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INTRODUCTORY REMARKS

THE question of how and in what way global changes are affecting or may affect in future the Indian society is now being seriously examined by several institutions in India, along with many international bodies. A major activity is now in progress in India on the preparation of National Communication to the UN Framework convention on Climate Change: one objective of this work is to assess quantitatively the effects of such changes on rainfall pattern, on agriculture, on health, on water balance, on ecosystems.

Global change is broader than climate change. We are concerned with changes in the entire earth system arising from human activities. But climate change is one of the key elements.

Over the years the question of climate change and its impacts globally and regionally, have moved from the realm of doubts and uncertainties to one of serious concern. The most recent statements of the Intergovernmental Panel on Climate Change bring out convincing evidence of such changes, summarise possible impacts on agriculture, health, water balance and on ecosystem. While the matter and magnitude of such impacts on global scale are quantified reasonably well (for a variety of scenarios) those on regional scale are still, in many cases, at the initial stages of understanding.

Climate change, caused by changes in greenhouse gases, is a slow process. The life times of the greenhouse gases CO_2, CH_4 and N_2O are long – decades to centuries. The impacts are, therefore, not always visible on short tem scales.

In this special issue, we have brought together a number of articles describing how climate change may affect society. These describe the monsoons, the lifeline of Indian economy, in the past, present and future; soil and crop productivity, health, water resources; the changing land use patterns in India and their consequences; on the problems of rural environment; the role of megacities and several other aspects.

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The key point concerns the regional aspect of the climate change particularly any changes in monsoon pattern. It is not enough to know that global temperature will increase by a certain magnitude or precipitation will change. We need to know the projected changes over different parts of India with a spatial resolution fine enough to estimate impacts. For this one needs to develop regional climate models (RCMs). In the first article Rupa Kumar et al describe how monsoons have changed over the years. They point that the summer monsoon has been, on the whole, remarkably stable for more than a century with a coefficient of variation of 10%. Superposed on this interannual

variability, we find weak monsoon to have been associated with large Southern Oscillation Index and El Nino events and strong monsoons with large positive SOI and absence of El Nino events. What is of special concern is the occurrences of monsoon extremes. Whether these will change in future is still debated. Models of long term changes with increased CO_2 concentrations indicate intensification of summer monsoon. Rupa Kumar et al show that such results are not always unanimous. While two models indicate increases by 10-13%, another show a reduction by 6%.

For the future world if climate changes occur in the ways projected, the first concern for countries like India, will center around agricultural yields. There are many interacting parameters, connected with climate change and the changing atmosphere composition, that have to be considered. A simplified picture of the perturbing sources and their effects are shown Fig.1. One should note that most of the effects are adverse, excepting those related to rainfall changes and increases in CO_2 concentration. In this issue we have two articles portraying some of the changes expected. The first is that of Kalra et al dealing with the impact of climate variability and climate change on soil and crop productivity. They look into the effects of climate change on soil fertility, on biological health of soil, soil erosion and sediment transportation, on the CO_2 fertilizers effect on crops with C3 photosynthetic pathway, on rice productivities, on pests. Much of their studies relates to effects resulting from changes in temperature and rainfall (and of water availabilities), but they also deal briefly with effects of reduction of sunlight from absorbing aerosols and those of changes in tropospheric ozone and UV-B radiation.

