CHAPTER-III: CLIMATE CHANGE VULNERABILITIES IN INDIA

Introduction

India with its large and growing population, densely populated and lowlying coastline, and an economy that is closely tied to its natural resource base, is highly vulnerable to climate change. Two-thirds of the total sown area of the country is drought-prone, with monsoon rains showing high inter-annual, intra-seasonal, and spatial variability. 40 million hectares of land is liable to floods, with 8 million hectares and 30 million people affected each year on average (NCDM & NDMD 1999). In the pre-monsoon and post-monsoon seasons, the coastline, particularly the east coast, is vulnerable to tropical cyclones. Over the period 1971–2000, India has been among the top four countries in terms of number of people killed in natural disasters.

India's first national communication, which was submitted to the UNFCCC (United Nations Framework Convention on Climate Change) in 2004 describes the potential impacts of climate change. Climate projections indicate marked increase in seasonal surface air temperature in the 21st century, becoming conspicuous after the 2040s.

Models predict little change in total monsoon rainfall for India as a whole, but project overall decrease in the number of rainfall days and increase in rainfall intensity over a major part of the country. Preliminary assessments reveal a general reduction in the quantity of available runoff, and increase in severity of droughts and intensity of floods in various parts of India. Wheat yields in central India may drop by 2% in a pessimistic climate change scenario (GoI 2004). Sea-level rise and higher storm surges may adversely affect coastal ecosystems and structures, leading to loss of settlements, property, recreation beaches, and tourism infrastructure. Extreme events like droughts, floods, and cyclones may become more frequent, leading to widespread damage to life, property, and livelihoods.

The consequences of all these impacts are likely to disproportionately burden the poor, and thereby exacerbate inequities in health status and access to adequate food, clean water and other resources (IPCC 2001). The poor depend for their livelihoods on climate-sensitive sectors, often live on marginal lands that are vulnerable to extreme events, and lack the financial, technical, and institutional capacity needed to adapt to the impacts of climate change. For developing countries like India where levels of poverty continues to be very high, climate change represents an additional stress on physical and social systems already pressured by population growth, urbanization, industrialization, and environmental degradation. Yet, India has taken long strides in human and social development within the overall context of sustainable development. Since the early 1990s we see a paradigm shift in focus from producing goods and services (and increase the per capita income) to the enhancement of human well being. The Eleventh Five Year places much more emphasis by making 'inclusive growth' the central agenda of development in India. A key feature of this developmental agenda is democratic decentralisation, focusing also on promoting centrality of PRIs in the implementation of centrally sponsored and central sector programmes. Hence vulnerability and adaptation to climate change cannot be studied in isolation, but must be viewed in the larger context of sustainable development in India.

The second feature of development in India in the 1990s is related to economic reforms, per Washington Consensus. Development in India is far more tied to economic globalisation now, with a consequence that the population and the systems have become more vulnerable to global economic change than ever before. In this chapter, therefore, some of the important aspects of climate change in India are highlighted - and for this two production systems which are most relevant to the rural poor in India, agriculture and forests, have been kept in focus. This section will also highlight - in the context of bottom-up adaptation policies described in the previous chapter - that rural people in India have been regularly experiencing major climate related events, like flood and drought, and their experience in dealing with those events could be quite instructive for framing successful climate adaptation policy for India.

The next section of this chapter also highlights how the vulnerabilities in India have deepened because of the conjoint effects of climate change and globalisation. Further, as climate change modelling takes a long view of climatic shifts (say the climate in 2050s), one has to take into account demographic changes also. In India, this trend is very conspicuous as the pace of urbanisation has been quite rapid in the last few decades. As per the UN Population Fund estimates (2008), the urban population of India has risen from 27.8% in 1991 to 29% in 2008, and by 2050 the urban population will become 55% (comprising of 900 m urban people) of the total population. The last section of this chapter, therefore, touches upon climate change effects in relation to this changing demography.

