Climate change research initiative: Indian Network for Climate Change Assessment

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The present article provides a brief overview of Indian Network for Climate Change Assessment (INCCA) which is a new initiative of the Ministry of Environment and Forests. It has been visualized as a network of institutions countrywide and is designed to undertake a range of activities in the area of climate change, e.g. science, impacts, vulnerability, mitigation and adaptation. Under the aegis of INCCA, two assessments, viz. Greenhouse Gas Emissions 2007 and a Sectoral and Regional Analysis of Climate Change in 2030s have been brought out. A National Carbonaceous Aerosols Programme has been developed. INCCA contemplates other initiatives which could serve as basis to respond to concerns of climate change.

Keywords: Black carbon, climate change assessment, INCCA, research initiative.

CLIMATE change is recognized as a significant man-made global environmental challenge and is also treated as a threat. Consequently, there is now a growing recognition of the vulnerability of key sectors of economy and development due to climate change. The various assessment reports brought out since 1990s by the Intergovernmental Panel on Climate Change (IPCC) have progressively tracked the development and build-up of knowledge and understanding of the science, impacts and mitigation of climate change at the global and regional levels. Wide-ranging implications and adverse impacts due to climate change have been projected on developing countries. The IPCC has concluded that the impact of human activities on climate is unequivocal[1]. The current debate is on the extent and magnitude of climate change. While the Fourth Assessment Report of the IPCC provides the latest understanding regarding climate change at the continental level, the information and details at the regional and sub-regional levels are rather inadequate and fragmentary, clearly underscoring the need for more comprehensive studies and information at such levels.

Climate change may alter the distribution and quality of India's natural resources and adversely affect the livelihoods of its people. With an economy closely tied to its natural resources such as agriculture, water and forestry, India may face major threat because of the projected changes in climate[2]. Impacts of climate change on sectors such as water resources, agriculture, natural ecosystems and forestry, human health, infrastructure and energy have been assessed and reported for the 2050s and 2080s (ref. 3). These assessments did not specifically articulate impacts at the sub-national level, especially impacts on climate-sensitive regions in India. In recognition of the need for more accurate, reliable and comprehensive understanding of the implications of climate change, the Ministry of Environment and Forests (MoEF), Government of India on 14 October 2009 announced the launch of the Indian Network for Climate Change Assessment (INCCA). It has been conceptualized as a network-based scientific programme designed to: assess the drivers and implications of climate change through scientific research; prepare climate change assessments once every two years (GHG estimations and impacts of climate change, associated vulnerabilities and adaptation); develop decision support systems, and build capacity towards management of climate change-related risks and opportunities.

INCCA is visualized as a mechanism to create new knowledge and engage existing knowledge institutions already working with the MoEF as well as other agencies[4]. Currently, the institutions of the various ministries such as MoEF, Ministry of Earth Sciences (MoES), Ministry of Agriculture, Ministry of Science and Technology, Defence Research and Development Organization (DRDO), etc. along with the research institutions of the Indian Space Research Organisation (ISRO), Council of Scientific and Industrial Research, Indian Council of Agriculture Research, Indian Council of Medical Research, Indian Institute of Science, Indian Institutes of Technology, Indian Institutes of Management and prominent State and Central Universities, and reputed NGOs and industry associations are working on the various aspects of climate change.

The programmes under INCCA have been developed on the basis of the fundamental questions for climate-proofing systems and the society dependent on climate, which include, *inter alia*: short, medium and long-term projections of climate changes over India at sub-regional scales; impacts of changes in climate on key sectors of

