waste. Prof. Satheesh played a key role in measuring and recognizing the role of these aerosols in altering the climate over the Indian subcontinent. He made measurements from aircraft, ship, ground-based platforms and satellites. This enabled him to quantify the impact of these particles on climate. He has underscored the importance of both dust, which a natural aerosol and soot, which is an anthropogenic aerosol on altering climate.

Aerosols influence the formation of clouds and alter precipitation patterns. The scattering aerosols like sulphates reduce the warming due to greenhouse gases, but absorbing aerosols can augment warming by greenhouse gases. The work of Prof. Satheesh's pioneering work has helped us to understand the differences and the similarities in the interactions of the soot particles with solar radiation from other aerosols.

His work has highlighted the presence of higher amount of soot in the middle of the atmosphere on account of emissions from aircraft. These soot particles can reach the stratosphere and can reduce the amount of ozone present there.

The prize will be formally awarded to Satheesh on January 5th, 2019 in a glittering ceremony in Bengaluru.

AIR POLLUTION AND HEALTH

Guest speaker Dr. Paramesh (left) with Prof. Anurag Kumar, Director of Indian Institute of Science.

Dr. Paramesh, an eminent pulmonologist, was the guest speaker for the Tenth Edition of the Climate and Environment Science Quiz conducted by Divecha Centre for Climate Change on 11th September 2018.

In this lecture, he brought to light the direct impact of air pollution on human health and ways to reduce them. He spoke about the perils of rapid urbanization; the direct impact of deforestation; increase in high rise buildings; and the rapid reduction of green cover in urban areas. He drew attention to the health problems that arise due to lesser known allergens like dust mites, cockroaches, pet fur, and fungi. He mentioned the ill effects of the deteriorating air quality, the increased risk of chronic disease caused by such pollutants on the urban youth and the increased mortality rate.

He said, "Studies have shown that pollution has a significant impact on lung health, especially among children and on occupational groups like traffic policemen and street vendors."

Children suffer more from air pollution due to anatomical and physiological reasons. He showed that the number of children affected by sinusitis, mouth breathing, and sleep apnoea has increased; and so, has the number of children affected by persistent, severe varieties of asthma.

"In the last 20 years, the number of children needing hospital admissions for asthma has increased from 4% to 11%", said Dr Paramesh. According to him, prevalence of asthma in children from urban cities has increased from 9% in 1979, to 25.6% in 2009. Sulphur dioxide and ozone are major irritants for the respiratory system. Ozone is formed more around traffic signals, when

bright sunlight interacts with vehicular emissions. This may be contributing to the rise in asthma cases among children during summer," said, Dr. Paramesh.

Speaking about lifestyle changes he said the reduced physical activities, change in eating habits, and increased use of air conditioners, and lack of fresh air are adding to the health problems. Reverting to traditional dietary habits will prove beneficial, he said. Discussing the challenges faced by medical practitioners in rural areas he said, educating the masses regarding the causative agents of pollution was the biggest hurdle. The indiscriminate uses of fossil fuel for cooking, small confined living spaces with poor ventilation, lack of proper hygiene and tobacco smoking were the main causes of lung diseases in rural areas.

He highlighted the importance of a holistic approach for better health. He said, "As a nation with the tradition of practising yoga and recognising the health benefits of yoga we should make some changes in our education system to include yoga in the school curriculum".

The talk reiterated that preserving our environment and bringing about life style changes can go a long way in restoring good health.

Dr. Paramesh, visiting professor, Divecha Centre for Climate Change, delivering the talk.

INTERCOLLEGIATE CLIMATE SCIENCE QUIZ 2018

The annual Climate Science Quiz program for college students was held at J. N. Tata Auditorium, Indian Institute of Science on 11th September 2018. This event, which attracted more than 1200 students and faculty from 80 colleges across Karnataka, is being held every year to create awareness about climate and climate change among the youth. The research students and project staff of the centre have created posters highlighting glacier retreat in Himalayas, water crisis and solutions, effects of climate change on agriculture and renewable energy. A few students provided live demonstrations of climate science through experiments. This created excitement and awareness among the students. Some of the experiments were on the greenhouse effect, cloud formation and micro physics and infrared measurements of carbon dioxide concentrations. This provided an excellent learning experience for these youngsters who viewed the posters and demonstrations with great enthusiasm. These helped the students to understand the adverse affect of climate change and its impact on our health and well being.

A preliminary written test on climate science was conducted for about 75 teams to select the best teams for the quiz. The top three teams were St. Joseph's college, Academy for Climate Change from Kerala and Maharani's College for Women, Mysuru. The three teams competed for the first spot in the quiz competition. The first prize was won by the students from St. Joseph's College, Bengaluru.

