

Climate Change and Domestic Mitigation Efforts

Climate change can manifest itself in gradual changes in temperature, precipitation and a rise in sea level, resulting in changes in the frequency, intensity and duration of extreme events. Climate change will impact different regions and sectors differently based on their sensitivity and adaptive capacity, and therefore their vulnerability. For the Indian economy, which mainly depends on natural resources, climate change could represent an additional stress on agriculture, forestry, coastlines, water resources and human health. This paper discusses future emissions scenarios in India, highlighting the extent of India's vulnerability to climate change, and critically analyses the initiatives undertaken at home to mitigate GHG emissions.

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I Introduction

Recognition of climate change as a significant global environmental challenge has its origin in the adoption of the United Nations Framework Convention on Climate Change (UNFCCC) in 1992. Global negotiations have paid greater attention to the minimising of the cost of mitigating greenhouse gas (GHG) emissions, which has obscured the importance of the vulnerability of natural and human systems in weaker economies and their adaptation to such changes. Against this background, this paper projects the future emissions scenario in India, highlights the extent of India's vulnerability to climate change and critically analyses the initiatives undertaken at home to mitigate GHG emissions.

The growth in commercial energy use is closely related to the growth of industry, transport and urban areas. India accounted for 3.5 per cent of world commercial energy demand in 2001 reaching 314.7 million tonnes of oil equivalent (mtoe) [GoI 2003]. A large part of India's population does not have access to commercial energy. India's per capita energy consumption of 482 kgoe is 29 per cent of the world average of 1,671 kgoe and compares poorly with some other developing countries. India's energy use efficiency (measured as the ratio of GDP to energy use) was 4.4 (ppp \$ per kgoe) in 1999 [WDI 2002], which is lower than some industrialised nations but more than double of energy efficiency has been achieved since 1980. The energy elasticity (energy growth rate/economic growth rate) was more than unity for the period 1953-2001.

However, elasticity remained less than unity for the period 1991-2000 due to improvement in the efficiency of energy use and structural changes in the economy [GoI 2003]. Industrial and power generation sectors consume maximum energy at 49 per cent while the transport sector consumes 22 per cent of total energy consumption as shown in the figure.

II Greenhouse Gas Emission

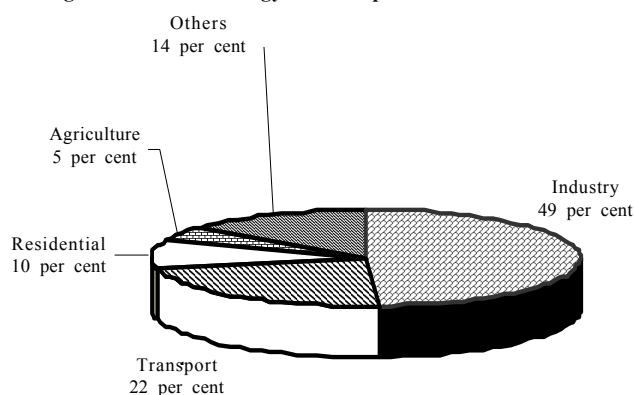
As per Intergovernmental Panel on Climate Change (IPCC) methodology, the total carbon dioxide (CO₂)-equivalent emissions from India were estimated to be 1,001,352 gg, which was

about 3 per cent of the global CO₂-equivalent emissions in 1990. Based on this, the per capita CO₂-equivalent emissions for 1990 was estimated to be 325 kg of carbon for India as compared to 2,400 and 5,400 kg of carbon for Japan and the US respectively [ADB 1998]. In 1999, the US contributed 22 per cent of GHG emissions, China 14.8 per cent, Russian Federation 6.8 per cent, India 5 per cent and Japan was responsible for 4 per cent of total GHG emissions [ABARE 2003]. India's per capita CO₂ emission of 1.1 thousand metric tonnes (tmt) in 1998 was again well below the global average of 1.9 tmt and the 10.8 tmt of the north. India has experienced dramatic annual growth in CO₂ emissions of 5.8 per cent since 1950. Since 1990 alone, India's CO₂ emissions have risen by 59.5 per cent to 294 million metric tonnes which has made it the world's fifth largest emitter. Coal contributed 87 per cent to the emissions in 1950 and 70 per cent in 1999, as the third largest producer of coal in the world, while the oil fraction increased from 11 per cent to 21 per cent, reflecting a fuel switch [Marland et al 2002]. The power, steel, cement, residential, and transport sectors are the most polluted sectors in India and offer possibilities for large reductions in emissions [Garg et al 2001].

