Climate Change and Development

CLIMATE CHANGE: INDIA'S PERCEPTIONS, POSITIONS, POLICIES AND POSSIBILITIES

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FOREWORD

In January 2001, the OECD held an expert seminar as part of a pilot project to investigate interactions between the long term agenda for climate change and sustainable development strategies. Experts from both OECD and developing countries attended. Participants identified issues and approaches, based on their regional perspectives, relevant to an evolving, equitable regime for addressing climate change, given various national circumstances, political interests, institutions and capacities to achieve sustainable development objectives. They stressed the importance of both climate mitigation and adaptation policy within a sustainable development framework.

Discussions and presentations centred around two broad themes:

- Synergies and trade-offs between sustainable development objectives and long-term strategies to limit climate change.
- How to build analytical and implementation capacity in developing countries to maximise synergies at local, regional and global levels of decision-making.

To support seminar discussions, the OECD commissioned several papers (including this one) from non-OECD country experts; authors were asked to comment on key interactions between climate change and sustainable development from their own regional or national perspectives. This paper is being released as an informal working paper in the hope that it will continue to stimulate interest and discussions on these topics in other fora.

The paper expresses the opinions of the author(s), and does not necessarily represent the views of either the OECD or its Member countries. Comments on the paper may be provided directly to the author(s): jp@igidr.ac.in

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I. INTRODUCTION

The threat of climate change that led to the Framework Convention on Climate Change (FCCC) at Rio, is perceived differently by different countries. This fact has delayed any effective international agreement on how to deal with the problem. In the case of the Montreal Protocol covering ozone-depleting substances, there was a wide consensus and effective action was mobilised quickly. Thus, an understanding of perceptions and positions of different countries makes it easier to explore possibilities of effective action. In this paper, we present India's perceptions on the problem of climate change and sustainable development; the kind of negotiating positions that follow from these perceptions; the policies India has undertaken so far and finally India's possibilities for action that can help contain the threat of climate change.

2. CLIMATE CHANGE: PERCEPTIONS

2.1 Unsustainable Consumption Patterns

Unsustainable consumption patterns of the rich industrialised nations are responsible for the threat of climate change. Only 25% of the global population lives in these countries, but they emit more than 70% of the total global CO_2 emissions and consume 75 to 80% of many of the other resources of the world (Parikh et.al., 1991). In per capita terms, the disparities are also large: an Indian citizen emits less than 0.25 tonnes of Carbon per year whereas a citizen of the USA, for example, emits more than 5.5 tonnes. Parikh et. al. (1991) emphasise the need for an equitable and efficient solution to climate change and suggest that efficiency can be obtained through a system of tradeable emission quotas and equity through equal allocation of global environmental space to all human beings.

These findings were well received by developing countries and are echoed in the UNFCCC, which recognised the rights of developing countries to economic development and also the "common but differentiated responsibilities" of different countries.

2.2 Methane Emissions and Subsistence Emissions

Another theme of Indian analysts has been the lack of reliability of GHG emission estimates, particularly of methane. According to initial estimates, large emissions of methane from paddy fields were ascribed to developing countries. However, the empirical basis of these estimates was questioned; subsequently experimental measurements by Indian researchers showed these doubts to be well-founded (Mitra, l992, 1996). Moreover, Agarwal and Narain (1991) argue that emissions by poor who live on the margin of subsistence should be considered a basic human right and should not be counted when ascribing responsibilities for emission reduction.

2.3 Why should India be Concerned about Climate Change?

Indians should be concerned about climate change since this phenomenon might have substantial adverse impacts on them. Not all possible consequences of climate change are yet fully understood, but the three main 'categories' of impacts are those on agriculture, sea level rise leading to submergence of coastal areas, as well as increased frequency of extreme events. Each of these pose serious threats to India.