The Academy for Climate Change from Kerala and the Maharani's College, Mysuru, won the second and third prizes respectively. The winners were presented with trophies, certificates and cash prizes. Prof. Anurag Kumar, Director, Indian Institute of Science distributed the prizes.

The students of St. Joseph's College receiving the prizes.

NATIONAL CONSULTATION ON BURDEN OF DISEASE FROM AIR POLLUTION

Dr. Paramesh, visiting scientist, Divecha Centre for Climate Change, delivering the talk.

Rtn. Dr. Paramesh, Pulmonologist, Lakeside Hospital, visiting scientist, Divecha Centre for Climate Change, delivered a talk on health issues due to air pollution on 3rd to 5th October 2018, at the Windsor Palace, New Delhi.

Air pollution in the environment has a huge impact on our health, causing allergic airway diseases such as asthma and allergic rhinitis in our respiratory system. The onset of non-communicable environmental disease epidemic, which can be attributed to many environmental factors, causes a significant disease burden as measured by psycho-social, and economic indicators. Dr. Paramesh substantiated statistics of these diseases due to anthropological factors and how changes in the structure of the human population has caused an increase in these diseases. He highlighted the ill effects of air pollution caused due to lead present in the atmosphere and how the spinal problems affect airways thereby obstructing it. He also emphasized the role of pets causing asthma. He spoke about the dangers occurring due to inhalation of foods such as anaphylaxis and other allergies.

Dr. Paramesh indicated some positive measures to mitigate global warming and air pollution to maintain good health. He underlined the need to educate stake holders on the degree of consequence of disease economic burden and advised certain guidelines to follow so that one may reduce air pollution. He condemned the use of fossil fuel and urged the people to find newer energy sources, increase greenery around them and control population growth. He encouraged people to follow traditional food habits and indulge more in foods rich with antioxidants, Omega 3 fatty acids to

overcome oxidative stress.

Dr. Paramesh concluded his talk by asserting significant pointers on how stake holders should take more responsibility and follow guidelines for sustainability. He appealed to the society to think, participate and, promote global awareness on health care management thereby overcoming air pollution and other environmental risks.

THE IPCC 1.5 ^{0}C REPORT MEET 2018

Prof. J. Srinivasan (extreme left) attending the meeting on the IPCC 1.5 ^{0}C report.

Prof. J. Srinivasan was invited to talk at the conference on the IPCC special report on 1.5 ^{0}C: significance, challenges and implications. This conference was organized by The Energy Research Institute (TERI) and the Ministry of Environment, Forests and Climate Change in New Delhi on 15th October 2018.

Prof. Srinivasan, had concerns over the lack of available studies on the effect of SO_2 on global warming. He reminded the audience of the cooling effect of SO_2 when it is converted into highly reflective sulphate aerosols that bounce a portion of the incoming solar radiation directly back into space, and warned that as developing countries like India tackled their air pollution problem and reduce SO_2 emissions, the cooling effect which SO_2 has will be cancelled, leading to increased global warning. He also cautioned against global models which have limited use regarding regional phenomena such as total rainfall. He pointed out that developing countries face multiple threats including but not limited to global warming; hence one of the report's shortcomings is that it looks at impacts only from a temperature rise lens. He gave the example of land subsidence leading to flooding of the Sundarbans and Bangladesh much faster and more immediately than the anticipated temperature rise. He urged for more scientific studies to be undertaken in this aspect.

CLIMATE SCIENCE QUIZ AT KOCHI 2018

Prof. S.K. Satheesh giving away the prize.

Divecha Centre for Climate change conducted a quiz program for school children on 26th and 27th Oct 2018 at Bhavans Vidya Mandir, Kochi, Kerala.

This program was to create awareness on "Climate Change and the Environment" for high school students so that they can perceive the consequences of global warming and its impact on human welfare. This program was cosponsored by EduWorld and Talentspire Intelligent Learning (TSPIRE).

The program consisted of lectures on climate science and the environment by eminent scientists, demonstration of methods for the measurement of air pollution, and a quiz contest.

There was an invited lecture by Prof. A. A. Mohamed, Professor at School of Marine Sciences, Kochi, who spoke about the Indian Arctic Expedition. He spoke about the impact of climate change on Arctic environment. He deliberated on how marine eco systems are being affected due to climate change which is causing serious threats.

About 719 academically gifted students participated in this program. The lectures on "The Science of Climate Change" and "Aerosols and health" elicited many questions and concerns. Many students indicated that this program convinced them to pursue a career in environmental science and technology.

THE 14TH JEREMY GRANTHAM LECTURE

Prof. David Battisti, Professor of Atmospheric Sciences, University of Washington, Seattle delivering the talk.

The 14th Jeremy Grantham lecture was delivered by Prof. David Battisti, Professor of Atmospheric Sciences, University of Washington, Seattle, USA at Divecha Centre auditorium, on 9th November 2018.