IPCC's Alternate Futures

Future GHG emissions depend on the development pathways taken by economic, demographic, land use, agricultural, technological and energy drivers. The interactions among these key drivers are complex and have profound regional specificity. IPCC describes four alternate futures that may evolve leading to different global GHG emissions [SRES 2000]. These four futures are differentiated by the extent of market integration (liberalisation and integration with global markets) and types of governance (centralisation or decentralisation). The four Indian (referred with prefix I) scenarios are named IA1, IA2, IB1, and IB2 to follow IPCC, SRES scenarios. The IA1 termed as a high growth scenario, is a combination of centralisation and a high level of market integration; IA2 is business as usual (BAU) with centralisation and fragmented markets, IB1 is sustainable development with decentralisation and high market integration and; IB2 scenario is termed as self-reliance with decentralisation and a fragmented market. The IA2 BAU scenario captures the continuation of present government policies, and forecasts various macroeconomic, demographic and energy sector indicators [Shukla et al 2003].

Figure: Sectoral Energy Consumption in India 1999-2000



However it does not represent a preferred or most likely scenario. IB1 could be the most preferred scenario with a condition of protecting vulnerable economies since there exist more chances of being exploited in global markets.

Future Emissions Scenario

Coal dominates the Indian CO₂ emissions inventory, accounting for about half of commercial energy consumption. Carbon emissions are expected to grow from 260 mt in 2000 to 841 mt by 2030 in the IA1 scenario and 560 mt in the IB1 scenario. This is due to sustainable development policies to be undertaken in the future. The basket of six gas emissions for the IA2 (BAU) scenarios are integrated via their global warming potential as shown in Table 1.

CO₂ emissions shall continue to dominate national GHG emissions, with its share reaching 74 per cent in 2030 vis-à-vis 65 per cent in 2000. The major contributor is the coal consumed in electricity generation. Methane emissions grow at a slower pace as its main contributors – rice paddy cultivation and livestock – have slow growth rates. The share of methane emission thus drops to 15 per cent in 2030 compared to 27 per cent in 2000. The share of N₂O emissions, driven by nitrogen fertiliser use in agriculture stagnates at around 6-7 per cent throughout the entire period. Presently the combined share of the three fluorochemical GHGs (PFC, HFC and SF₆) in the CO₂ equivalent emissions of all six gases is below 1 per cent in India and 1.5 per cent globally. In 2020, this share will increase to 3 per cent in India and 6 per cent globally [Olivier and Bakker 2001]. Under the BAU scenario, a fourfold increase in GDP shall be accompanied by an increase in CO₂ emissions by 2.8 times, methane by 1.3 times, nitrous oxide by 2.6 times and other three fluorochemical GHGs (combined) by 15 times, but per capita emission for the basket of six gases for India would still be 2.56 tonnes – the CO₂ equivalent per capita in 2030 – which would remain significantly below than the global average [Shukla et al 2003]. Three per cent of India's contribution to global CO₂ emission will turn into 9 per cent by the year 2050, much less than the countries in competition [EPRI 2003].

III

India's Vulnerability to Climate Change

India has reasons to be concerned about climate change. A vast population depends on climate sensitive sectors like agriculture, forestry and fishery for livelihood in the country. The adverse

impacts of climate change, in the form of declining rainfall and rising temperatures and thus the increased severity of drought and flooding, would threaten food security and livelihood in the economy. To add to this, poor infrastructure facilities, weak institutional mechanisms, lack of financial resources and vast sectoral and regional variability adversely affect the adaptive capacity of the country to climate change. Climate change could represent additional stress on the ecological and socio-economic systems that are already facing tremendous pressure due to rapid industrialisation, urbanisation and economic development.