However, these are long term issues. The overriding immediate concern for India should be the fast pace at which negotiations are taking place on the climate front. India's main energy resource is coal. With the threat of climate change, India is called upon to change its energy strategy based on coal, its most abundant resource, and to use other energy sources (e.g. oil, gas, renewables and nuclear energy) instead, which may turn out to be expensive. Thus, an immediate issue is to come up with a better negotiation strategy such that we have more freedom to decide which type of energy we use, how we generate power, how to reduce methane emissions by agricultural practices or forestry and so on. Negotiations are important for us as a means to reduce or postpone future vulnerability by getting the developed countries to reduce their emissions.

2.4 Risk of Lower Agricultural Production

The FCCC objective states that GHG concentrations should be stabilised at levels where food production is not threatened (UN, 1992). Thus, by examining the impact on agriculture of different climate change scenarios, one can get an idea of what is tolerable. Rosenzweig and Parry (1994) have estimated significant adverse impact on the agriculture of many developing countries. In a more detailed study of India, Kumar and Parikh (2001a and 2001b) examined the impact of climate change on agricultural crop yields, GDP and welfare. Considering a range of equilibrium climate change scenarios which project a temperature rise of 2.5^oC to 4.9^oC for India, Kumar and Parikh (2001a) estimated that: (a) without considering the carbon dioxide fertilization effects yield losses for rice and wheat vary between 32 and 40%, and 41 and 52%, respectively; (b) GDP would drop by between 1.8 to 3.4%. Their study also showed that even with carbon fertilization effects, losses would be in the same direction but somewhat smaller. Using an alternative methodology Kumar and Parikh (2001a) showed that even with farm-level adaptations, the impacts of climate change on Indian agriculture would remain significant. They estimated that with a temperature change of +2°C and an accompanying precipitation change of +7 %, farm level total net-revenue would fall by 9%, whereas with a temperature increase of +3.5°C and precipitation change of +15%, the fall in farm level total net-revenue would be nearly 25 %.

For a developing country, these are very large changes which can cause much human misery. From India's point of view, a 2°C increase would be clearly intolerable. Other developing countries may be even more vulnerable (possibly Bangladesh or Small Island States).

2.5 Risk of Sea Level Rise

Large-scale emigration from coastal zones is expected due to submergence of coast-lines after sea levels have risen. This will create large numbers of environmental refugees especially from low-lying delta regions in poor countries. Furthermore, intrusion of sea-water in the ground water and changes in temperature can reduce agricultural and fishing incomes. Countries dependent on coastal fishery and agriculture, which most often include developing countries, are likely to be adversely affected.

If a one-meter sea level rise were to take place today, it would displace 7 million persons in India (ADB, 1995). In the future many more may be displaced. 35% of the land in Bangladesh would be submerged by a one-meter rise. The estimates for costs to build walls along the zones vulnerable to sea level rise for the USA is $107 billion in 1989 prices (Yohe, 1990). That may be a small share of the GDP of developed countries , but such measures, even scaling for their coast lines, for say, Bangladesh, could require a very large share of its GDP. Who shall pay Bangladesh or India for such a wall? Given that these countries are unlikely to be able to pay for protective measures, tens of millions of people will be displaced in Bangladesh and many of them could spill over into India.

2.6 Risk of Extreme Events

Increased occurrence of extreme events due to climate change will also affect the poor most. In the cyclone in Andhra Pradesh in India in 1996, more than 1,000 people died and there was huge property loss. Cyclones of similar intensity in advanced countries like the U.S. may not lead to any deaths and much hardship, due to stable and durable housing and other infrastructure and extended safety net available to the people in distress.

2.7 The Costs of Changing Energy Strategy

If India has to reduce its carbon emissions, it would mean a major reorientation of her energy strategy, especially if that warranted a shift from its current coal-based to a oil and gas based energy system. Murthy, Panda and Parikh (2000) estimated costs associated with a low GHG energy strategy in terms of foregone income and welfare of the poor. They examined the consequences of alternative CO_2 emission reduction strategies on economic development and, in particular, the implications for the poor by empirically implementing an economy-wide model across India over a 35-year time horizon. A multi-sectoral, inter-temporal model is used for this purpose. The model has specific technological alternatives and endogenous income distribution with dynamic behaviour; it covers the whole economy in an integrated top-down-bottom-up model.