Recurring disasters in India, and the lessons learnt

The histories of disasters are quite instructive for future climate change adaptation policy in India as India has been historically vulnerable to natural disasters on account of its unique geo-climatic conditions. Disasters like floods, droughts, cyclones, earthquakes and landslides are common occurrence events here. The multi-hazard scenario depicted in the Vulnerability Atlas of India (produced by Building Materials and Technology Promotion Council (BMTPC), New Delhi, India), shows that out of the total geographical area of 328.7 million ha about 60% of the landmass is prone to earthquakes of various intensities; over 40 million hectares is prone to floods; about 8% of the total area is prone to cyclones and 68% of the area is susceptible to drought. During 1990-2000, on an average of about 4344 people lost their lives, about 30 million people were affected by various disasters every year and average annual damage has been estimated to be approximately Rs. 270 Cr. As per the World Bank estimates, during 1996-2001 the total losses due to disasters, including the super cyclone of Orissa in October 1999 and the Bhuj earthquake in Gujarat in January, 2001, amounts to US$ 13.8 billion. Noting that official numbers tend to underestimate true economic losses, the World Bank (2003) further estimates that direct natural disaster losses amount to 2% of India's gross domestic product. It also observed a rising trend in reported monetary losses.

As noted by the World Bank (2006) the increase in disaster occurrences costing human and economic losses has become rather rapid in the last two decades. It has been argued that this might be due to high vulnerabilities of people to natural disasters. The need is felt to reduce disaster risks by improving capabilities of people and ensuring preparedness, mitigation and response planning processes at various levels. The objective is to look at the entire cycle of disaster management in reducing risk and linking it to developmental planning process. In the past, disasters were viewed as isolated events, responded to by governments and various agencies without taking into account the social and economic causes and long term implications of these events. In short, disasters were considered as 'emergencies'. But this concept is changing now.

Table 1: Disaster history by major hazard in India (1996–2001)

Hazard	Reported events	Reported deaths ('000)	People affected ('000)	Reported Loss (mil. USD)	Loss Reported	Percent reported
Windstorm	15	14.6	25213.7	5619	15	100
Flood	29	8.9	150980.3	2928	18	62
Earthquake	3	20.1	16387.0	4707	6	200
Drought	4	90000.0	588.0	3	–	–
Other	24	5.9	356.9	–	–	13

The recent disasters and its socio-economic impact on the country at large, and in particular on the poor rural communities has underscored the need to adopt a multi dimensional approach involving diverse scientific, engineering, financial and social processes to reduce vulnerability in multi-hazard prone areas. A noticeable shift in approach to disaster management, from "relief and emergency response" to a balanced approach covering all phases of the Disaster Management Cycle is very much evident now. This approach acknowledges disaster management as a part of development process, and investments in mitigation are perceived to be much more cost effective than relief and rehabilitation expenditure. In this regard, Government of India has taken various initiatives in area of disaster preparedness, mitigation and response through networking of various institutions, institutional capacity building, and policy interventions at all levels.

Indeed, community participation and community ownership in disaster risk reduction has emerged as one of the key factors in reducing vulnerabilities of people and minimizing the loss. It promotes community involvement and strengthening of their capacities for vulnerability reduction through decentralised planning process. Analyses of response to past disasters have highlighted reaching out to the victims within the critical period during an emergency as a major requirement to protect people and assets. This has resulted in developing mechanisms to mitigate disasters at the grassroots level through participation of communities. Communities being the first responder and having more contextual familiarity with hazards and available resources are in better position in planning and executing immediate rescue and relief actions. In areas that have experienced repeated disasters, the communities are accumulating rich experience in working out a plan to prevent losses and at the same time enable faster recovery in the event of an emergency situation. This experience is not only relevant to the how efficient the local government (PRIs) could be in the major area of their responsibility (i.e. planning and execution of local level developmental plans), but also how their structure might shape up in the future.

Climate change and Indian agriculture

Agriculture and allied activities constitute the single largest component of India's gross domestic product, contributing nearly 25% of the total. The tremendous importance of this sector to the Indian economy can be gauged by the fact that it provides employment to two-thirds of the total workforce. The share of agricultural products in exports is also substantial, with agriculture accounting for 15% of export earnings. With a weight of 57% in the consumer price index, food prices are closely linked with inflation and any adverse shock on agriculture could have cumulative effects on the economy.