Impacts

Temperature, precipitation and occurrence of extreme events:

Several severe examples of the consequences of climate change are available from around the globe. Nine of the hottest years recorded in more than a century have occurred since 1988. Worldwide, July 1998 was the hottest month ever. In 1998, India experienced its worst hot spell in 50 years, which took a toll of over 3,000 lives. The tropical cyclone of Orissa in 1999 took a toll of about 10,000 lives. Himalayan glaciers are retreating at the rate of 18m per year in Gangotri.

Under future scenarios of increased GHG concentrations, a marked increase in rainfall and temperature is projected into the 21st century. India's climate could become warmer by 2.33 to 4.78°C, under conditions of doubling of CO₂ concentration [Longern 1998]. An increase in annual temperatures of 0.7 to 1.0°C by 2040 is predicted with respect to the 1980s [Lal et al 1995]. In the region south of 25° N (south of cities such as Udaipur, Khajuraho and Varanasi), the maximum temperature will increase by 2 to 4°C during the 2050s. In the northern region, the increase in maximum temperature may exceed 4°C. A general increase in minimum temperature up to 4°C all over the country has been predicted. Very little change in monsoon rainfall is projected up to the 2050s on an all-India scale. There is an overall decline in the number of rainy days over a major part of the country. This decline is more in the western and central parts (by more than 15 days) while near the foothills of Himalayas and in north-east India, the number of rainy days may increase by 5 to 10 days [Kumar et al 2003].

Water resources: India's rich water resources are unevenly distributed and result in spatial and temporal shortages. The demand for water has increased tremendously over the years due to an increasing population, expanding agriculture, and rapid industrialisation which are responsible for considerable imbalances in the quantity and quality of water resources. According to the ministry of water resources the amount of water available per person in India is decreasing steadily – from 3,450cm in 1951,

Table 1: Future GHG Emission Projections under BAU Scenario, CO₂ Equivalent Terms
(In mt per year)

CO ₂ Equivalent Emissions	2000	2010	2020	2030	CAGR*
Carbon dioxide (CO ₂)	956	1507	2080	2572	3.35
Methane (CH ₄)	391	422	462	529	1.01
Nitrous oxide (N ₂ O)	95	156	214	250	3.26
Perfluorocarbons (PFCs)	7	10	15	24	4.13
Hydrofluorocarbons (HFCs)	4	15	56	110	11.96
Sulfur hexafluoride (SF ₆)	0.3	4.4	12	21	15.12
Total CO ₂ equivalent	1454	2115	2839	3507	2.98

Note: * Compounded annual growth rate during 2000-2030.

Source: Shukla et al 2003, p 153.

to 1,250cm in 1999 and is expected to decline further to 760cm per person in 2050.

Lower rainfall and more evaporation would have the dire consequence of less runoff, substantially changing the availability of freshwater in the watersheds, decline of soil moisture and increasing aridity level of hydrological zones. By the year 2050, the average annual runoff in the river Brahmaputra will decline by 14 per cent [TERI 2004]. The Himalayan river systems draining into the Ganga basin is gradually dying out [Tangri 2003]. The perennial rivers originating in the high Himalayas receive water from snow and glaciers. Snow, ice, and glaciers in the region are approximately equivalent to about 1,400 km³ of ice. The melting of snow will lead to flood disasters in Himalayan catchments. Impacts will be observed more in the western Himalayas as the contribution of snow to the runoff of major rivers on the western side is about 60 per cent compared to 10 per cent on the eastern side [IPCC 2001]. Mahanadi, Brahmani, Godavari and Cauvery basins are projected to have increasing precipitation due to the increase in evapotranspiration on account of the increased temperature, further intensifying flooding conditions. Sabarmati and Luni basins will be experiencing drastically decreased precipitation which will further deteriorate drought conditions [Gosain and Rao 2003]. It is projected that there will be general reduction in the quantity of the available runoff.

