

## Climate change in Asia\*

A workshop focusing on the science, impacts and policies related to climate change in Asia was held in Bangalore recently. It brought out how policies have been developing subsequent to the reorientation of international strategy agreed upon at Copenhagen and Cancun in 2009 and 2010 respectively.

In the inaugural session, Julian Hunt (Malaysian Commonwealth Studies Centre, Cambridge, UK) noted how global mean land temperatures were rising during the last decade, although global mean ocean surface temperatures have remained constant. Nevertheless, temperatures below the ocean surface are rising leading to significant sea-level rise, especially in the tropics. Hunt stressed the need for networking among Asian scientists to address common problems related to the impacts of climate change in Asia. J. Srinivasan (Indian Institute of Science (IISc), Bangalore) discussed the special problems faced by Asian countries in dealing with climate change, such as high population density, rapid urbanization and large coastal communities.

The first day of the workshop was devoted primarily to the science of climate change. B. N. Goswami (Indian Institute of Tropical Meteorology, Pune) presented the link between climate change and the Indian monsoon as seen in the recent east-west variations in precipitation. He highlighted the fact that decrease in the Atlantic meridional overturning circulation can lead to weakening of the Indian monsoon, and argued that global warming may reduce its predictability. H. J. Fernando (University of Notre Dame, USA) showed that the adverse impact of global warming in urban areas is amplified by anthropogenic activities. He highlighted the interaction between air pollution and global warming in these regions.

Sally Daultrey (Cambridge Central Asia Forum, Cambridge, UK) stressed the im-

portance of environmental monitoring to understand the impact of climate change on mountainous regions, such as the devastation caused by high-intensity rainfall in Ladakh. The value of improved monitoring systems and effective community organization in areas subject to extreme geophysical events was emphasized by A. Habib (Bangladesh Meteorological Department, Dhaka, Bangladesh).

Bodo Bookhagen (UC Santa Barbara, USA) used high-spatial resolution satellite rainfall data to characterize the spatial and temporal distribution of extreme rainfall events. He discussed how changes in the intensity of extreme rainfall events would alter the dynamics of erosion in the Himalayas. S. K. Dash (Indian Institute of Technology (IIT) Delhi, New Delhi) talked about the changes in rainfall and temperature in India during the past 100 years, especially the increase in short-spell rainfall events (duration <4 days) and decrease in long-spell rainfall events (duration >4 days).

The evidence for climate change in China, especially Hong Kong, was presented by H. Y. Mok (Hong Kong, Observatory, Hong Kong). He showed that temperatures above 35°C and extreme rainfall events (>100 mm/h) had a return period of 32 and 37 yrs respectively, in the early 20th century in Hong Kong, had a return period of 4.5 and 18 years respectively, in the early 21st century. The number of hot nights (16/yr during 1980–1999) will increase to 137/yr during 2090–2099 according to climate models.

The impact of domain size on the simulation of the hydrological cycle was discussed by B. Bhaskaran (Met Office, Exeter, UK). He showed that a smaller domain size leads to a more intense hydrological cycle. S. G. Ghosh (Vellore Institute of Technology) outlined the role of aerosols in the formation of clouds and the microstructure of soot aerosols and provided data on the prevalence of aerosols in Chennai. During the panel discussion on 'How can science improve the prediction of future climate?', the large error in the estimation of evaporation at low wind speeds, the need for better understanding of the interaction between aerosols and clouds and the

need for data-sharing among Asian countries were stressed.

The second day focused on the impact of climate change on hydrology. Wouter Buytaert (Imperial College (IC), London) showed how increases in population and groundwater use for irrigation have caused a dramatic increase in the demand for water in Asia. He explained how water resources management can help alleviate poverty under conditions of climate change. Jim Falk (The University of Melbourne, Australia) discussed the complex interaction between climate systems, hydrological systems and user communities that is modulated by governance structures. He talked about knowledge-action initiatives with communities and stressed the need to overcome institutional barriers for sharing of data in the Asian region. Nazia Mintz-Habib (CAM) discussed water-usage decisions in the Bangladesh shrimp industry and the impact of sea-level rise on coastal fisheries.