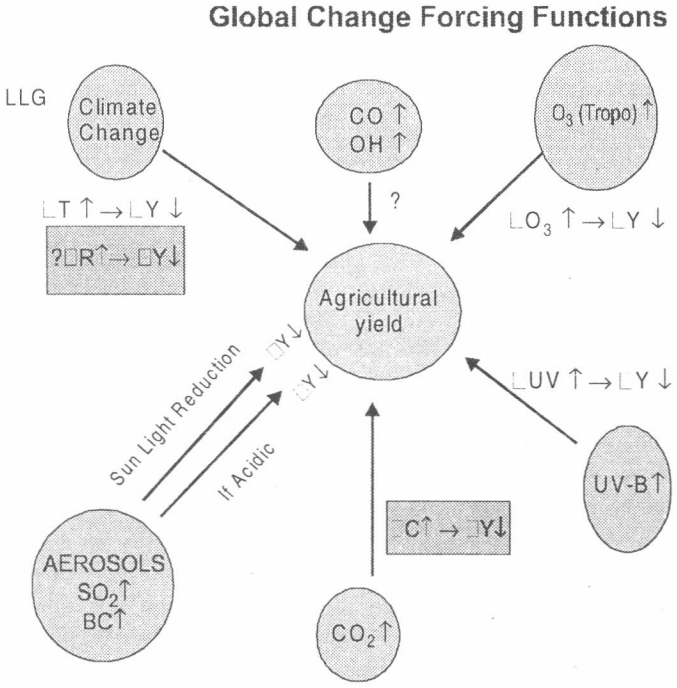

Fig. 1

In the second article, relating to agriculture, Parashar et al discuss how agriculture practices may in turn affect atmospheric composition – the reverse path. This has been an exciting story and is now well known. The crop here is rice and the atmospheric constituents is CH_4. Parashar et al, describe the exciting story of how a new effort was mounted that changed radically the view of methane emission from paddy fields. How the very large initial estimate of US-EPA (37 Tg/yr out of the global emission of 100 Tg.) had to be downsized to $1/10^{th}$ of this value. This prompted new and serious studies in several countries including China, Philippines, Indonesia, Thailand. In a recent Workshop in Shanghai, the unanimous conclusion was that paddy fields contribute no more than about 30 Tg/yr global emissions from all sources. There is, therefore, no immediate threat from expansion of rice fields.

One of the most serious concerns in future will certainly be the lack of adequate water availability. Per capita water availability in India has already decreased from over 5000 m^3/yr in 1955 to about 2500 in m^3/yr in 1990. Around 2050 this may come down to as low as 1200 m^3/yr. This depletion scenario is due to the increasing demand from the rising population. India is rich in renewable water resources through rainfall, snowfall and glaciers feeding rivers, lakes and groundwater. Irrigation accounts for over 90% of the total water utilisation. One would expect significant changes in the hydrological cycle from climate change, both in global and regional scales. R.N. Singh in his article discusses such changes: the receding glaciers in the Himalays, low filtrations from short heavy spells of precipitation, changing frequency of occurrence of cyclones in Northern Indian Ocean, rapid degradation of water quality in ground water specially in areas where there is excessive extraction of groundwater without adequate recharging. Whether we need over 90% of available water for agriculture will have to be examined very seriously.

Large scale changes have occurred in the past in land use and land cover changes and in forestry. These have direct bearing on the net CO_2 emissions from India. Forests are efficient carbon sinks, but large-scale deforestation and biomass burning can lead to a net CO_2 emission. On this, we have two articles. The first, from Dadhwal and Abrol, relates to the Indo-Gangetic Plains, cutting through India, Pakistan, Nepal and Bangladesh. This region has gone through major changes in the last few centuries: principally from land conversion and land use intensification. We are concerned here with carbon cycles and pools. The authors point out that from 1880 to 1980 (a period of hundred years), the total C-pool in five states in the Indo-Ganetic Plain decreased from 987 Tg to 524 Tg while the C-pool in the agricultural sector increased from 162 Tg to 219 Tg.

The article on forestry by Ravindranath and Murthy deals with the likely adverse impacts of climate change on forest ecosystems, biodiversity and biomass production. They point out that for Western Ghats, one of the "hot

spots" of global biodiversity, one may expect substantial changes in forest types. The changes are different for different scenarios. They also point out that the technical mitigation potentials for 13 developing countries in the LULUCF sector is as large as 32GtC. Forestry sector mitigation activities contribute also to socio-economic benefits on a large scale.

In the same context rural India poses special problems and special opportunities. In the article by Sharma et al the energy scenarios in the rural sector and their effect on environment are discussed. Biomass fuel accounts for as much as 97% of the rural household energy. Use of fuelwood and also of dungcake and agricultural residues lead to emissions of CO and particulates that are known to pose serious health hazards. CO emission are particularly large in Uttar Pradesh.