Agriculture and food security: Highly climate sensitive Indian agriculture, 65 per cent of which is in rainfed areas, contributes nearly 25 per cent of GDP, employs 65 per cent of the total workforce and accounts for 13.3 per cent of total exports together with allied activities [GoI 2002]. Several studies predict that despite substantial increase in national foodgrain production, the productivity of some important crops such as rice and wheat could decline considerably with climatic change [for example, Achanta 1993]. Due to a 2 to 3.5°C rise in temperature accompanied by a 7 per cent to 25 per cent change in precipitation, farmers may be losing net revenues between 9 per cent to 25 per cent, which may adversely affect GDP by 1.8 per cent to 3.4 per cent [Kumar and Parikh 1998; Sanghi et al 1998]. Brazil, India, and many sub-Saharan African countries could lose out to climate change; winners could include Russia, China, Canada and Argentina. There will be serious consequences for food security in the south and India stands to lose a massive 125 mt equivalent to some 18 per cent of its rainfed cereal production potential [Fisher et al 2001]. The major impact will be on rainfed crops.

In India, the estimated total requirement for foodgrains 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 per cent [Sinha et al 1998]. Because land is a fixed resource for agriculture, the need for more food in India can be met only through higher yield per unit of land, water, energy, and time, such as through precision farming.

Forestry: Forests in India play a crucial socio-economic role, contributing 2.37 per cent to GDP [GoI 2003]. Nearly 55 million people in India depend upon non-timber forest products, a critical component for their sustenance. Changes in forestry could have profound implications for traditional livelihoods, industry, biodiversity, soil and water resources, and hence, agricultural productivity. Moreover, climate change induced effects will aggravate the existing stresses due to non-climate factors, such as land use changes and the unsustainable exploitation of natural

resources. Climate change is expected to affect the boundaries of forest types and areas, primary productivity, species populations and migration, the occurrence of pests and diseases, and forest regeneration. The increase in GHGs also affects species composition and the structure of ecosystems because the environment limits the types of organisms that can thrive and the amount of plant tissues that can be sustained [Melillo et al 1996].

In a case study of Kerala, the precipitation effectiveness index was linked to the net primary productivity of teak plantation. Results indicate that the soil moisture is likely to decline and, in turn reduce teak productivity from 5.40 cubic metres (m³)/ha to 5.07 m³/ha. Also, the productivity of moist deciduous forests could decline from 1.8m³/ha to 1.5m³/ha [Achanta and Kanitkar 1996]. Increased temperature and rainfall can result in greater productivity, migration of forest types to higher elevations, and transformation of drier forest types to moister types [Ravindranath and Sukumar 1998].

Coastal areas: India has a low-lying densely populated coastline extending to about 6,500 km identified as one of the most vulnerable to a sea level rise [UNEP 1989]. Most of the coastal regions are agriculturally fertile, with paddy fields that are highly vulnerable to inundation and salinisation. Coastal infrastructure, tourist activities, and onshore oil exploration are also at risk. The impacts 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 rural coastal areas. In the absence of protection, a one metre sea level rise would inundate 1,700 km² of prime agricultural land in Orissa and West Bengal [IPCC 1992], and is likely to affect 5,763 km², and put 7.1 million people at risk. The dominant cost is land loss, accounting for 83 per cent of all damages [JNU 1993]. However, the extent of vulnerability depends not only on physical exposure, but also on the level of economic activity in the region. The economic implications of a one metre sea level rise on the most and least vulnerable district range from Rs 2,287 billion for Mumbai to Rs 3.6 billion for Balasore [TERI 1996].

Coral reefs play a crucial role in fishery production and in protecting the coastline from wave action and erosion [Ruddle 1998]. In the Andaman Islands of India, the reef community structure has switched from fast-growing branching species to the more physically rigorous and slow-growing massive corals [Wilkinson 1998].