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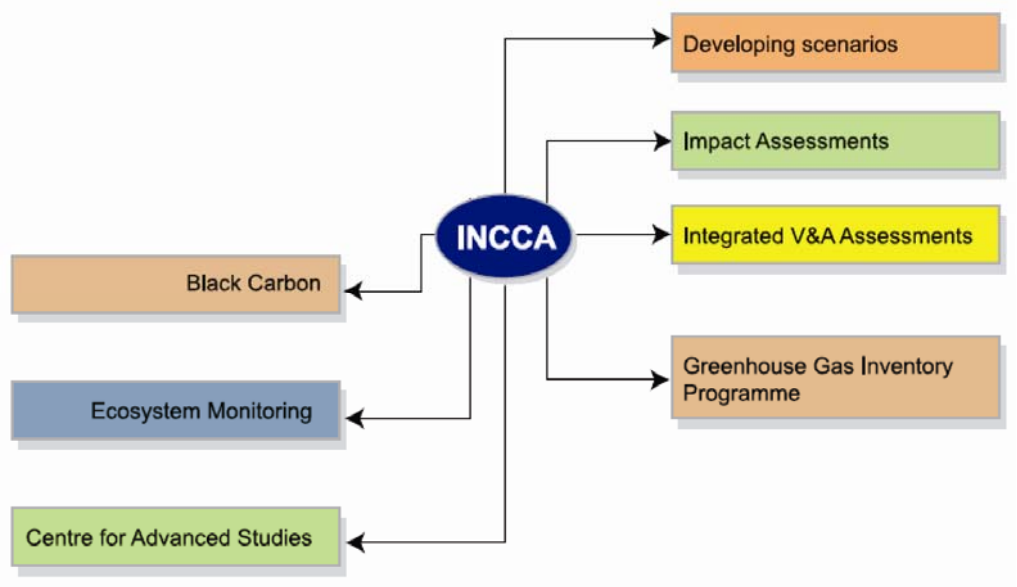

Figure 1. Programmes envisaged under INCCA.

economy at regional scales; anthropogenic drivers of climate change, i.e. GHGs and pollutants emitted from various sectors of the economy, and the processes through which GHGs and pollutants interact with the climate system and change the biophysical environment. The mandate of INCCA will continue to evolve to include the new scientific questions that confront humanity. The aim of scientific research under INCCA is envisaged to encompass research that will develop understanding on the regional patterns of climate across India, how it is changing over time and likely to behave in the future. Consequently, INCCA will also focus on the impacts of the changing climate on regional ecosystem hotspots, human systems and economic sectors.

The following programmes (Figure 1) have been undertaken and/or envisaged under the aegis of INCCA:

- A provisional assessment of GHG emission profile of India for 2007 by sources and removal by sinks;
- An assessment of the impacts of climate change on water resources, agriculture, forests and human health in the Himalayan region, North East region, the Western Ghats and coastal regions of India;
- Undertaking an assessment of black carbon and its impact on ecosystems;
- Undertaking a long-term ecological, social and economic monitoring of ecosystems to identify patterns and drivers of change that influence the sustainability of livelihoods dependent on these systems across India;
- Building capacity through thematic workshops and training programmes;
- Synthesizing information thus generated in appropriate communication packages for informed decision-making.

Some details of the INCCA initiatives and research programmes of other Ministries of the Government are provided in the following.

India: GHG emissions 2007

This was the first INCCA report[5] released on 11 May 2010. The GHG emissions in 2007 with land use, land-use change and forestry (LULUCF) were 1727.71 million tonnes of CO_2 equivalent (eq.), of which CO_2 emissions were 1221.76 million tonnes, CH_4 emissions were 20.56 million tonnes, and N_2O emissions were 0.57 million tonnes. The GHG emissions from energy, industry, agriculture and waste sectors constituted 58%, 22%, 17% and 3% of the net CO_2 eq. emissions respectively. This assessment was an outcome of contributions of more than 80 scientists from 17 institutions across the India. Details of the emissions are available in the INCCA assessment[4].

