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A CRITICAL ASSESSMENT OF CLIMATE CHANGE IMPACTS, VULNERABILITY AND POLICY IN INDIA

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Key words : climate change, India, economy, vulnerability, impacts, climate policy.

Abstract. There is considerable disagreement on the extent of the changes in the variables of climate, but is expected that these changes will lead to submergence of coastal areas, and increased severe occurrence of floods and droughts and harm productivity in agriculture, fishery, forestry, human, all converted into loss of lives and livelihood, productivity, employment opportunities, with high opportunity cost of adaptations and mitigations in India. The developing countries are particularly vulnerable to climate change due to their vast population depending on natural resources. In spite of no commitment to reduce GHGs under Kyoto protocol, India can not afford to ignore it due to its agenda of higher growth. Its concerted efforts for sustainable economic development would not only provide an insurance against the impact of climate change and increase adaptive capacity of vulnerable sectors and sections, but also lead to avoidance of binding commitment to reduce GHGs emissions in the next phase of Kyoto Protocol. This paper critically analyzes the impacts and vulnerability of Indian economy to climate change and analyzes India's efforts in addressing and reducing the vulnerability of its natural and socio-economic systems to climate change and enhancing the adaptive capacity of the same under uncertainty.

Introduction

The historical evidences of India reflect the change of climate and so the change in the availability of natural resources bringing structural change and migration in the economy. India needs to be concerned about climate change since its vast population depends on climate sensitive sectors like agriculture, forestry and fishery for livelihood. To add to this, poor infrastructure facilities, weak institutional mechanism, lack of financial resources and vast sectoral and regional variability adversely affect the adaptive capacity of the country. Climate change could represent additional stress on the ecological and socio-economic systems that are already facing tremendous pressure due to rapid industrialization, urbanization, and economic development. This paper attempts to gather historical evidence for climate change in India since the last glacial period till recent times. It also

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attempts to analyze the impact of climate change on the Indian economy and critically assesses the climate policy India proposes to follow at home in its serious response to climate change. It concludes that there are serious evidences of climate change bringing changes in the civilizations, culture and the economy in India. In the absence of adaptation, mitigation strategies and development process, climate change may alter the distribution and quality of India's natural resources and adversely affect the livelihood of its people.

This paper is arranged in 5 Sections. Section 2 discusses the extent of impacts and vulnerability of Indian economy to the climate change. Section 3 provides the background to the climate policy of India. Section 4 discusses critically the climate policy of India. The paper closes with Section 5 critical assessment of climate policy of India.

1. The Impacts and Vulnerability of the Indian Economy to Climate Change

The adverse impacts of climate change would threaten India's food security and livelihood. The rising temperature, variations in rainfall, disappearance of glaciers, increased frequency and severity of extreme events of floods in the plains as well as in the coastal areas, droughts, storms are likely to impact more particularly the vulnerable section of the economy.

1.1 Temperature, Precipitation and Occurrence of Extreme Events. As per the Indian Institute of Tropical Meteorology (IITM), Pune simulation, annual temperature rises from 3-5°C under A2 and 2.5- 4° C under B2 scenarios of IPCC, with warming more pronounced in the northern parts of India by the end of century. Also, the summer monsoon intensity may increase beginning from 2040 and by 10% by 2100 under A2 scenario of IPCC. Other studies suggest that India's climate could become warmer by 2.33° C to 4.78° C under conditions of doubling of CO_2 concentration (Longern, 1998). Also, an increase in annual temperatures of 0.7-1.0°C by 2040 is predicted with respect to the 1980s (Lal et al., 1995).

At the national level, an increase of 0.4° C has been observed in temperatures over the past century. In addition, the variations in the distribution of rainfall are also being observed to the range of +12% to -8% of the normal over the last 100 years. The analyses of daily rainfall data set have shown (i) a rising trend in the frequency of heavy rain events and (ii) a significant decrease in the frequency of moderate events over central India from 1951 to 2000 (Goswami et al, 2006). The daily rainfall data for 1954–2003 show vulnerability of Kerala to increasing probability of water scarcity in the pre-monsoon time and a delaying monsoon onset (Pal andTabbaa, 2009)

In 1998, India experienced its worst hot spell in 50 years, which took a toll of over 3,000 lives; tropical cyclone of Orissa in 1999 took toll of about 10,000 lives.