The results show that CO_2 emission reduction imposes costs in terms of lower GDP and higher poverty. A 30% CO_2 reduction over a period of 30 years using annual emissions reduction targets leads to a fall in GDP of 4% and raises the number of poor by 17.5% in the 30th year (that is, if 2000 were taken as the baseline, these changes would occur by 2030). Cumulative emission reduction targets are, however, preferable to annual reduction targets and an optimum strategy where the country is free to decide when to reduce emissions as long as over 30 years the same amount of cumulative emissions are reduced. It reduces the hardship of emission reductions with a cumulative reduction target of 30% (i.e. not specifying annual targets), the fall in GDP is 1.4% and increase in the number of poor is 6% in the 30th year both of which are less than in the case of annual reduction. The scenarios involving compensation for the loss in welfare are not very encouraging, as they require large capital inflows. The required minimum compensation to maintain welfare levels is $278 billion for annual reduction and $87 billion for cumulative reduction respectively. The payments are large, and are concentrated in the early years of the period concerned. A more realistic strategy would call for compensation payments which are spread out over the years even though it may require larger total inflow over the years.

Contrasted with these, scenarios involving tradable emission quotas give India an incentive to be carbon efficient. It becomes a net seller for the first 25 years, say up to 2020, if the quota are in the range of 1 ton per person as per 1995 population. Because of the reduction in carbon intensity due to the incentives provided by tradeable quota, less is emitted in later years when India becomes a net buyer. The results suggest that for India, and other developing countries, the window of opportunity to sell carbon quotas is only in the next two decades or so. Thus, precious time is lost during prolonged negotiations.

3. PROFILE OF INDIA'S EMISSIONS FROM AN INPUT-OUTPUT MODEL

Parikh and Gokarn (1993) put in the first effort to identify India's emissions profile by using an input-output model. They aggregated the 1979-80 table into 40 sectors. These input-output coefficients are updated by the Planning Commission at least every 10 years. Subsequently, the 1989-90 table was available some time in the early nineties and was used by Murthy et al (1997a, 1997b) to study the structure of CO_2 emissions where one looks at the coal, oil, gas and electricity rows that cut across different sectoral columns multiplied with the level of activities. We studied emissions

- From different sectors: power, steel, transport and so on.
- By different expenditure groups, rural, urban, low, middle and high income.
- For different purposes: different fuels (coal, oil and gas).

The results are as follows:

a) Figure 1 gives emissions by sectors and shows that the power sector accounts for 48% of emissions, followed by road transport (10%), iron and steel (10%) and so on. This gives an idea which sector will be affected if, say, a carbon tax was levied on them or which sectors offer possibilities for large reduction in emissions, if modernised [Parikh J. et al (1997)].

b) Figure 2 shows direct and indirect emissions in the final demand, where the measure for indirect emissions takes into account both direct emissions and the emissions arising from the production of inputs and the production of inputs required to produce the inputs and so on (e.g. construction components for the case of construction and the materials required to produce those components and so on). Surprisingly, the construction sector is the highest even though the energy used for construction at the site is very small. This is because energy intensive materials such as steel, aluminium, bricks, cement, glass, lime and so on are used in contribution.