Climate change and India: a 4×4 assessment – a sectoral and regional analysis for 2030s

This was the second major assessment[6] released on 16 November 2010. It deals with the impact of climate change in the 2030s on four key sectors of the Indian economy, namely agriculture, water, natural ecosystems and biodiversity, and health in four climate-sensitive regions of India, the Himalayan region, the Western Ghats, the coastal areas and the North East region. This comprehensive assessment was brought with involvement of more than 43 scientists and 19 institutions. This 4×4 assessment examines the implications of climate change for India in the 2030s deduced from a regional climate

model, HadRM3 (Hadley Centre Regional Model Version 3) run for A1B scenario. This scenario, amended assumes significant innovations in energy technologies, including renewables, which improve energy efficiency and reduce the cost of energy supply. The 2030s is the average of the period 2021–2050. All the changes in the 2030s are measured with respect to the period 1961–1990, also referred to as '1970s' or 'baseline'. The climate change scenarios for the 2030s indicate an overall warming for all the four regions in focus, with a net increase in annual temperatures in the 2030s with respect to the 1970s ranging between 1.7°C and 2.2°C, with extreme temperatures increasing by 1–4°C, and with maximum increase in coastal regions. The extreme maximum and minimum temperatures are also projected to increase in the 2030s with respect to the 1970s. All the regions are projected to experience an increase in precipitation in the 2030s with respect to the 1970s and the increase is highest in the Himalayan region and lowest in the North Eastern region. The extreme precipitation events are likely to increase by 5–10 days in all the four regions. Sea level along the Indian coast has been rising at the rate of 1.3 mm/yr and is likely to rise in consonance with the global sea-level rise in the future. Further projections indicate that the frequency of cyclones is likely to decrease in the 2030s, with increase in cyclonic intensity. In the agriculture sector, it is estimated that irrigated rice is likely to gain in yields marginally due to warming compared to the rainfed crop, as irrigated rice tends to benefit from CO_2 fertilization effect. Maize and sorghum are projected to have reduced yields in all the regions. Coconut productivity is projected to rise in the western coast and reduce in the eastern coastal region. Observations indicate a reduction in apple production in the Himalayan region, which is likely to continue in the future. In the case of marine fisheries, some species such as sardines will gain in yield, as the warming favours their productivity. Some species like Indian mackerel are likely to move upwards to the northern latitudes, thus maintaining their yields. Species like threadfin breams may shift their spawning seasons, adjusting to the season which optimally favours spawning temperatures. With overall warming, the thermal humidity index is projected to increase in all the regions, especially in the months of May and June, leading to stress to the livestock and hence reduction in its milk productivity. The water yield (which is a function of precipitation, total surface run-off, evapotranspiration and soil properties), is projected to increase by 5–20% in the Himalayan region in the 2030s. However, water yields are likely to be variable across the North East region, the Western Ghats, and the coastal region in some places it is projected to increase, whereas in others it is projected to decrease. Compared to the other regions, the Himalayan region will experience moderate to extreme drought severity in the 2030s. All the regions are likely to experience flooding exceeding the existing magnitude by 10–30%. In the forestry sector, vegetation change is projected for 8%, 18%, 56% and 30% of the vegetation grids and increase in net primary productivity by 23%, 20%, 57% and 31% is projected in the North East region, the Western Ghats, the Himalayan region and the coastal region respectively. Malaria is projected to spread to new areas in Jammu and Kashmir in the Himalayan region. In the North East region, opportunities for transmission are likely to increase for a longer period. In the Western Ghats, no change is observed between 2030s and 1970s. However, in the coastal region, especially in the eastern coast a marked decrease in the number of months in which the malaria transmission window would be open is projected.

Black carbon research initiative – Science plan of the National Carbonaceous Aerosols Programme

The Science plan initiative[7] was launched on 29 March 2011. The initiative is significant, especially in the context that there is an emergence of interest in the role of black carbon (BC) in global warming, since aerosols may modify the planetary albedo. The composition of aerosols varies depending on the sources, and temporal and spatial variations. Sulphate aerosols cool the atmosphere. The issue has engaged the attention of scientists and experts in addressing the scientific questions associated with sources, transport and impact of BC worldwide. The latest scientific studies indicate positive contributions to global warming. However the magnitude of the impact of aerosol on climate remains uncertain.