Prof Battisti indicated that the data from models revealed that high seasonal temperatures would become widespread in India and other tropical countries through the later part of 21st century. He concluded that such changes could have very serious effects on agriculture, particularly in the tropics. The decling yields in food crops would be augmented by increasing population. Using global datasets of maize production and climate variability, Prof Battisti explained how yield variability will affect world's largest maize-producing and maize-exporting countries. Prof Battisti's talk highlighted that there would be at least a 20% decline in the yield of major crops such as maize, wheat, rice and soybean by 2050. The factor of precipitation would be difficult to determine in the above models hence Dr Battisti said it was omitted. In maize and sorghum, the increasing CO_2 levels did not matter much because CO_2 could help to improve water use efficiency. The models showed that there would be year-to-year volatility in maize production and this would increase in all the mid-latitude breadbasket countries. This volatility in maize and perhaps soybean would occur even with no change in the weather statistics. Prof Battisti's data led to the conclusion that the rising instability in global grain trade and international market grain prices could influence poorer section of the people. In North West Mexico, the increasing temperature was a major cause of yield decline. A 1-degree

centigrade rise in temperature there would lead to a reduction in the yields of maize (10%) in NW Mexico, wheat (15%) in India and rice (17%) in Phillipines. Although the plant breeders have been trying to breed plant for high temperature tolerance, there has been no major success in obtaining high temperature tolerant varieties. The exception among crops has been observed for sugarcane which thrives well at high temperatures.

Prof Battisti dealt with models which established relationships between temperature, population growth and metabolic rates of insects to determine the losses in major crops like rice, maize, and wheat due to pests. The loss in yield would be rapid in areas where warming increases both population and metabolic rates of insects. Global warming would have impact on the pest infestations and this would further aggravate the food security worldwide. The yield losses due to insects would be 20-50% and primarily in temperate region. The insects would decrease the yield of in maize, rice and wheat by 10-25% for every degree increase in temperature. The temperate zones would be hit the hardest.

Prof Battisti's talk explored the likely impact of climate change and volatility on food production and food availability in future. Agricultural practices would tend to shift with global warming. The larger impact would be felt on the poorer consumers and people living in chronic hunger.

Prof. Battisti interacting with the audience.

SCIENCE AND TRAINING WORKSHOP ON CLIMATE CHANGE OVER THE HIGH MOUNTAINS OF ASIA

(Left to right) Prof. Ravi Nanjundiah, Prof. Satheesh, Prof. V. K. Gaur, Honorary Emeritus Scientist CSIR and Dr R. Krishnan, Executive Director, CCCR, at the workshop.

Divecha Center for Climate Change (DCCC), Indian Institute of Science, Bengaluru and the Monsoon Asia Integrated Research for Sustainability - Future Earth (MAIRS-FE) at DCCC, along with The Centre for Climate Change Research (CCCR) in IITM and the Earth System Science Organization (ESSO) of the Ministry of Earth Sciences (MoES), Goverment of India, organized a 5 day 'Science and Training Workshop on Climate Change over the High Mountains of Asia (HMA) and Annual Climate Change workshop of CCCR-IITM' during 8th to 12th Oct 2018, at IITM, Pune. The workshop was inaugurated by Prof. V. K. Gaur, Honorary Emeritus Scientist, CSIR, Fourth Paradigm Institute (Bengaluru) in the presence of Prof. S.K. Satheesh, Chairman, Divecha Centre, IISc (Bengaluru); Prof Ravi Nanjundiah, Director, IITM (Pune); and Dr R. Krishnan, Executive Director, CCCR, IITM (Pune) on 8th Jan 2018. The workshop emphasised regional climate downscaling activities, facilitating cross-fertilization of scientific expertise and engaging the community of Asian scientists for further capacity building pertaining to the High Mountains of Asia. This enabled them to develop appropriate inputs for further exploitation of the science-based climate information, with higher-level of confidence using model-based projections and knowledge of regional / local experts. There were 48 participants (8 foreign and 40 Indian) and 28 Scientific Experts which included 5 International and 23 National Faculties (including experts from IITM). The foreign participants were from Nepal, Srilanka, Cambodia, Laos, Thailand and Spain. The foreign experts were from Nepal, Japan, South Africa, UK and USA. More details are available on the workshop webpage:

http://cccr.tropmet.res.in/home/workshop/oct2018/index.jsp

THE INDIAN TECHNICAL AND ECONOMIC COOPERATION PROGRAM

The Ministry of External Affairs, Government of India, requested Divecha Centre for Climate Change to conduct a training program for scientists from Africa and Asia on climate and environment. This was under The Indian Technical and Economic Cooperation (ITEC) program of the Ministry.

The training program was conducted from 12th to 26th November 2018. Thirteen scientists from Mauritius, South Sudan, Thailand, Sri Lanka, Nigeria, Ethiopia, Mongolia and Madagascar participated in this program.