Figure 1. Direct CO_2 Emission: India, 1989-90

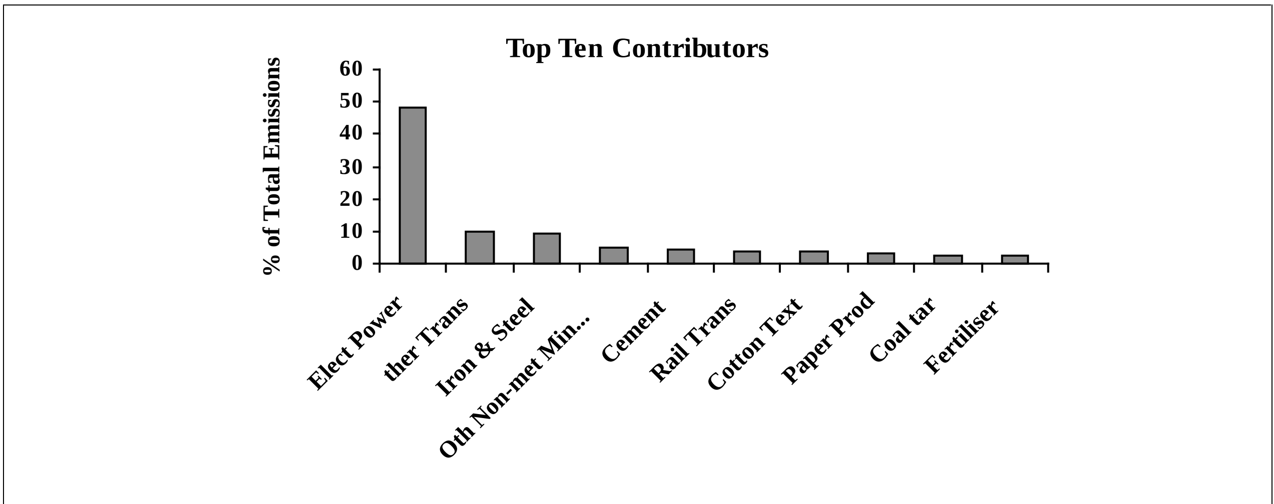


Figure 2. Direct + Indirect CO_2 Emissions: India, 1989-90

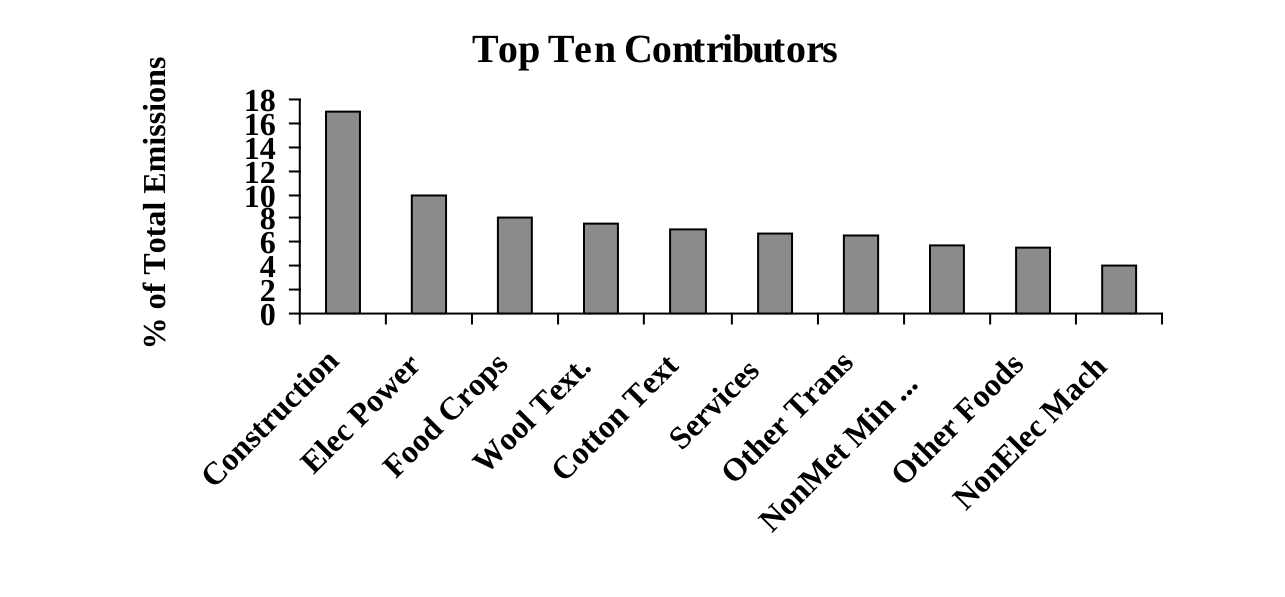


Table 1 shows the proportions of intermediate and final uses of energy from different sources. Almost all coal is used for intermediate purposes which means that the full burden of a carbon tax will not fall on the consumers if rationalisation of production processes or efficiency improvements are cost effective. On the other hand, 30% of oil and 20% of electricity are used for direct consumption in carbon using sectors. A carbon tax or price changes could matter to the consumers directly either in terms of costs or adjustments.

Table 1. Structure of Energy Demand 1989-90

	Intermediate	**Final**		**Total (Magnitude)**
		Household	Government	
Coal	99%	1%	-	218 mt
Oil	70%	25%	5%	54mt
Electricity*	80%	13%	7%	210 000 Gwh

- **Energy use occurs mostly at the intermediary stage. Hence, Input-Output Analysis is suitable.**
- **Inter-industry linkages are also captured.**
-

* Excl. auxiliary *consumption* And power T&D losses ~30% of total supply.

Table 2 shows the distribution of direct and indirect consumption of coal, oil and electricity by different rural and urban income groups and their corresponding carbon emissions. It can be seen that the bottom 50% of rural people emitted in 1990 a mere 54 kg of carbon per person per year. The richest 10% of urban people emitted 12 times as much at 656 kgC per person per year, which is still way below the world average of 1.1 t and much below the average emission in developed countries. This is not surprising if one sees Table 3, which shows that the per capita expenditure of even the urban top 10% income group is only about $1000 in 1990.