Human health (spread of malaria): Malaria is endemic in all parts of India except at elevations above 1,800 metres and in some coastal areas [Sharma 1996]. In most parts of the country, periodic epidemics of malaria occur every five to seven years, with central India being more prone to them. WHO (1999) estimates indicate that in the year 1998, about 5,77,000 DALYs (disability-adjusted life years) were lost due to malaria. Among the central states, Orissa and the north-eastern states, where the average annual parasite index (API) is the highest and the greater than 10 (API>10), followed by Madhya Pradesh (API>6-10), and Gujarat and Rajasthan (API>2-5) are the most seriously affected [NMEP 2002].

The best-fit analysis indicates that there exists a greater correlation between malaria incidence and temperature ($R^2 = 0.8$) than between incidence and precipitation ($R^2 = 0.6$) for a given condition of humidity, which indicates that other than the climatic parameters, socio-economic conditions such as poverty, irrigation, agricultural practices, urban settlements, land use change, etc, are also responsible for the epidemics. It is projected that

under BAU in the 2080s, 10 per cent 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 three to five months in Jammu and Kashmir and western Rajasthan, while they may reduce by two to three months in the southern states as temperature increases [Mitra et al 2003].

IV

Domestic Efforts to Mitigate GHG Emissions

India believes that it is not only sustainable production but also sustainable consumption patterns that can lead to a stress free environment and help achieve the goals of higher economic development. Therefore, its economic development efforts have always been guided by the principles of sustainable development, with a commitment to a greener environment. Although it does not have GHG reduction targets, India has undertaken wide-ranging reforms that have spurred economic growth and broken the barriers to efficiency. Major efforts are highlighted below:

Pollution Control, Energy Conservation and Energy Efficiency

The improvements in petrol and diesel quality have facilitated the adoption of India 2000 (Euro-I equivalent) emission norms in the entire country and Bharat Stage-II (Euro-II equivalent) emission norms in the four metros. Euro-III equivalent norms in seven mega cities will be applicable from 2005, for which further reduction of sulphur content needs to be undertaken by Indian refineries [GoI 2003]. The cost-effectiveness (\$/tonne of CO₂) of CNG cars and CNG buses has been estimated 4500 and 12 respectively [ADB 1998]. In spite of the cost effectiveness of commercial CNG vehicles, implementation generally finds resistance among the owners of commercial vehicles.

It can be seen from Table 2 that in most of the cases, India has adopted a command and control (CAC) approach and remained shy in using market based instruments (MBIs). This is because the Pigouvian approach would need an exact estimation of externality, imposition of MBIs, followed by strong enforcement. Supreme Court directives have specified the technology-based standards with progressively stringent norms. In other cases, standards for fuel and emissions have been set, leaving the choice of technology to the polluter. Under public interest litigation (PIL), 168 polluting units around Delhi were closed down or relocated. The increase in environmental PILs and judicial activism began to be perceived as a significant threat by polluting units across the country. These environmental cases have dragged polluters to the court to pay for the social cost imposed on a large number of urban victims. But sometimes, because of weak law enforcement, powerful polluting sources are easily able to get law enforcement either waived or extended.

Ethanol blended petrol (5 per cent gasohol) has been made mandatory in the first phase in the nine sugar producing states of Andhra Pradesh, Gujarat, Karnataka, Punjab, Haryana, Maharashtra, Tamil Nadu, Goa and Uttar Pradesh and four union territories since 2002. The whole country will be covered in the second phase and in the third, ethanol content will go up by 10 per cent. This is not only less polluting, but will also boost the sugar industry. Also, a massive drive for planting Ratan Jyot (Zatropa) plants on both sides of railway land has been embarked

upon. Environmentally friendly and a cheaper source of energy, bio-diesel distilled from Ratan Jyot can be freely mixed with diesel oil. Indian Oil Corporation will grow Ratan Jyot and sell the oil to the railways. Bio-diesel can also be extracted from the seeds of trees like mahua, karanja, kusum, dhupa, sal, pipal, jojoba, tumba, rubber-seed, neem and mango kernel which can grow in waste land and degraded lands [GoI 2004].