The program was inaugurated by Professor Satheesh who underlined the need to understand the impact of climate change on developing countries. The program consisted of lectures in the morning covering topics related to climate change aerosols, cryosphere, glacier hydrology, monsoons, air pollution and health.

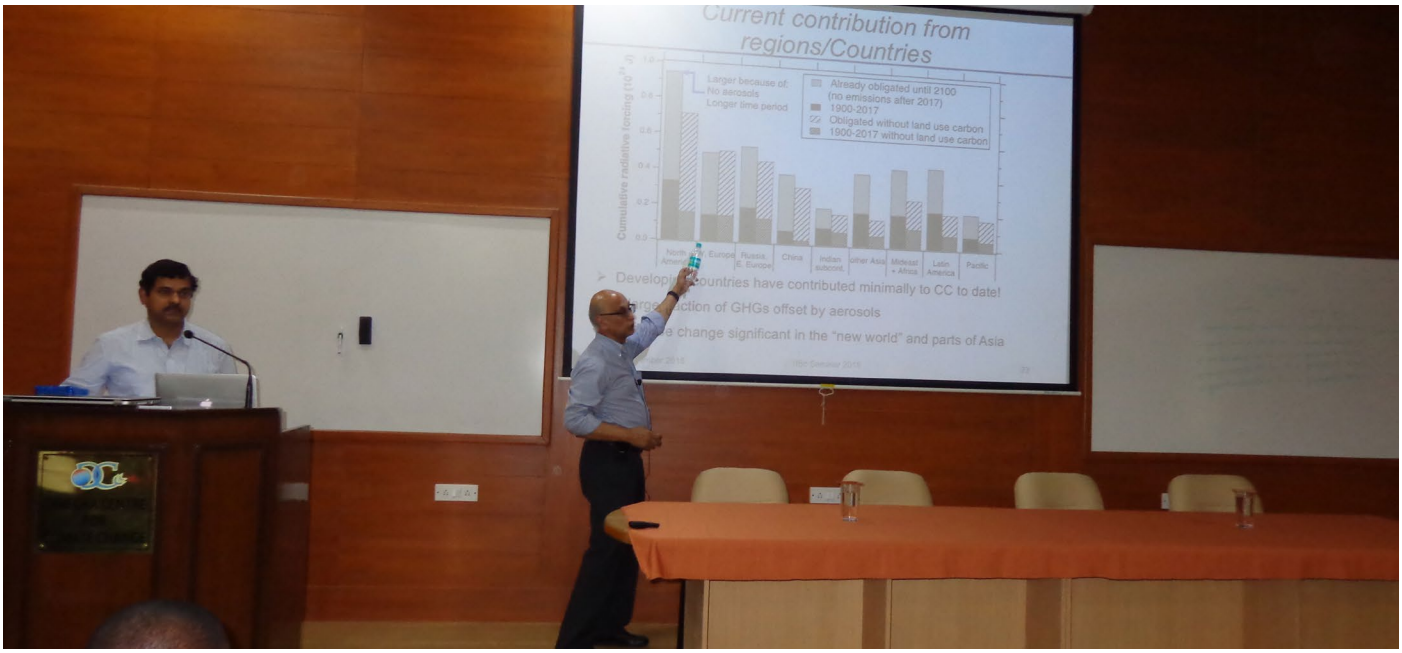
The afternoon sessions were devoted to providing training on various software that can be used to assess the impact of climate change.

Participants who attended the training program.

CONTRIBUTIONS OF AEROSOLS (PM) TO CLIMATE CHANGE AND AIR QUALITY: INDIA AS A CASE STUDY

Prof. Ravishankara, University distinguished professor at Colorado State University gave a popular lecture on “Contributions of aerosols to climate change and air quality: India as a case study” on 23rd November 2018 at Divecha Centre for Climate Change. The synopsis of his talk is given below.

Aerosols play key roles in global climate because of their interaction with incoming solar radiation, and human health. The emissions of greenhouse gases and precursors for aerosols are not same in all countries. Hence their contribution to global climate warming and air pollution are different. Burning of fossil fuels increases the amount of carbon dioxide in the atmosphere and hence leads to global warming. The burning of fossil fuels lead to formation of particulate matter called aerosols. The aerosols reduce the amount solar radiation reaching the surface of the earth and hence cause cooling of the earth. If the aerosols were not present, the global mean temperature would have increased by 1.5 C above the pre-industrial value. The presence of these aerosols has limited the global warming to 1 C. The presence of aerosols in the atmosphere leads to severe local air pollution and hence most countries have enacted laws to control air pollution. As more and more countries adopt laws to control air pollution, the global mean temperature will increase more rapidly on account of the presence of carbon dioxide. Hence, we need to find ways to control air pollution as well as amount of carbon dioxide in the atmosphere. North America and Europe are the leading contributors to climate change irrespective of the scenario. We have used a personal aerosol sensor to see how much a person is affected by the aerosols in Bengaluru. The conclusion from this study was that there is a large aerosol loading in Bengaluru and indoor and outdoor pollution is not very different



Prof. Ravishankar, Distinguished professor, Colorado State University delivering the talk.