Table 2. Per Capita Annual Energy Use (Direct and Indirect) 1989-90*

Income Group	Coal (kg)	Oil (kg)	Elec (Kwh)	Carbon (t)
Rural				
Bottom (50%)	74	22.5	95	054
Middle (40%)	127	39.7	152	093
Top (10%)	262	89.8	284	204
Urban				
Bottom (50%)	130	45.6	164	101
Middle (40%)	302	118.6	366	246
Top (10%)	765	332.3	858	656
EDR[@]	10.3	14.8	9.0	12.0

* Excluding. Energy used directly and indirectly to make deliveries to other than demand for private consumption.
@ Extreme Disparity Ratio – Urban top / rural bottom

Even the projected emission for 2020 show, Table 3, that the bottom 50% of rural population would emit a mere 60 kgC per person per year and the top 10% in urban areas 795 kgC. Their projections assume an annual growth rate of per capita real income of 3.5 %.

Table 3. Per capita expenditure and carbon emissionsa by income classes in India

Income classes	Emission intensity: Kg of Carbon per Thousand Rupees[b] of Expenditure (at 1990 prices)	Per capita expenditure Rupees[b] (At 1990 prices)		Per capita emissions (kg of Carbon)	
		1990	2020	1990	2020
RURAL					
Bottom (50%)	30.6	1764	1964	54	60
Middle (40%)	30.3	3168	3503	95	106
Top (10%)	31.4	6688	9345	209	293
URBAN					
Bottom (50%)	33.2	2739	3122	90	103
Middle (40%)	35.2	6226	6922	218	243
Top (10%)	36.3	16273	21901	590	795

[a] Direct and indirect carbon emissions due to private consumption of respective classes. Per capita emissions due to other elements of final demand like government consumption and investment is not included.
[b] 1 US$ ≈ Rupees 17 in 1990.
Sources: Murthy et al. (1997a) and Murthy et al. (1997b)

The stark reality is that the poor contribute very little to global carbon emissions as they have a life below subsistence level and they essentially use biofuels for cooking.