Agricultural growth also has a direct impact on poverty eradication, and is an important factor in employment generation. The National Commission for Integrated Water Resources Development has estimated that, to meet the requirements of food grains alone, the net sown area will have to be increased to 145 mha and the cropping intensity to 145% by 2050 (Planning Commission 1997). However, there is not much scope for increasing the area under food grains in the country, and the growth of food grain output can be achieved only through rapid increases in productivity. Finally, given that rain-dependent agricultural area constitutes more than 60% of the net sown area of 142 mha (TERI 2005) Indian agriculture continues to be fundamentally dependent on the monsoon.

Agriculture is the predominant means of livelihood for a large number of peasant cultivators and agricultural labourers, for whom it is not easy to shift to other occupations. Due to their low financial and technological adaptability, such groups are highly vulnerable to the impacts of climatic changes. For a country like India, sustainable agricultural development is essential not only to meet the food demands of present and future generations, but also for poverty reduction through economic growth, which creates employment opportunities in non-agricultural rural sectors (Fischer et *al*. 2002).

Climate change is challenging agriculture with increasing uncertainty and variability, particularly in terms of water and temperature regimes. Crops, livestock and people are increasingly suffering from disastrous floods and droughts, for example in Bihar, Orissa and West Bengal. More gradual but measurable changes in thermoclines and annual precipitation present risks unless trend monitoring and forecasting is conducted, and measures taken to adapt. Variable and diminishing rainfall and other forms of precipitation including highland snow, melting to supply spring sown crops and pastures, puts high risks on dryland farming and grazing in the Himalayan region.

The IPCC (2001) notes that a temperature rise of 1.5 degree centigrade and 2 mm increase in precipitation could result in a decline in rice yields by 3 to 15%. Sorghum yields would be affected and yields are predicted to vary from +18 to -22% depending on a rise of 2 to 4 degree centigrade in temperatures and increase by 20 to 40 % of precipitation. The Indian NATCOM notes that decline in yields are offset by increase in carbon dioxide concentrations with the magnitude varying from one crop to the other in different regions depending mostly on the scenario chosen. Wheat yields in central India may drop by 2% in a pessimistic climate change scenario (GoI 2004). In a TERI study (2005) it is noted that districts in western Rajasthan, southern Gujarat, Madhya Pradesh, Maharashtra, northern Karnataka, northern Andhra Pradesh, and southern Bihar are highly vulnerable to climate change in the context of economic globalization. The National Action Plan for Climate Change (GoI 2008) also notes that as per studies by Indian Agriuclture Research Institute, every $1^{0}C$ rise in temperature reduces wheat production by 4-5 million tonnes. Equally important is to note that slight variation in temperature, rainfall and moisture condition could significantly affect the quality of fruits, vegetables, tea, coffee, aromatic and medicinal plants, basmati rice, etc., and thus, rob away competitiveness of the agriculture sector vis-a-vis the modern economy.

Numerous physical (e.g. cropping patterns, crop diversification, and shifts to drought-/salt resistant varieties) and socio-economic (e.g. ownership of assets, access to services, and infrastructural support) factors come into play in enhancing or constraining the current capacity of farmers to cope with adverse changes. It has been assessed that economic impacts would be significant even after accounting for farm-level adaptation. The loss in net revenue at the farm level is estimated to range between 9% and 25% for a temperature rise of 2 °C–3.5 °C (Kumar & Parikh 1998).