Forestry

India has had its forest policy in place since 1894. The main plank of the forest policy is the protection, conservation and development of forests. Forests covers 19.39 per cent of the total geographical area, [FSI 1999], which increased to 20.55 per cent in 2001, and it is hoped that this is extended to 33 per cent of the total geographical area [FSI 2001]. India has implemented a large number of developmental programmes for the protection of wildlife, mangroves, coral reefs, and lake ecosystems. It promises a wide scope of forestry options for climate change mitigation by carbon sequestering, conserving forests, reducing human interventions and improving productivity from 0.7-1.5m³/ha per year to the world average of 2.1 m³/ha per year through joint forest management (JFM). JFM particularly benefits from the rural and tribal community's intimate knowledge of species, their growth characteristics, utility, medicinal value, etc. This enhances the adaptive capacity of people who depend on forests to multiple stresses including climate change.

But due to the limited knowledge and uncertainties involved in regional climate projections, India could only focus on planning and implementation strategies of conservation and sustainable extraction. There is a need to explore implementing a few

Table 2: Major Supreme Court Rulings on Vehicular Pollution, 1990-2002

Case and Year of Ruling	Court Ruling	Status	Instrument Type
Vehicular pollution a serious issue (1990)	Registration of defective vehicles suspended effective from 1991, financial incentives for new CNG vehicles	Done	CAC, MBI
Lead phase out of all vehicles (1994)	Lead free petrol to be sold in metros and low lead petrol in entire country, catalytic converters for petrol driven cars made available by April, 1995	Done	CAC
Government vehicles (1996)	All official government cars to be fitted with catalytic converters or a CNG kit by August 1996.	Done	CAC
Ban on old commercial/transport vehicles (1998)	All commercial and transport vehicles more than 15 years old not permitted to ply in Delhi and other metros	Delayed/done in Delhi	CAC
Buses to use natural gas (2001)	Commercial vehicles in Delhi should convert to CNG, effective from April 2001.	Delayed	CAC
Phasing out of diesel buses (2002)	At the rate of 800 diesel buses per month starting from May 2002, till all the buses are replaced. Beyond January 2002, fine of Rs 500 and after 30 days Rs 1,000/ per day fine to be imposed	Delayed	CAC, MBI

Note: CAC – command and control; MBI – Market based instruments.

Source: Compiled from legal cases listed in *Legal and Scientific Resources for Asia*.

precautionary strategies such as anticipatory planting and linking protected area and nature reserves.

Renewable Sources of Energy

Institutionalisation of Climate Change Research

The research initiatives have been undertaken in India by the ministries of environment and forests, health and family welfare, water resources, agriculture, science and technology, and premier academic and research institutions. India's first National Communication (NATCOM) to the UNFCCC project has for the first time brought these together in a formal network to cover diverse research areas. NATCOM will provide a comprehensive estimation of emissions of greenhouse gases from five major sectors in the country: energy, industrial processes, agriculture, land use, land use change and forestry and waste. Besides this, activities under the project would also include uncertainty reduction in GHG estimations, vulnerability assessments and adaptation strategies, setting up of a data centre, and targeted research and capacity building initiatives.

Population Growth and Urban Agglomeration

Even after 50 years of population control efforts, India is the world's second most populous country of 1.03 billion people. By 2050, India will most likely overtake China with 17.2 per cent of the world's population. It is not only population growth but also the increase of urban agglomerations/cities with a population of more than one million, (from 5 in 1951 to 35 in 2001) that contribute to the problem. The National Population Policy, 2000 outlines the long-term objective as one "to achieve a stable population by 2045, at a level consistent with the requirement of sustainable economic growth, social development, and environment protection". Decadal growth of the population between 1991-2001 witnessed the sharpest decline since the 1950s with an average growth rate of 1.93 per cent per annum [GoI 2002]. The achievement in controlling population growth has been restrained because of poor planning, bureaucratic inefficiency, low status of women, extreme poverty and lack of administrative and financial support.