WORKSHOP ON CLIMATE CHANGE

Divecha Centre for Climate change and The World Academy of Sciences (Central and South Asia regional partner) organized a workshop on climate change for young scientists from 5 to 7th December 2018 at Indian Institute of Science in Bengaluru. The workshop attracted young scientists from Africa, Central Asia, South and South east Asia. The workshop began with an inaugural talk by Prof. J. Srinivasan on the challenges that will be faced by developing countries on account of climate change. He highlighted the fact that the developed countries benefited by the exploitation of world resources during the 19th and 20th centuries. The developing countries have been warned that there is a limit to the amount of fossil fuel that can be burned in the next fifty years. The adverse impact of climate change will be more in the developing countries than in the developed countries. Most developing countries are in the tropics and an increase in the temperature in the tropics will decrease the agricultural yield, cause increased extreme events and decrease in the availability of water. The developing countries will have to learn to adapt to climate change and reduce their consumption of fossil fuels. The developing countries have to chart new path for economic growth without having an adverse impact on the environment.

Dr. Renu Swarup, Secretary, Department of Biotechnology, Government of India delivering the talk.

Prof. Anil Kulkarni discussed the impact of climate change on the glaciers in the Himalayas and the threat of glacier lake outburst floods. Prof. R. Srinivasan discussed the geological and soil characteristics of glaciers. The TWAS prize lecture on “Technology and Innovation: The Indian policy perspective for science diplomacy” was delivered by Dr. Renu Swarup, Secretary, Department of Biotechnology, Government of India. The first lecture on the second day was by Dr. Suresh Babu, Space Physics Laboratory, Thiruvananthapuram on climate research based on space and ground-based observations. Dr. V.M. Tiwari, National Geophysical Research Institute, Hyderabad discussed the estimation of water loss during droughts. Dr. R.R. Yadav, Birbal Institute of Palaeobotany, Lucknow spoke about Gangotri glacier. Dr. Satish Shenoi, Indian National Centre for Ocean Information System, Hyderabad, highlighted the detection and modelling of Tsunamis in the Bay of Bengal. Prof. Prosenjit Ghosh, Indian Institute of Science provided an overview of methods to use proxies to infer the climate change in the past. Dr. Paramesh, Divecha Centre for Climate Change showed the impact of climate change on human health. On the third day, Prof. Vinaychandran, Divecha Centre for Climate Change discussed the variability of climate in the Bay of Bengal.

This was followed by presentations from scientists from Benin,Ghana,Sri Lanka,Ethiopia, Uganda ,Cameroon and Kenya. The valedictory address was by Mr. Ajith Seth (former cabinet secretary, Government of India) on the evolution of policies related to climate change.

Dr. Ajit Seth, former Cabinet Secretary, Government of India, delivering his talk.

RESEARCH HIGHLIGHTS

HOW WILL REDUCTION IN AIR POLLUTION IN UNITED STATES, EUROPE AND CHINA AFFECT THE INDIAN MONSOON?

Aerosols are small solid or liquid particles suspended in the atmosphere. They alter the climate of the earth by reflecting or absorbing solar radiation. Among the aerosols released by human actions the sulphate aerosols constitute 90% of the emissions. They reflect solar radiation and hence cool both the atmosphere and the surface of the earth. Aerosols like soot are released during incomplete combustion and they heat the atmosphere by absorbing solar radiation but cool the surface of the earth by reducing the solar radiation reaching the surface. The local cooling of the atmosphere and the surface by sulphate aerosols leads to a weaker monsoon. The impact of soot on the monsoon rainfall is not so simple. Since soot heat the atmosphere it can locally enhance the monsoon rainfall. Both soot and sulfate aerosols have remote impact by altering the meridional and zonal gradient of temperature in the tropics.