It is important to recognise that policy decisions related to agriculture or water resources will influence decisions from the farmer's level to the national level, and have the potential to enhance adaptive capacity to climate change. Alternately factors that reduce vulnerability to climate risks – spanning the entire gamut from irrigation, better infrastructure, electricity, credit, crop insurance, markets, transport, and price information - reduce a farmers' heavy dependence on climate, and help him to benefit from market opportunities, or switch to alternative crops or employment options. At the other end of the scale are better health facilities, education, and awareness, which are key developmental priorities but are often ineffectively implemented due to conflicts and policy gaps and the sheer magnitude of the problem. The incorporation of climate change risks in such policies can help farmers tackle current climatic variability as well as extreme events like droughts and floods, and have significant implications for longer-term vulnerability reduction and poverty alleviation.

River and inland flooding and extreme rainfall events in India

The most important climate-change risk in India, after drought, is increased riverine and inland flooding, especially in northern and eastern India (and adjoining Nepal and Bangladesh). In eastern India, tens of millions of people are currently affected by flooding for three to six months of the year. Increased precipitation and higher peak monsoon river flows due to glacial regression could exacerbate the situation for tens of millions more. This is largely due to the high population densities across this region, combined with very high vulnerability to flooding, due to a mix of poorly designed and executed flood-management systems, complex land and water tenure regimes and high levels of poverty, which over the last few decades has severely degraded the coping capacity of millions of people (De Vries et *al*. 2007).

Climate change is expected to increase the severity of flooding in many Indian river basins, especially in the Godavari and Mahanadi basins, along the eastern coast. Floods are also expected to increase in north-western India adjoining Pakistan, and in most coastal plains in spite of upstream dams. Extreme precipitation is expected to increase substantially over a large area over the west coast and in central India. Gujarat, one of India's most prosperous states, has experienced severe flooding for three consecutive years starting in 2004, causing large economic losses in its cities due to extreme precipitation in upstream catchments. The devastating Mumbai floods of 2005 were caused by an extreme weather event. The bulk of the city services were shut down for almost five days with no contact via rail, road or air with the rest of the country. Over 1,000 people lost their lives and the city's economy effectively ceased - due to a combination of institutional failures, poor preparedness and the extreme vulnerability of the poor.

Impact of climate change on forest ecosystems in India

IPCC (2007) concluded that for increases of global average temperatures exceeding 1.5 to 2.5°C, major changes in ecosystem structure and functions, species' ecological interactions and shifts in species' geographical ranges, with predominantly negative consequences for biodiversity and ecosystem goods and services. Further, about one-third of plant and animal species are likely to face increased risk of extinction at even moderate warming.

Studies by Indian Institute of Science using Global Dynamic Vegetation Models (DGVMs) such as IBIS (Integrated Biosphere Simulator Model) and BIOME (Ravindranath et *al*., 2006) have shown that majority of the currently forested grids will be adversely impacted. Modelling studies show that 62% of the forested grids will undergo changes in forest types (Plant Functional Type, PFTs) by 2085 as shown in Figures 3, 4. Further, even in the short (2025) and medium (2055) term, more than 36% and 44% of the forest vegetation grids respectively, would become unsuitable for the existing vegetation types, with Himalayan ecosystems likely to be most vulnerable. The climate change impacts will lead to forest die-back, mortality and changes in species dominance and loss of biodiversity.

NPP seems to increase across the country in general, principally owing to carbon fertilization effect. The NPP values are projected to increase for majority of the forest types of Bihar, Jharkhand, West Bengal, Orissa, Eastern Coastal Area, and Western Ghats (Fig. 4). However, some forest types in regions such as north Karnataka, north Tamil nadu, south Andhra Pradesh, Himachal Pradesh, Uttaranchal and Rajasthan are likely to experience decline in NPP. However, the NPP increase in some of the forest types should be viewed with caution, as the model does not take into account the impact of climate change on pest outbreaks and increased dynamic forest fires.

Modelling assessment of impact of climate change on the dominant plantation species showed that by 2085 more than 80% of Teak grids and more than 90% of Pine grids are likely to become unsuitable for the currently existing teak and pine species, due to changing climate. Sal is likely to be impacted less with less than 40% of the grids likely to be vulnerable.

Given the projected adverse impacts of climate change on forest ecosystems, including plantations, it is very important to consider this aspect in the National Mission for a 'Green India' and explore the possibility of incorporating adaptation strategies.