Pak Sum Low (Universiti Kebangsaan Malaysia, Malaysia) stressed that very little is known about the response of local ecosystems to climate change. He explored the dilemmas faced by developing countries in adapting to climate change and discussed the role of the Green Climate Fund in assisting these countries. N. H. Ravindranath (IISc) discussed the impact of climate change on forests. He outlined the Greening India Mission, whose aim is to enhance carbon sinks and assist vulnerable species and communities to adapt to climate change.

A. W. Jayawardena (International Centre for Water Hazard and Risk Management, Japan) highlighted the challenges in coping with water problems in the 21st century and discussed the link between water security, food security and climate change in developing countries. B. R. Neupane (United Nations Educational, Scientific and Cultural Organization, New Delhi) provided an overview of water and climate change policies in Nepal. He pointed out that out of the 250 billion m<sup>3</sup> of precipitation over Nepal, more than 200 billion m<sup>3</sup> leaves the country as river discharge. He showed that climate models predict a wetter summer and a drier winter here.

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P. P. Mujumdar (IISc) addressed the issues of scale interaction and uncertainty in hydrological modelling by downscaling from the larger grid size of climate models. His studies show that model uncertainty is larger than scenario uncertainty in many cases. E. Chavez (World Bank) showed how modern statistical methods should be combined with more comprehensive data collection to monitor and predict extremes, especially for agriculture.

The different mechanisms that control the advance and retreat of glaciers in the Himalayas were outlined by T. N. Venkatesh (National Aerospace Laboratories, Bangalore). He demonstrated how a glacier can advance even if global warming leads to an increase in glacial melt, provided the slope and size of the glacier is sufficiently high. The panel discussion on 'Impact of climate change on hydrology' brought out the need for sharing of data on river discharges between Asian countries and for regional workshops to train people in tackling issues related to hydrology.

The last day concentrated on policy issues. T. Jayaraman (Tata Institute of Social Sciences, Mumbai) related India's future carbon budget to its climate policy. He argued that cumulative emission during the period 2000–2050 must be kept below 1000 GT to ensure a reasonable chance that the increase in global mean

temperature is kept below 2°C. He emphasized the need to treat atmospheric space as a global commons and argued for equitable access to this space. Because a drastic reduction of carbon emissions by developed countries is unlikely in the near future and because developing countries are extremely sensitive to global warming, the latter should have sustainable energy policies to minimize emissions where possible.

Dilip R. Ahuja (National Institute of Advanced Studies, Bangalore) enumerated the various policy instruments available to mitigate climate change and argued that these policies pose difficulties because they involve many political, economic and social interests of nations in different stages of development. He also discussed India's climate change action plan. Anshu Bharadwaj (Centre for Study of Science, Technology and Policy, Bangalore) talked about climate change and India's energy policy. He stated that the per capita energy consumption in India is just above 700 kWh at present and is expected to increase to 1200 kWh by 2020. A special feature of increasing electricity generation by different technologies in India is the need to balance this goal with minimizing the loss of agricultural land.

Anand Patwardhan (IIT Bombay, Mumbai) indicated that mitigation must be combined with adaptation to tackle

climate change. He analysed different options for adaptation and provided estimates of the cost of adaptation. Navroz K. Dubash (Centre for Policy Research, New Delhi) argued that global climate negotiations are stuck between fundamentally different conceptions of what it can and should achieve. He claimed that achieving environmental effectiveness and equity is blocked by a coalition of Northern countries; a regime based on a global cap but without explicit allocation of emission budgets is blocked by a coalition of Southern countries; the default approach is rapidly becoming a system of country pledges.

The concluding session discussed ways to increase the interaction between Asian scientists and the growing number of climate research institutions. One possibility is to set up a virtual Asian climate change network to share data and ideas and to help plan future workshops focusing on common scientific and policy problems in trying to deal with climate change.

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