Economic Reforms

The refining sector was delicensed in 1998 and permitted to import crude oil. Customs duty was reduced on crude oil (27 per cent to 10 per cent), on products (32 per cent to 20 per cent), equipments for high voltage transmission (25 per cent to 5 per cent), which facilitated the dismantling of Administered Price Mechanism (APM) from March, 2002, opening the way for the entry of new players into marketing of transportation fuels. Subsidies on kerosene, LPG and fertilisers will be phased out in the 10th Five-Year Plan [GoI 2003]. Policies that remove price distortions (namely, marginal cost pricing and elimination of subsidies) combined with freer imports of high quality coal, could reduce carbon emission by 6.6 per cent, increase the volume of electricity generated, lower coal consumption and increase social welfare by 8.6 per cent [Khanna and Ziberman 1999]. Moreover, due to liberalisation, the Indian economy is now exposed to the rigours of competition and efficiency upgrades. Joint ventures in consumer capital goods such as vehicles and home appliances have resulted in energy efficient products, which are also being preferred by Indian consumers.

India is endowed with abundant natural and renewable resources of energy and is one of the major countries harnessing renewable resources. India is second only to China in installing biogas plants and improved wood stoves, the use of which results in the saving of over 16 million tonnes of fuel wood every year. Rural distribution of LPG for cooking has been extended to 7 million customers. The world's largest solar steam cooking system for 15,000 people has been installed in Tirumala, Andhra Pradesh and is working well. Small hydro projects of 538 MW capacities are under consideration in 15 potential states [GoI 2004].

India has been able to achieve significant capacity addition of 1,367 MW through wind farms and ranks fifth in the world after Germany, the US, Spain, and Denmark. The country also has significant potential of ocean thermal, sea wave and tidal power. The government of India (GoI) is funding incentive-driven research in solar energy, wind turbines, and hydrogen fuel as alternatives to fossil fuels. India intends to achieve a 10 per cent share for renewable energy in electricity capacity additions by 2012, and a 15 per cent improvement in energy efficiency by 2007-08. The GoI has endorsed activities implemented jointly (AIJ) projects in agriculture (in Andhra Pradesh); direct reduced iron (Gujarat), energy recovery from waste gas and liquid (Gujarat), biomass gasification (20 sites in India), and agro forestry in dry land (Karnataka) with the help of the World Bank, the Netherlands and US. Under Global Environment Facility (GEF), GoI has also undertaken projects on fuel cell bus, small hydel, bio energy, and coal bed methane, and biomass energy for rural India.

The wide gap between availability and potential exploited shown in Table 3 indicates that there is a long way to go. Renewable resources need to be exploited by giving them a commercial orientation, encouraging private and foreign direct investment and simplifying procedures, providing of fiscal and financial incentives and by subsidising energy requirements of rural areas.

Participation in Global Negotiations and Concerns

India is signatory to many international treaties in matters of the environment, health, trade, etc. It has been a party to the UNFCCC since 1992 and ratified it in 1993, and acceded to the Kyoto Protocol (KP) in 2002. The Indian government has also specified development policies and priorities that reflect the concerns expressed in the millennium development goals and its commitment to the Rio Declaration, 1992 on Agenda-21, the UN Millennium Summit, 2003, Johannesburg Summit on sustainable development and Delhi Declaration, 2002.

Under the 'flexibility mechanism' of the Kyoto Protocol, Clean Development Mechanism (CDM) projects (Article 12) to be

Table 3: Renewable Energy Sources Potential

Source/Technology	Units	Potential/ Availability	Potential Exploited Till March 31, 2002
Biogas plants	Million	12	3.52
Biomass-based power	MW	19,500	537.17
Efficient wood stoves	Million	120	35
Solar energy	MW/Sq Km	20	1.74
Small hydro	MW	15,000	1,519
Wind energy	MW	45,000	1,870
Energy recovery from waste	MW	1,700	25.25

Source: GoI 2003: 763, GoI 2004:238-39.

undertaken by Annex B country in non-Annex B country, must advance the sustainable development goals of the non-Annex B country and support climate change mitigation activities. India is concerned about getting fair compensation for its sink projects, ensuring real transfer of technology, getting sufficient additional funds and avoiding bilateral transactions. The Annex B and non-Annex B countries will definitely benefit from an emission-trading regime but the gains to non-Annex B countries from participation in GHG mitigation might vary from \$6-29 billion, about 7 per cent to 20 per cent respectively of global gains [Painuly 2001]. To optimise their gains, non-Annex B countries need to actively participate in the design and implementation aspects of CDM. The ultimate goal of transfer of technology should be to enhance the capabilities of developing countries so that they can assess their needs, select one, import, adapt, and then develop the appropriate technologies at home to improve, build capacity and export them.