4. MITIGATING CLIMATE CHANGE AND PURSUING SUSTAINABLE DEVELOPMENT: EXPLOITING THE SYNERGY – WHAT HAS INDIA DONE TO REDUCE GHG EMISSIONS?

India has for quite some time pursued GHG friendly policies in her own interest. India's obligation to minimise energy consumption - particularly oil consumption - and to deal with its environmental problems prompt it to follow many such policies. Directly or indirectly these efforts are made by Government as well as by people to reduce energy consumption. These include: -

a) Emphasis on energy conservation.
b) Promotion of renewable energy sources.
c) Abatement of air pollution.
d) Afforestation and wasteland development.
e) Economic reforms, subsidy removal and joint ventures in capital goods.
f) Fuel substitution policies.

Some of these efforts are on-going for several decades and are institutionalised in a number of ways through policies, programmes and the creation of specific institutions. These are government efforts; in addition there are a number of measures taken by people themselves. Some because of resource-minimising cultural traditions as well as good practices that exist in India and some due to sheer poverty and deprivation. We discuss each of the above separately.

While some of the energy savings are due to conscious resource utilisation practices in a positive sense, the dark side has to do with human drudgery and deprivation. These include "compulsory (or perverse?) forced energy savings" by the poor due to deprivation. These range from

a) Lack of electricity connections and if connected, then a lack of electric appliances and even of adequate light bulbs in rural households.
b) Lack of piped water or pumps that require long trips by women and children on foot to obtain surface water.
c) Lack of even cooking fuels due to which the poor depend on biomass rather than clean and convenient fossil fuels.
d) Lack of fans and heating devices for a large percentage of households that are necessary for comfort and productivity.
e) Lack of basic infrastructure such as schools, hospitals, and roads that are essential elements for human development.

All of the above save energy at the cost of human welfare. Clearly, it is not recommended to continue the existing state of affairs

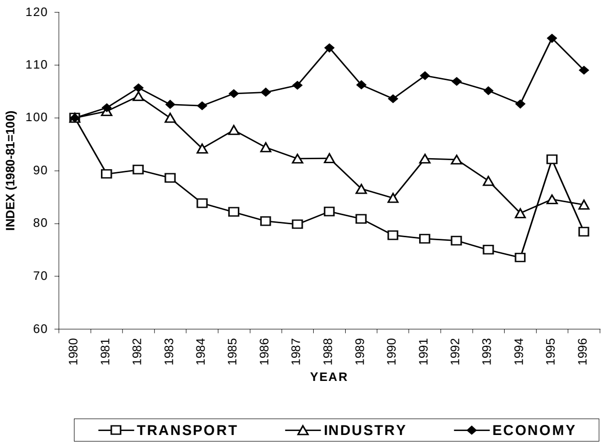
If India is committed to human development, poverty eradication should take place. This may result in an increased energy use. This may be considered a due right of the poor, even if it increases India's GHG emissions.

4.1 Energy Efficiency and Conservation:

Energy conservation and increased efficiency is gradually taking an important place in the energy and industry sector plan in India. As was noted earlier, the power sector is responsible for the highest direct CO_2 emissions in India (42%), followed by iron and steel, road, railways and air transport, and coal. (Parikh et.al 1993). Improving the efficiency of coal and electricity use could significantly reduce emissions from these sectors.

Tangible results of efforts to increase efficiency can be seen (Nag, B. and J. Parikh, 2000) in declining energy intensity for industry and transport sectors where many factors jointly contribute to such a result. Unfortunately, there is a marginal economy-wide increase in commercial energy intensity due to the substitution of non-commercial energy by commercial energy Non-commercial energy is not accounted for in the conventional energy statistics which are used to derive carbon intensities. Non-commercial energy is largely used for cooking and unorganised industries (viz., fuelwood, crop residues and animal dung). Its share is now reduced by increased use of commercial energy. viz., kerosene and liquified petroleum gas.(Figure 3).