Snow, ice, and glaciers in the Himalayan region are approximately equivalent to about 1,400 km^3 of ice. The melting of snow will lead to flood disasters in Himalayan catchments (IPCC, 2001). Mahanadi, Brahmani, Godavari and Cauvery basins are projected to have increasing precipitation due to increase in evapotranspiration on account of increased temperature, further intensifying flooding conditions. Sabarmati and Luni basins will be experiencing drastically decreased precipitation which will further deteriorate drought condition (Shukla, 2003).

1.2 Water resources. The amount of water available per person in India is decreasing steadily – from 3450 cm in 1951, to 1250 cm in 1999 and further to 760 cm per person in 2050. By the year 2050, the average annual runoff in the river Brahmaputra will decline by 14 % (TERI, 2004). The Himalayan river systems draining into the Ganga basin are gradually dying out (Tangri, 2003). A decline in total run-off for all river basins, except Narmada and Tapti, is projected in India's NATCOM I. Due to sea level rise, the fresh water sources near the coastal regions will suffer salt intrusion. The demand for water has increased tremendously over the years due to an increasing population, expanding agriculture, and rapid industrialization that are responsible for considerable imbalances in the quantity and quality of water resources. The climate change is further aggravating the problem.

1.3. Agriculture and Food Security. Highly climate sensitive Indian agriculture with 65% of rain fed area, contributing 17% of the GDP, 12.2% in exports, employs 52% of the total workforce in 2009 (GOI, 2009). Several studies predict that the productivity of some of the important cropping systems such as rice and wheat could decline considerably with climatic change in India (for example, Achanta, 1993). Due to 2-3.5°C of temperature rise accompanied by 7-25% of precipitation change, farmers may be losing net revenue between 9-25% that may adversely affect GDP by 1.8-3.4% (Kumar and Parikh, 1998, Sanghi et al., 1998). There will be serious consequences for food security in the South and India stands to lose a massive 125 Mt equivalent to some 18% of its rain fed cereal production potential (Fisher et al., 2001). In India, the estimated total requirement for food grains would be more than 250 Mt by 2010; the gross arable area is expected to increase from 191 to 215 Mha by 2010, which would require an increase of cropping intensity to approximately 150% (Sinha et al., 1998). Studies by Indian Agricultural Research Institute (IARI) indicate every 1°C rise in temperature reduces wheat production by 4-5 million tons. It will also significantly affect the quality of fruits, vegetables, tea, coffee, aromatic and medicinal plants, and basmati rice. Global reports indicate a loss of 10-40% in crop production by 2100. By the end of the next century, it can cause annual damages in farm income between 4% and 26% in India (Sanghi and Mendelsohn, 2008).

1.4 Forestry. Forests in India play a crucial socio-economic role, contributing with 0.7% to GDP in 2008(GOI, 2009). Nearly 55 million people in India depend upon non-timber forest products. The forest covers is 23.60% in 2008, and there are hopes to extend the forest cover to 33% by 2012 (MoEF, 2008). India promises wide scope of forestry options for climate change mitigation through carbon sequestration, conserving forests, reducing human interventions and improving productivity from 0.7-1.5m^3/ha per year to the world average of 2.1 m^3/ha per year through Joint Forest Management (JFM). Using A2 and B2 scenarios and the BIOME4 vegetation response model, it is shown that 77% and 68% of the forest areas in the country are likely to experience shift in forest types, respectively under the two scenarios, by the end of the century, with consequent changes in forests produce, and, in turn, livelihoods based on those products. Correspondingly, the associated biodiversity is likely to be adversely impacted (Ravindranath et. al. 2006).