BC is the soot released in the atmosphere due to indoor combustion of biofuels such as wood, dung and crop residue in cook stoves, and in outdoors it is released from combustion of diesel, coal and open biomass burning (forest fires, cut and slash burning in forests, and crop residue burning on fields). The lifetime of BC in the atmosphere is small compared to the GHGs. BC sources vary by regions. On a global basis, approximately 20% of BC is emitted from burning biofuels, 40% from fossil fuels and 40% from burning biomass in the open.

The knowledge and understanding on aspects such as vertical distribution and mixing of BC with other aerosols, effects of cloud cover and monsoon still remain uncertain and incomplete. There is thus a need to have better understanding on: the contribution of BC aerosols to regional warming; the role of BC on atmospheric stability and the consequent effect on cloud formation and monsoon; the role of BC in altering the ability of hygroscopic aerosols to act as cloud condensation nuclei; the role of BC-induced low-level temperature inversions and their role in the formation of fog, especially over north India, and the role of BC on Himalayan glacier retreat.

The Black Carbon Research Initiative builds on the existing work of ISRO, MoES and other experts countrywide and sets out the science programme. The science

plan has been developed through an intensive consultative process with the involvement of experts in the subject. The initiative is visualized as an ambitious programme with the involvement of over 101 institutions with 65 observatories nationwide.

The study would lead to long-term monitoring of aerosols; monitoring of impact of BC on snow and estimating the magnitude of BC sources using inventory (bottom-up) and inverse modelling (top-down) approaches and modelling BC atmospheric transport and climate impact. The major expected outcomes are understanding the effect of change in albedo due to BC on glacier depth and mass balance using airborne sensors like laser altimeter, ground-penetrating radar and pyranometer; modelling effect of enhanced melting on glacier mass balance and retreat, and development of snow/glacier melt run-off models to understand the influence of changes in snow and glacier melt pattern.

Long-term ecological observatories

Under the aegis of INCCA, research and monitoring in context of climate change, e.g. phenology, forest ecosystems, water flow, pest incidence, and plantations are envisaged through establishment of long-term study sites and ecological observatories.

Climate change modelling and other initiatives

In recognition of the significance of South Asian monsoon for agriculture, efforts are being made to conduct a suite of regional model simulations to downscale the projection of climate change. The regional climate model simulations are conducted by the Centre for Climate Change Research (CCCR) at the Indian Institute of Tropical Meteorology (IITM), Pune.

Recognizing the significance of climate change and its implication, several Ministries/Departments are implementing research programmes/projects to address the concern of adverse climate in relevant sectors of their domain. The MoES (IITM, Pune, its autonomous institution) is implementing various programmes and initiatives relating to climate change. These include *inter alia* FLUX-NET environmental and greenhouse gas Flux Monitoring Programme, Whole Spectrum Aerosol (Carbonaceous as well as Non-carbonaceous) Cloud and Radiation Programme, Ocean Biogeochemistry and Geotracers. Besides, CCCR undertakes climate change research on modelling and scenario generation. The Department of Science and Technology, New Delhi has launched a major research and development programme on institutional and human capacity building on climate change under the National Mission for Strategic Knowledge on Climate Change.

Conclusion

INCCA serves as a consortium of knowledge, credible and independent research capacity on climate change at the national level, which provides a platform to integrate the intricate processes of climate change science and socio-economic conditions in a sustainable manner, which would assist in informed decision-making and policy framework. The outcome of these initiatives, programmes and activities would strengthen India's capacity for developing the mitigation and adaptation strategies and preparedness towards futuristic consequences for climate change.

Thus, INCCA represents a network of institutions with capability of contributing to diverse subjects and a range of climate change issues, including preparation of GHG inventory estimation, development of scenarios; short-, mid- and long-term implications of climate change on sectoral and regional scale; and identification of capacity and research needs commensurate with projected adverse impacts of climate change. INCCA thus serves as a good basis to respond to concerns of climate change, fulfillment of obligations to the United Nations Framework Convention on Climate Change (UNFCCC) and further requirements emerging from the recent agreements under the aegis of UNFCCC.

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