India is also concerned that its 6.17 per cent of its forest area is prone to severe fire damage, which would cost the country US\$ 100 million [IFFN 2000]. Carbon-neutral and fire prone forests may become a liability under land use, land use changes and forestry (LULUCF-Article 3). If better options of land use are made available in the future, the opportunity cost of blocking our limited land into forests may be much higher than removal units (RMUs) earned through sink projects. Carbon prices are not standardised, and they differ on a project basis. A drop in the price of carbon may question financial viability of CDM projects. Therefore, the KP needs to set minimum support prices (MSP) on a project basis, sufficiently above than non-Annex B country's marginal abatement cost, so as to provide for a transfer of resources from the north to the south, if the mechanism aims for this at all [Gupta 2003].

Regulation

Constitutional and legal requirements have been used to get standards and norms compliances for a greener India. A variety of legislations, policies and programmes have been formulated by GoI for the protection and preservation of the environment. A list of some of the environmental legislation is given in Annexure 1. Constitutional amendments are made from time-to-time to incorporate increasing environmental concern into development programmes. Various national policies such as the National Forest Policy, 1988, National Water Policy, 1987 and 2002, are all important moves towards ensuring the path of sustainable development. The National Climate Change Policy is due to be announced. But sometimes the monitoring and enforcement of these legislations have been constrained due to the lethargy of the courts, poorly funded pollution control boards, low penalties for non-compliance, regular and widespread corruption, lack of technical, financial and managerial capabilities.

V Conclusion

Global climate change has emerged as a threat to sustainability. In the absence of adaptation and mitigation strategies climate change can seriously damage agriculture, water resources, forests, coastal areas and health, etc, in the Indian economy. 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. The quality of development would provide an insurance against the impact of climate change and increase adaptive capacity. India has realised that more rigour in efforts today might avoid its reduction commitment in the next commitment period of the Kyoto Protocol and it has therefore initiated domestic efforts for enhancing adaptive capacity and mitigating GHG emissions. However, there is a long way to go to achieve the desired results. An adequate focus on institutional arrangements to devise suitable incentives and disincentives is needed. Community action is also necessary to have bargaining capacity, build social pressure on the polluter and force the regulatory body to respond to the problem quickly and more responsibly. Environmental issues can be addressed by using cost-effective market based instruments, particularly with respect to monitoring and enforcement, directing CDM projects in energy-intensive industries, and using nuclear power and renewable resources in production operations, etc.

India should be alert, active and assertive in its global participation and ask for risk minimisation in the south, over the much-hyped cost minimisation of GHG mitigation in the north. Responsibility should not be shirked in the name of affecting the economy or the provision of equal per capita rights. ■■■

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Annexure 1

Environmental Legislation In India

- (1) The Water (Prevention and Control of Pollution) Cess Act, 1977
- (2) The Air (Prevention and Control of Pollution) Act 1981
- (3) The Environment (Protection) Act, 1986
- (4) The Indian Forest Act, 1927
- (5) The Public Liability Insurance Act, 1991
- (6) The National Environment Tribunal Act, 1995
- (7) Energy Conservation Act, 2001
- (8) Electricity Act, 2003
- (9) The Biological Diversity Act, 2002
- (10) The Prevention of Cruelty to Animals Act, 1960
- (11) The Indian Wildlife (Protection) Act, 1972
- (12) The Batteries (Management and Handling) Rules, 2001
- (13) The Municipal Solid Wastes (Management and Handling) Rules, 2000
- (14) The Recycled Plastics Manufacture and Usage Rules, 1999
- (15) The Chemical Accidents (Emergency Planning, Preparedness and Response) Rules, 1996
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