Impact of climate change on human health is still in the early stages of investigation. Of the many possible health hazards, we consider the following three categories to be particularly relevant for India: vector borne diseases from changes in temperature, rainfall and humidity; respiratory diseases from the increasing concentrations of airborne particulates; and cataract and retinal damages from UV-A and UV-B radiations (Fig.2) Bhattacharya et al in their article discuss the first two categories. In these studies there is need for medical and physical scientists to come together, have simultaneous observations on related parameters, and establish a sound base of hospital cases. The very high prevalence of diseases and the enormous national cost in treatment and workdays lost cannot be considered in isolation. For malaria, the changing scenarios are slower to evolve than for respiratory diseases where offending particles have a short lifetime of a week or so.

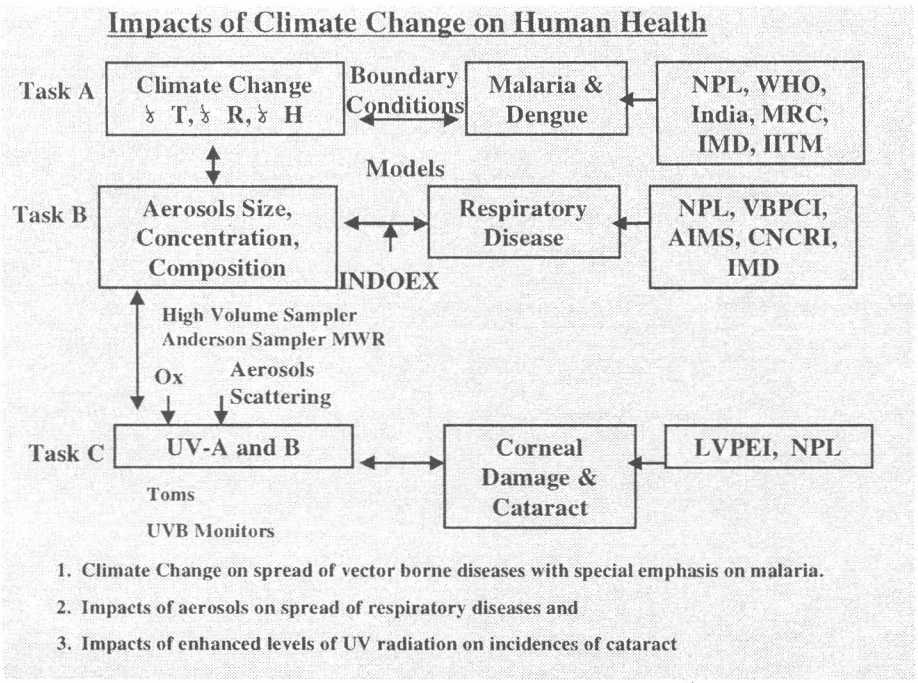

Fig. 2

The role of megacities in the emission of GHGs and other pollutants is emerging as a major area of discussion. Megacities with more than 10M population are now located increasingly in the developing world. These consume bulk of the key resources and can be major emitters of GHGs and pollutants. An approach towards optimization (and mitigation) of emission cannot ignore these large "hotspots". A study is now in progress covering emissions from 7 megacities: Tokyo, Beijing, Shanghai, Seoul, Manila, Calcutta and Delhi. Social scientists believe that megacitieis need not be considered as eco-hazards. With opportunitis for integrated resource management, these could in fact be eco-devices. In the article on megacities, Mitra and Sharma, show that Calcutta and Delhi "behave" differently. Per capita emissions are much larger in Delhi than in Calcutta. In all these cities, there are increasing health hazards, from emissions of CO, hydrocarbon and particulates. Much of these originate from road transport.