1.5 Coastal areas. India has a low-lying densely populated coastline extending to about 6500 km and has been identified as one of the most vulnerable to sea level rise (UNEP, 1989). Most of the coastal regions are agriculturally fertile, with paddy fields that are highly vulnerable to inundation and salinization. Coastal infrastructure, tourist activities, and onshore oil exploration are also at risk. The impact of any increase in the frequency and intensity of extreme events, such as storm surges, could be disproportionately large, not just in heavily developed coastal areas, but also in low-income rural areas. In the absence of protection, one meter sea level rise would inundate 1700 km^2 of prime agricultural land in Orissa and West Bengal (IPCC, 1992), and likely affect 5763 km^2, and put 7.1 million people at risk. The dominant cost is land loss, accounting for 83% of all damages (JNU, 1993). The economic implications of one-meter sea level rise on the most and least vulnerable district range from Rs. 2287 billion for Mumbai to Rs. 3.6 billion for Balasore (TERI, 1996). A mean Sea Level Rise (SLR) of 15-38 cm is projected along India's coast by the mid 21st century and of 46-59 cm by 2100 (NATCOM, 2004). Using the records of coastal tide gauges in the north Indian Ocean for more than 40 years, it was estimated, that sea level rise was between 1.06-1.75 mm per year. These rates are consistent with 1-2 mm per year global sea level rise estimates of IPCC (Unnikrishnan and Shankar, 2007).

1.6 Human Health (Spread of Malaria). Malaria is endemic in all parts of India except at elevations above 1800 meters and some coastal areas (Sharma, 1996). In most part of the country, periodic epidemics of malaria occur every five to seven years, with central India being more prone to it. WHO (1999) estimates indicate that in the year 1998, about 577,000 DALYs (disability-adjusted life years) were lost due to malaria (NMEP, 2002). There is a greater correlation between malaria incidence and temperature and precipitation for the epidemics

(Mitra et al., 2003). It is projected that under BAU in 2080s, 10% more states may offer climatic opportunities for malaria vector breeding through the year with respect to the year 2000. These opportunities are projected to increase by 3 to 5 months in Jammu and Kashmir and western Rajasthan, while they may reduce by 2 to 3 months in the southern states as temperature increases (Shukla et al., 2003).

2. The Background to the Climate Policy of India

Economic reforms, implemented since 1991, have resulted in faster growth of the Indian economy roughly averaged 8% during 2004-2008. However, 25% of the population still lived below the poverty line in 2007(GoI, 2008). The poor are the most vulnerable to climate change. Therefore, poverty eradication and improving standards of living will also reduce climate related vulnerability. The adverse impacts of climate change are causing severe droughts, floods; risks to human health, food security, lives and livelihood in the economy. Climate change can cause a loss of 10-40% crop production by 2100 and reduce farm income between 4% and 26% in India (Sanghi and Mendelsohn, 2008) decline in forest productivity (Ravindranath et. al. 2006), would inundate 1700 km^2 of prime agricultural land in Orissa and West Bengal (IPCC, 1992), and is likely to affect 5763 km^2, and put 7.1 million people at risk (JNU, 1993).

In the recent years, India's primary energy consumption has been increasing due to population growth and economic development and grew at the rate of 6% between 1981 and 2001, still very low compared to other developing countries (IEP, 2009). The energy-GDP elasticity during 1953–2001 has been above unity. The total installed power capacity in the country as on March, 2008 is 1,43,061 MW, 64.2% of which is thermal, 25.1% hydro, 7.8% renewable, and around 4% nuclear energy. India plans to enhance energy capacity by 78,520 MW by 2012, to electrify the rest of 20% of villages, to meet the additional demand (Deambi, 2008). India's per capita CO_2 emission of 1.02 tons is well below the world's average of 4.25 and of the developed countries like the USA 20.01(HDR 2008, Bacon and Bhattacharya, 2007). The per capita emission for India would still be 2.56 tons-CO_2 equivalent in 2030, which would be significantly below the global average. 4.6% of India's contribution to global CO_2 emission will turn into 9% by the year 2050, much less than the countries in competition. Also, India has just started experiencing a downturn in its environmental Kuznets curve for CO_2 emissions (Gupta, 2007).

3. Climate Policy of India

At the national level, there has been a paradigm shift from the erstwhile relief-centric and post-event syndrome to a pro-active prevention, mitigation and preparedness driven environmental and disaster management. Current government expenditure on adaptation to climate variability exceeds 2.6% of the GDP. In order to achieve a sustainable development path, the National Action Plan for Climate Change (NAPCC) has been initiated in June 2008 with Eight National Missions for achieving key goals till 12th Plan period of 2012-17 beside other programmes.