We have examined the impact of reduction of emissions of sulphate aerosols by United States, Europe and China by using a Hadley Centre Global environmental model (HadGEM3)

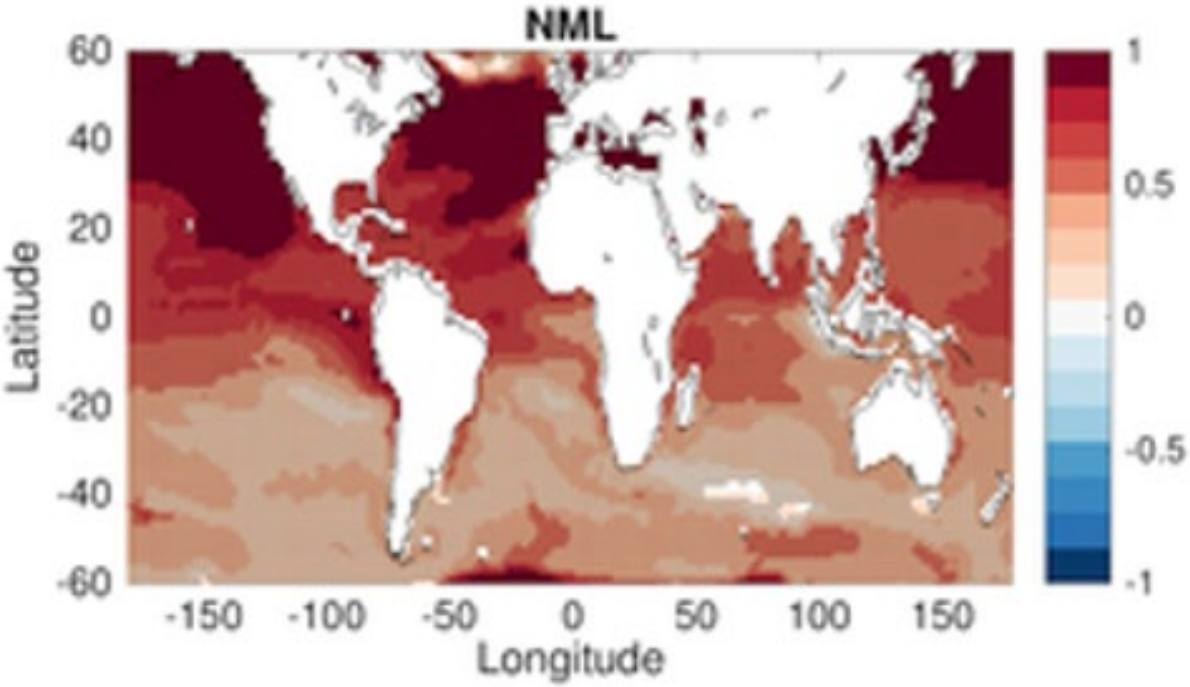


Figure 1 The change is sea surface temperature on account of cessation sulphate aerosol emissions from USA, Europe and China. The increase in sea surface temperature in the Northern Hemisphere is higher than in the Southern Hemisphere and this leads to the northward shift of the rain band and hence a higher rainfall over India.

coupled ocean model (NEMO). A 200-year simulation was conducted with this model. One simulation contained aerosol emissions all over the world. In the second simulation the aerosol emission from United States, Europe and China were removed.

In the first simulation, the presence of aerosols in the region from 25 deg north to 35 deg north reduced the meridional temperature gradient between the mid-latitudes and the equator and hence resulted in a southward displacement of the intertropical convergence zone (ITCZ) and thus reduced the monsoon rainfall over India. In the second simulation the removal of aerosols in northern midlatitudes increased the sea surface temperature in the northern hemisphere (figure 1). This increased in the meridional temperature gradient and hence caused a northward displacement of the ITCZ. The reduction of aerosol emissions in United States, Europe and India will therefore lead to increase in the Indian monsoon rainfall.

Reference:

Shawki, D & Voulgarakis, Apostolos & Chakraborty, Arindam & Kasoar, M & Srinivasan, Jayaraman, The South Asian Monsoon Response to Remote Aerosols: Global and Regional Mechanisms. Journal of Geophysical Research: Atmospheres. 10.1029/2018JD028623,2018