Figure 3. Changes in Energy Intensity Index



Index Data Sources:
1. Coal Directory of India, (1993-94),Coal Controller of India, Ministry of Coal
2. Monthly Abstract of Statistic, (1992),CSO Ministry of Planning and Implementation
3. National Accounts Statistics, 1993-94, Economic and Political Weekly Research Foundation

4.2 Promotion of Renewable Energy

Apart from energy conservation and efficiency improvements, the need to find, develop and exploit non-conventional energy sources, many of them clean and renewables, has long been recognised by the Government of India. Due to the importance given to the subject, the activity started in the fifties under the Ministry of Science and Technology, grew into a separate department under the ministry of energy and then became a full-fledged Ministry of Non-Conventional energy sources.

An aggregate installed capacity of 2302 MW through various renewable energy sources, namely, wind farms, micro-hydroelectric plants, biomass & cogeneration power plants, biomass based gasifiers systems and solar photovoltaic systems was expected by the end of the eighth plan - 1992-1997. This is likely to reach to 6500 MW in the ninth plan - 1997-2000. By the end of the eighth plan about 2.6 million family size biogass plants ($3M^3$ each) 25 million improved cooking stoves that use less fuelwood, about 390,000 [M^2] solar thermal collector area and 430,000 solar cookers had been cumulatively installed. Expected energy generation and energy savings from these renewable energy systems come to about 26.3 million tons of wood equivalent, which amounts to a significant 12 to 15% savings in total wood consumption.

4.3 Abatement of Air Pollution

Efficiency-enhancing measures in fossil fuel use may lead to the dual benefits of both local air pollution abatement and GHG emissions abatement. Pollution levels are prescribed for vehicles and have recently been made mandatory to reduce urban pollution. As a consequence, the transport sector is gearing up to face the challenges of urban air pollution by providing for more energy efficiency in vehicles. In addition, air pollution regulations result in higher fuel quality, which in turn lead to reduced GHG emissions. For example, improved gasoline can make vehicles run more efficiently.

It is difficult to say how much GHG can be saved due to such pollution control measures. Estimates indicate it to be in the range of 10 to 15% up to some point: say 2015 by which time the current stock would be largely replaced by the new vehicles. Then future reduction will be significant only if still stricter norms are followed at a later stage.

4.4 Afforestation and Wasteland Development

It is estimated that land-use change in developing countries could contribute to global emissions to the extent of 1.6 billion tonnes of carbon. However, indicators from India show that India's share of this contribution is minimal.

Biomass is widely used even today in India for a variety of purposes including fuel, timber and feedstock. Concern for the consequences -- degradation of woods and forests and consequent degradation of soils -- was expressed as far back as 1974 (Fuel Policy Committee, 1974). More recently, programmes for afforestation have found support from both governmental as well as non-governmental organizations. These programmes aim not only to halt deforestation but to increase green cover. Table 4 shows that various agencies spend as much as Rs.50 billion (US$1.25 billion) per year on wasteland development. If all the efforts at afforestation were to succeed, India's net emissions of CO_2 could come down significantly. In the nineties, the rate of deforestation has slowed considerably, if not marginally reversed as shown by recent satellite imagery (MOEF, 1995).

Table 4. Spending for Wastelands Development (1995).

	Rs. Million/year
Ministry of Rural Areas and Employment including Department of Wasteland Development	12500
Ministry of Environment and Forests	9060
Ministry of Agriculture and Cooperation	3620
Planning Commission	2600
National Bank for Agriculture and Rural Development (NABARD)	500
State Soil Conservation Departments	3410
State Land Development Banks	11060
Private Investments (unconfirmed)	7250
Total	50000

Source: Report of Task Force on Wastelands Development in the IX Five Year Plan, May 1996, Ministry of Rural Areas and Employment, Government of India, New Delhi.