3.1 Solar Power. India receives about 5,000 trillion kWh/year equivalent solar energy during 250 to 300 days of clear sunny weather in most parts of India. Just 1% of India's land area can meet India's entire electricity requirements till 2030. The estimated unit cost of generation is currently in the range of 20-25 Rs/KWh, much more than power produced by coal, water or wind. Although several financial measures, such as subsidy, soft loans, zero import duty on inputs, excise duty exemption etc. have been undertaken to stimulate solar energy production, the share of solar power is still relatively low due to high cost (Deambi, 2008).

Tab. 1 - The potential and the achievement in harnessing energy from renewable sources

Source/ Technology	Units	Potential/ Availability	Achievement till 31.3.09
Biogas plants	Million	12	4.13
Biomass-based power	MW	19,500	703.30
Efficient wood stoves	Million	120	41.27
Solar energy	MW/Sq. Km.	20	2.12
Small hydro power	MW	15,000	2429.67
Wind energy	MW	45,195	10,242.50
Energy recovery from waste	MW	1,700	34.02
Large hydropower	MW	148,700	35,000

3.2 Enhanced Energy Efficiency. The Energy Conservation Act of 2001 provides a legal mandate to save 10,000 MW by 2012 through tradable energy savings certificate, fiscal incentives, fuel switching, programmatic CDM, special financing mechanisms, standards and labeling for equipment and appliance, replacement of inefficient appliances, capacity building and information, policy transparency, risk funds, promoting imports, energy audit, promoting public transport, imports and competition, removing price distortions etc.

India's has one of the largest resources of thorium in the world and produces 3,700 MW of nuclear energy. It plans to produce 20,000 MW energy by 2020 (GoI, 2009). Although renewable energy promotes energy security, local employment opportunities, reduces GHG emissions, the cost of producing it is still very high and uncompetitive. The increased scale and further innovation in technology and deployment models may reduce costs. Efforts of generating energy from waste have not been successful due to the variety of systems, technology, pricing, variable quality of waste, insufficient segregation of waste, open dumping etc.

3.3. Sustainable Habitat. This mission focuses on energy efficiency in buildings, management of solid waste, public transport, infrastructure, disaster management, warning system for extreme weather events as part of urban planning and urban renewal. The BLY (Bachat Lamp Yojana) promotes energy efficient CFLs instead of incandescent bulbs and is expected to reduce electricity demand by 10,000 MW. There is a need to continuously update appliances, building energy norms and labeling, rationalize energy pricing, and provide fiscal benefits for improving efficiency. Also the monopolistic market for energy efficient products has resulted in non-competitive products like insulations, chillers, etc. The health programme also comprises provision of enhanced public health care services and assessment of increased burden of disease due to climate change through climate data to study the regional pattern of disease, health impact model, GIS mapping of health facilities, study of pollutants and pollen affecting health etc.

3.4. Water Resources. The amount of water available per person in India is decreasing steadily - from 3450 cm in 1951, to 1250 cm in 1999 and further to 760 cm per person in 2050. The regulatory structures with appropriate pricing and incentives, water-efficient technologies to minimize wastage, ensure equitable distribution, recycling of waste water, use of ocean water, improving efficiency of irrigation systems, increase storage capacity, recharging underground water, water harvesting, water assessments and audits; proper industrial waste disposal, improved drainage systems, conservation of wetlands, development of desalination technologies etc. are the instruments of this programme. India has a highly fertile and dense coastal line of 7,500 km vulnerable to sea level rise, cyclones and storms, and needs a high level of attention for coastal protection through adaptation, research, rehabilitation, awareness, timely forecasting, and warning systems.

3.5. Sustaining the Himalayan Ecosystem. 51 million people depend on the Himalayan ecosystem for their livelihood. The mission seeks to understand the causes and the extent of recession of Himalayan glaciers, to assess freshwater resources and health of the ecosystem and focuses on forestation to prevent erosion and land degradation, feeding perennial rivers, conserving biodiversity, providing a rich base for high value agriculture and sustainable tourism, and also promotes scientific collaboration with other countries sharing Himalayan ecosystems.