India's RUrban transformation, 2000–2050

Although the focus of this dissertation is on rural areas, it is indeed true that the rural India is urbanising very fast. Yet, the dimensions of climate change are different in urban and rural areas. Therefore, it is important to understand ongoing transformation processes that are rapidly altering India's rural and urban landscape. This includes changing livelihood opportunities and income and wealth distributions that in turn alter the vulnerability profiles of many rural-urban communities and stakeholder groups and their capacity to adapt to climate change, but also the governance patterns. [22] By 2007, India had around 30 per cent of its population living in urban areas but, given a total population of over 1.1 billion, its urban population is one of the world's largest – even exceeding that of the USA. India will further experience one of the most dramatic settlement transitions in history over the next 40–50 years as its urban population grows from about 300 million to over 700 million.

Climate-change risk to India needs to be seen in the perspective of an ongoing three-part transition: a demographic transition that will see India's population stabilizing at around 1.6 billion in the 2060s; a *RUrban* transition, which will see an addition of around 500 million people to an estimated 7,000–12,000 urban settlements over this period; and an environmental transition as the "brown" (environmental health) agenda is accompanied by the growing importance of the "green" (e.g. climate change) agenda.

But climate change could catalyse the ongoing agrarian crisis in rural India in unexpected ways, causing rapid rural-to-urban migration, driven by the increased intensity and frequency of extreme events and the expansion of drought in semi-arid areas, drought and flooding in the very dense Indo-Gangetic and Brahmaputra plains, and flooding and drought in the coastal plains. These scenarios have been only broadly articulated, and

[22] An illustration of the importance of such transformation comes from the cases of peri-urban villages in the National Capital Territory region, where many households maintain two rediences – one in the city and another in the village, as well as other villagers are critically dependent upon work sites in the cities.

not systematically investigated in fine-grained GIS-linked models, so most projections on this are only speculative. But India's future social and political stability will require a more nuanced, detailed and geographically explicit understanding of these risks.

Climate-change-induced drought and resource conflict may force the pace of rural–urban migration over the next few decades. Alternatively, severe stresses induced in urban areas due to a mix of water scarcity, breakdown of environmental services, flooding and consequent water-borne disease and malaria epidemics combined with a rapid rise in health expenditures could maintain the low current level of rural–urban migration. Maintaining two-way flows of food, biomass, water, livelihoods, products and services across the *RUrban* continuum will be crucial to India's development and medium-term sustainability. Climate-change adaptation in both cities and the rural economies and systems in which they are embedded is an undiscovered near-term policy concern - and one that is also intimately connected with livelihoods and drought, biomass and energy security.

Globalisation and climate change vulnerability in India

In the increasingly globalising world, communities' vulnerability to climate change could not be seen in isolation. Trade, particularly, global agriculture trade is a crucial issue for alleviation of rural poverty in particular and sustainable development in general. For example, trade liberalization and globalization are seriously impacting food and agriculture. Food production is increasingly promoted by large-scale commercial enterprises and competitive smaller agricultural farmers (ECOSOC 2008). Food for self-consumption is often cheaper in the market than through production in subsistence farming. While globalization is facilitating efficient transfer of food, it also increases bio-security risks from trans-boundary diseases, weeds, and unintended genetic drift, for example from genetically-modified crops. The choice of crops grown in the global agricultural market is increasingly driven by manufacturing market demand and consumer trends, which may threaten agricultural biodiversity and increase specialization, depending on local policy and comparative advantage (ECOSOC 2008). An assessment of the adaptive capacity, therefore, has to take into account both climate sensitivity (e.g. monsoon dependence and dryness) and trade sensitivity (e.g. trade barriers, distance to ports, import sensitivity of the production centre, etc.). These two, i.e. trade and climate sensitivities together affect each aspect of adaptive capacity, e.g. bio-physical, social and technological vulnerability (Fig. 5).