Road transport sector is going through a major change in India. Apart from the directions of the Supreme Court on the use of CNGs by commercial road transport sectors, a major milestone is the new Indian auto-fuel policy. In an article by Saxena, Jain and Singhal, the authors, who played an important role in the formulation of the policy, describe how in India steps have been taken from as early as 1991 to tighten emissions from the transport sector. The auto-fuel policy regards public health as a prime concern. It recommends introduction of Bharat Stage II norms (now in place in Delhi, Mumbai, Kolkata and Chennai) to three other cities (Bangalore, Hyderabad and Ahmedabad) by end of 2003, and to the entire country by April 1, 2005. Euro III equivalent emissions norms are to be put in place in the entire country by 2010. For Delhi they estimate CO emissions to come down from 293 thousand tones in 2000 to 228 in 2010 and particulates from 14 thousand tones to 7 thousand tones. These, in spite of sharp increase in vehicular population: A point of concern is that NO_x concentration does not increase from its current relatively low value. NO_x is a critical parameter in ozone formation.

The Sundarbans, one of the largest mangroves in the world, has been changing adversely from human activities. Hazra in his article describes some of these changes.

We have not covered all areas of social interest nor all sources leading to climate changes. We have not, for example, discussed how urban air

pollution can modify climate at regional scales. The recent results of the large Indian Ocean Experiment (INDOEX) showing the presence of an extensive haze layer over the Indian region have been discussed in several journals.

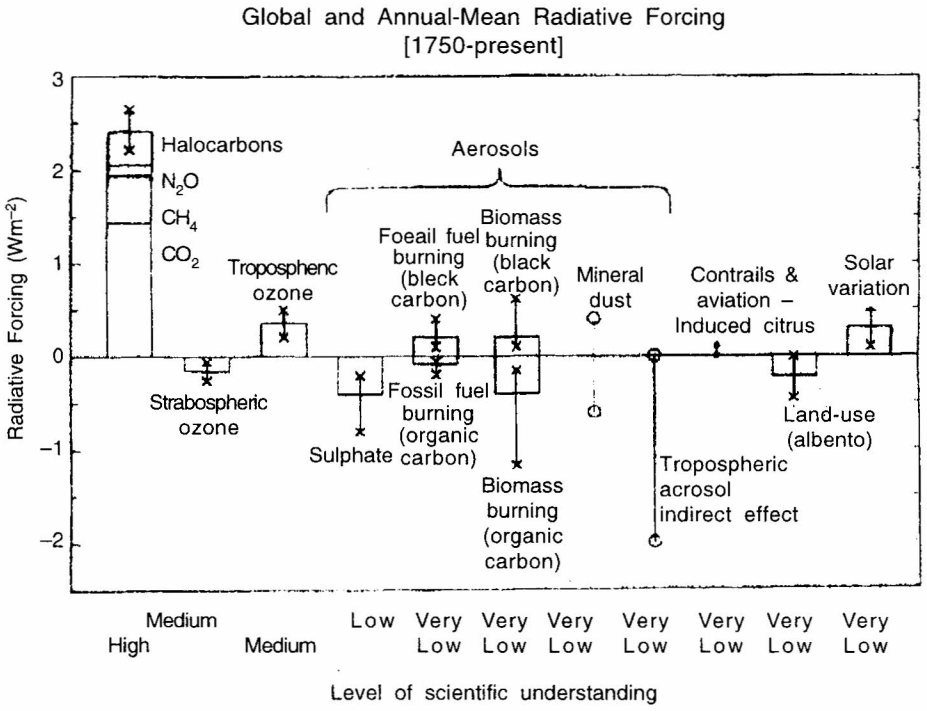

Fig. 3

Extensive haze layers do occur not only in Asian region, but also in Africa, South America and over Europe and North America. These layers move from one continent to another. When these layers contain an appreciable proportion of black carbon (from incomplete combustion of fossil fuel or biomass) as in many parts of the developing countries, there are additional perturbation on regional climate system, in agricultural yield, in hydrological cycle and in ecosystems. Initial calculations, summarised in a recent UNEP report although, very preliminary and limited in scope, indicate the need for considering such results seriously. Another aspect not considered here is the role played by short lived gases. Fig. 3 is an important reminder of the fact that climate forcing is caused both by natural and anthropogenic sources and that anthropogenic sources range from GHGs to ozone to aerosols.

This publication has been brought out with the support of START/SASCOM in time when 8th Conference of Parties (COP-8) is being held in New Delhi. It is hoped that the contents of this issue will be useful to the South Asian Scientists also.

A. P. Mitra
Guest Editor