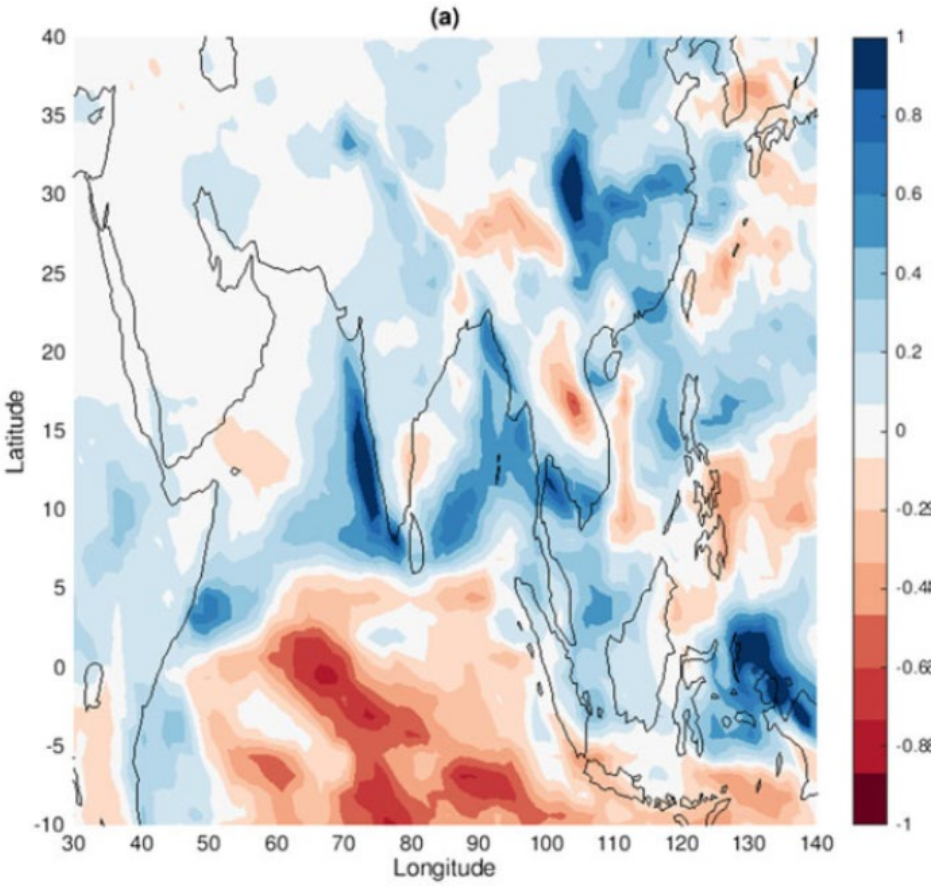
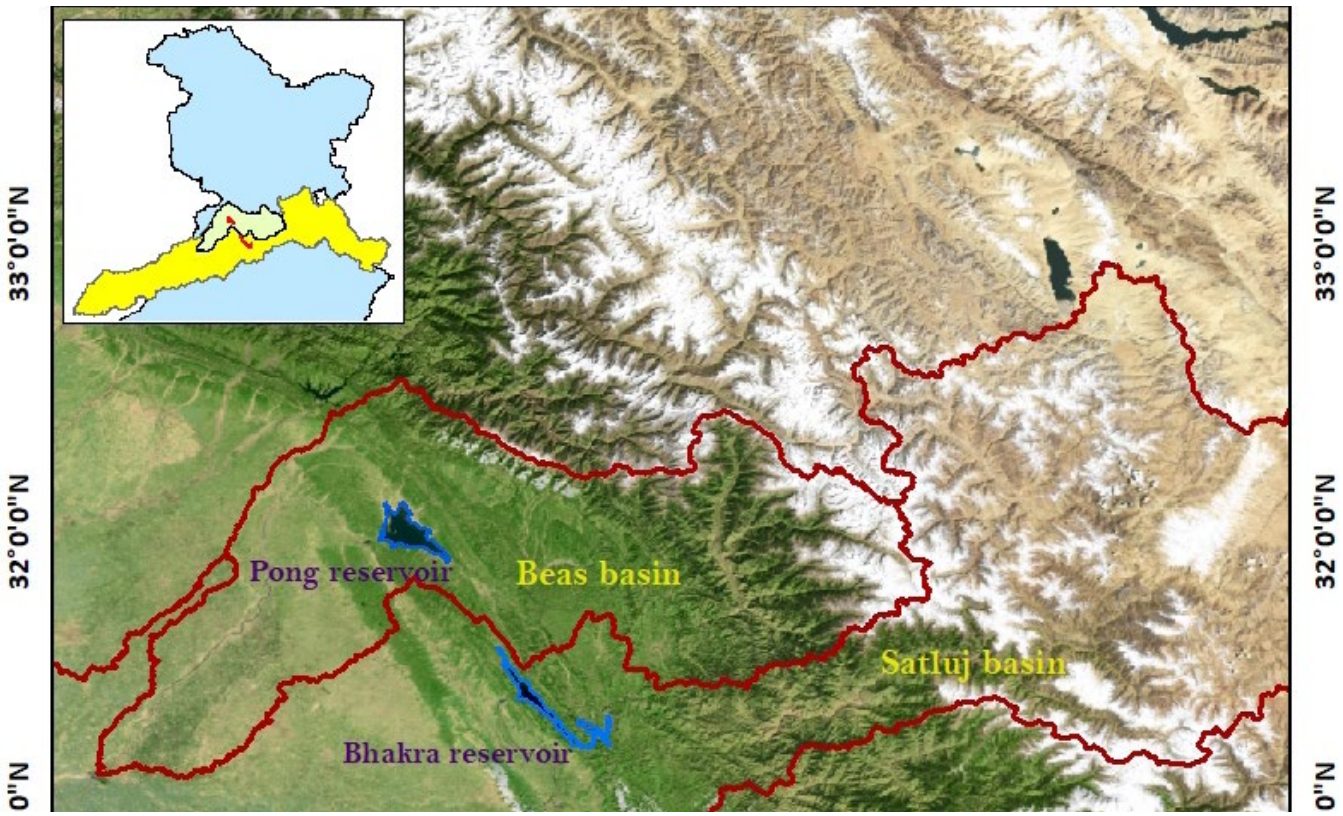


Figure 2 Change in rainfall (mm/day) during the monsoon season on account of reduction in aerosol emissions from United States, Europe and China.