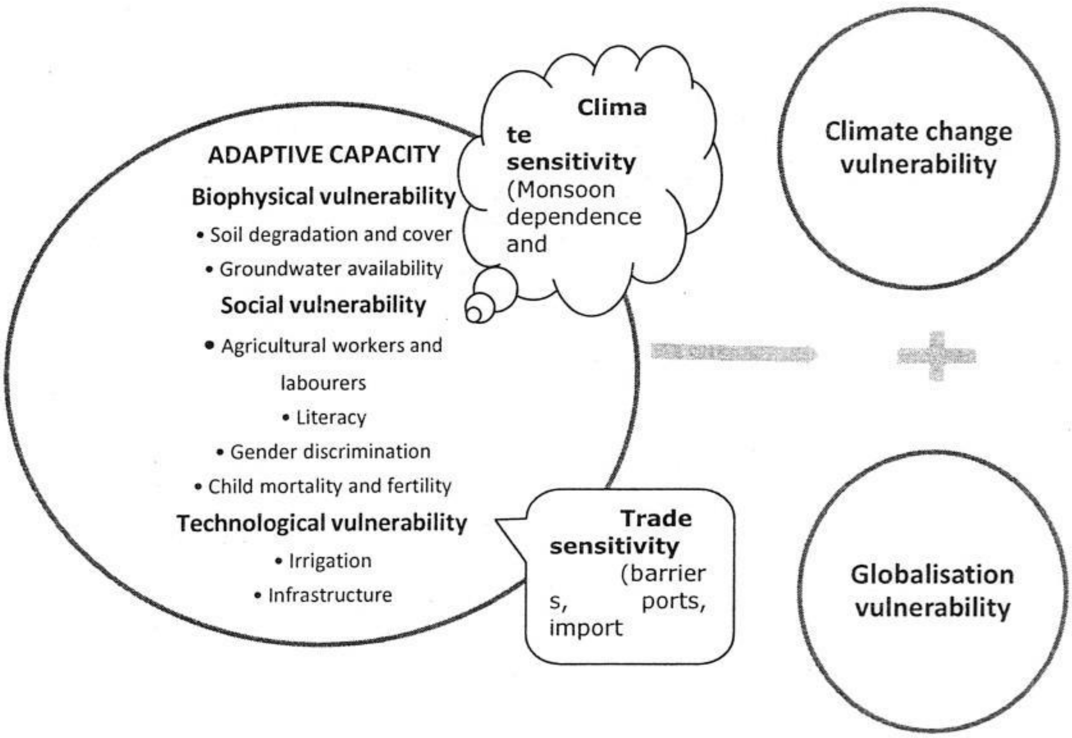

Fig.5: Elements of vulnerability profile

Once the two sensitivities – climate and globalisation- are combined, the vulnerability profile of India changes significantly. Large parts of western, central and south-western India would actually be much more vulnerable (Figs. 6, 7). Yet again the combined vulnerabilities would be dependent on the existing condition of vulnerability in the area. Thus, for example, the vulnerabilities of the poor in western Orissa (KBK Districts) would be much deeper due to climate change than the vulnerabilities of the poor in north-eastern Orissa (Mayurbhanj District) because of the existing state livelihoods crisis in the former.

Conclusions

India faces the unique challenge of facing an imminent climate threat, purported to have originated mainly from anthropogenic action, even though it has contributed very little to the global green house gas emission. Given the poverty of its masses and critical dependence of the poor on natural resources (agriculture, water, land, forests) which themselves face critical pressure due to the projected climate change. Adaptation, is imperative not an option. The ability to adapt to climate change is intertwined with sustainable development in both positive and negative sense though. In the positive sense, enhancement of adaptive capacity entails direct reduction in poverty, e.g. improved access to resources and infrastructure. On the negative side, the efforts of sustainable development and poverty reduction are going to be significantly challenged, with a propensity to turn into a downward spiral, by climatic extremes like that of 2008 Orissa floods, and 1999 Supercyclone. The next chapter, therefore, looks into specific details of climatic vulnerabilities and disasters in Orissa and see what are the broad responses to it, so as to fine-tune my analysis in Chapters-VI and VII.

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