3.6. Green India. The forest cover in India was 23.60% in 2008, and is to be extended to 33% by 2012 (MoEF, 2008). This mission focuses on enhancing ecosystem services including carbon sinks, conserving wildlife and biodiversity.

3.7. Sustainable Agriculture. Highly climate sensitive Indian agriculture with 65% of rain fed area, contributing with 17% of the GDP, 12.2% in exports, employed 52% of the total workforce in 2009 (GoI, 2009). The Mission would devise strategies to make Indian agriculture more resilient to climate change through new varieties of crops, thermal resistant crops, and alternative cropping patterns capable of withstanding extremes of weather and long dry spells, flooding, and variable moisture availability through converging and integrating traditional knowledge systems, information technology, geospatial technologies and biotechnology. It will particularly focus on dry land agriculture, risk management, access to information and use of biotechnology and enhanced financial support to farmers, insurance mechanisms, weather derivative models, and customized information in regional languages.

3.8. Strategic Knowledge for Climate Change. India's first National Communication (NATCOM) to the UNFCCC project provides a formal network for research initiatives in environment and forests, health and family welfare, water resources, agriculture, science and technology. NATCOM provides an estimation of GHG emissions besides vulnerability assessments and adaptation strategies, setting up a data centre, and targeted research and capacity building. A Strategic Knowledge Mission is to identify the challenges and responses to climate change through funding in high quality and focused research in health, demography, migration patterns and livelihoods of coastal communities. A Climate Science Research Fund and venture capital funds to innovate technologies for adaptation and mitigation and dissemination of new knowledge have also been initiated.

3.9. Other Policy Issues - International Cooperation on Climate Change. India is signatory to many of the international treaties on environment, health, trade etc. It is expected that this international cooperation will enhance the capabilities of developing countries to mitigate and adapt and the menu of cooperation mechanisms is not constrained for technology solutions, fairness and equity in the actions and measures, financing and IPR-sharing, scientific research, carbon markets and mechanisms like the CDM, enhancing the absorptive capacity of the developing countries. India accounts for about 32% of the world 1081 projects registered, followed by China (20%), Brazil (13%), and Mexico (10%) in renewable energy, biomass, energy efficiency, forestry, and municipal solid waste. The expected investments in 753 projects are about Rs. 106, 9000 million. About 493 million certified emission reductions (CERs) are expected to be generated until 2012. The portfolio of projects of India is dominated by small projects accounting for 63%, unilateral projects, lack of financial participation of Annex B countries, lack of insurance firm's participation and reliable information of carbon market on CDM transactions, high transactions costs etc.

3.10 Implementation. Ministries with lead responsibility for each of the missions are directed to develop objectives, implementation strategies, timelines, and monitoring and evaluation criteria, to be submitted to the Prime Minister's Council on Climate Change. The Council will also be responsible for periodically reviewing and reporting on each mission's progress. To be able to quantify progress, appropriate indicators and methodologies will be developed to assess both avoided emissions and adaptation benefits.

4. Critical Assessment of Climate Policy of India

The impact of vulnerability is not only decided by the extent of climate change, but also by the robustness of the developmental process in the economy. Global climate change has emerged as a threat to sustainability and seriously endangers the Indian economy. It is the quality of development that would provide an insurance against the impacts of climate change and increase the adaptive capacity of the vulnerable. Current government expenditure in India on adaptation to climate variability exceeds 2.6% of the GDP. India has initiated its efforts for adaptation and mitigation through comprehensive Climate Policy in the right direction. Adequate focus on institutional arrangements to devise incentives and disincentives has been given. But how far these incentives and disincentives will be suitable and work through market is a point of concern. The focus of the policy is unduly prescriptive (using Command and Control approach and less of Market Based Instruments), and prevents innovation in systems, procedures and new technologies. There is a need to focus on performance norms to be met in the cost-effective way, irrespective of systems, procedures and/or technologies. This would provide benchmarks for monitoring and enforcement, and also space for innovation. The success of the climate policy may be constrained by the magnitude of the impact of climate change affecting its vulnerability, adaptive capacity, policy acceptability and capability, policy responses etc. The overcoming of these constraints will strengthen the ability of a country to achieve sustainable economic development. Also, community action is needed in order to have bargaining capacity and force the regulatory body to respond to the problem.

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