UNTANGLING THE WATER-FOOD-ENERGY-ENVIRONMENT NEXUS FOR GLOBAL CHANGE ADAPTATION IN A COMPLEX HIMALAYAN WATER RESOURCE SYSTEM

Water from Himalayan rivers is used in domestic, agriculture, energy and industrial sectors. The river flow is sustained by rainfall, groundwater, snow and glacier melt. The contribution of each component varies from basin to basin, making the region hydrologically complex. In the Himalaya, glaciers are thinning, losing mass, and retreating due to climate change. These changes in the cryosphere will influence the water availability. The water stress will also be affected by increasing water demand. In this era of rapid modernisation, water demands can grow and diversify; making water resources management increasingly complex.

In the present study, Water Evaluation and Planning (WEAP) model was used to integrate climate and socio-economic changes in Satluj and Beas basins. This approach combines diverse hydrological drivers such as rainfall, seasonal snowpack and glaciers with major sectors such as irrigation, energy and infrastructure. In the first step, seasonal changes in precipitation and temperature based on the 25th, 50th and 75th percentiles of a 42 CMIP5 GCM ensemble for RCP4.5 were used to quantify the effect of climate change on mean annual runoff at Bhakra and Pong reservoirs. All these scenarios indicate increase in total annual water availability by 2050 compared to baseline period of 1978 to 2007. Early melting of snow increases runoff in April, whereas higher temperature and rapid melting of glaciers increase flows in summer. The decrease in



Basin Map.

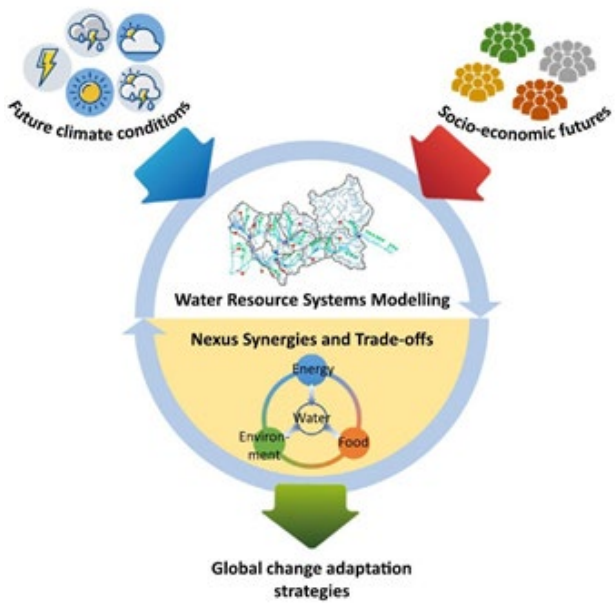
winter precipitation and enhanced glacier melt results in a negative mass balance of the glaciers. For the two scenarios that generated greatest and lowest runoff in the basins, total volume of glaciers was observed to decrease by 63-65% in Beas basin and 61-65% in Satluj Basin.

In the next stage, these two extreme climate change scenarios were incorporated in the socio-economic pathways (SSP). The indicators of each water, food, energy and environment components were analysed within 3 SSP scenarios. In the study area, the energy component is represented by the hydropower production; the food component refers to productivity of irrigated crops; the environment is represented by the maintenance of the flow regime downstream of reservoir relative to upstream flows; and the water component includes drinking water and flood abatement. SSP1 which focuses on total sustainability and high environmental awareness, SSP2 is middle of the road and SSP5 supports conventional development. In all SSP scenarios, population, consumption rate, irrigated land and hydropower demand increase. In the case of SSP2, growth of hydropower demand, drinking water and population are high.

The nexus analysis highlights the impact of both climate and socio-economic change together on each component. The results show that future socio-economic changes will have a much stronger impact on sustainable development than climate change. Hydropower generation and environmental protection represent the major sectors providing opportunities and limitations for adaptation. This approach is relevant as it considers the changes in both source and demand of various sectors.

Reference:

A.Momblanch, L. Papadimitriou, Sanjay. K. Jain, Anil Kulkarni, Chandra S.P.Ojha ,A.J. Adeloye, and I. P. Holman, Untangling the water-food-energy-environment nexus for global change adaptation in a complex Himalayan water resource system, Science of the Total Environment, doi.org/10.1016/j. scitotenv.2018.11.045



An illustration shwoing the approach of nexus analysis incorporating climate and socio-econmoic changes.