A little more than 23% of India's total geographical area of 329 million hectares is recorded as forest area. Another 75.5 million hectares is considered as waste land defined as "degraded lands which can be brought under vegetative cover with reasonable effort …"

The area under forests as opposed to under forest department, and changes in it are shown in Table 5.

Table 5. Forest cover: holding forth but barely

Forest category	**1981-83**		**1995**	
	Million hectares	**As % of total geographic area**	**Million hectares**	**As % of total geographic area**
Recorded forest area	75.13	22.8	76.52	23.4
Actual forest area	64.20	19.52	63.96	19.45
Dense forest (crown density >40%)	36.14	10.99	38.57	11.73
Open forests (crown density 10% to 40%)	27.65	8.41	24.93	7.58
Mangroves	0.40	0.12	0.45	0.14
Scrub land (crown density < 10%)	7.67	2.34	6.05	1.84
Uninterpreted	1.15	0.35	0.0	0.0
Non-forest area	255.74	77.79	258.7	78.70

Source: Forest Survey of India (1988 and 1996).

There is much scope for carbon sequestration through improving the quality of forests and regreening wastelands. Such afforestation programmes are also desireable to arrest soil degradation, to improve soil fertility, to provide renewable fuel timber and non-timber forest products as well as to provide livelihood to millions of poor people.

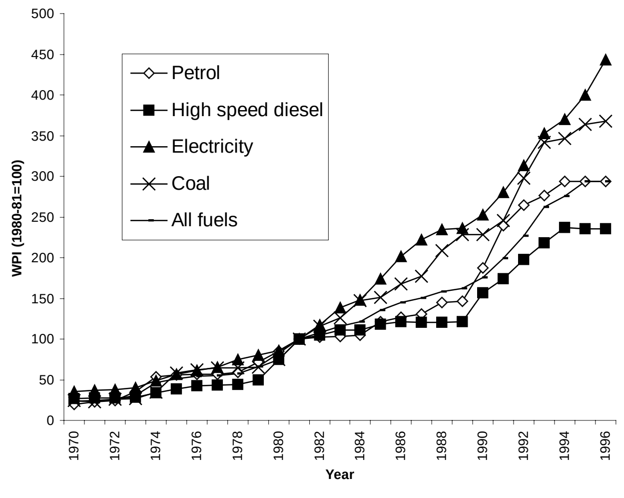
4.5 Price Reforms, Subsidy Removal and Joint Ventures in Consumer Goods

Under the recent economic liberalisation policy of the Government, the private sector – including domestic and foreign investors - is seeking entry into the energy supply sector, be it coal, oil, gas or electricity. This means that the old subsidy regime is gradually giving way to rational prices. For example, coal, electricity diesel are no longer cheap and under priced.

The time series data for the prices of important energy forms is shown in Figure 4. (Recently, there have been further increases which are not shown in the figure). Prices of electricity (most of which is coal based) and coal have shown the highest increase in percentage terms from 1983 onwards, despite abundance of coal in India. It is interesting to see that the rise in the electricity prices is larger than that of gasoline or total fuels.

Moreover, due to import liberalisation, the Indian economy is now exposed to the rigours of competition and efficiency upgrades. Joint ventures in consumer goods such as cars, refrigerators have resulted in a range of consumer goods being more energy efficient. Indian consumers are exercising their choices in the "buyers market" and showing preferences for energy efficiency. For example, prior to liberalisation in the nineties only 2 or 3 models of cars were available, which were essentially reproduction of models of the fifties and sixties. They were not fuel-efficient. Now, the consumers can choose among 10 to 15 reasonably priced models (and some luxury models). The same holds for consumer appliances such as televisions, refrigerators, air-conditioners where more choices are available. Although consumer awareness for green production is not very high, there is concern for mounting energy bills.

Figure 4. Prices of Fuels and Electricity

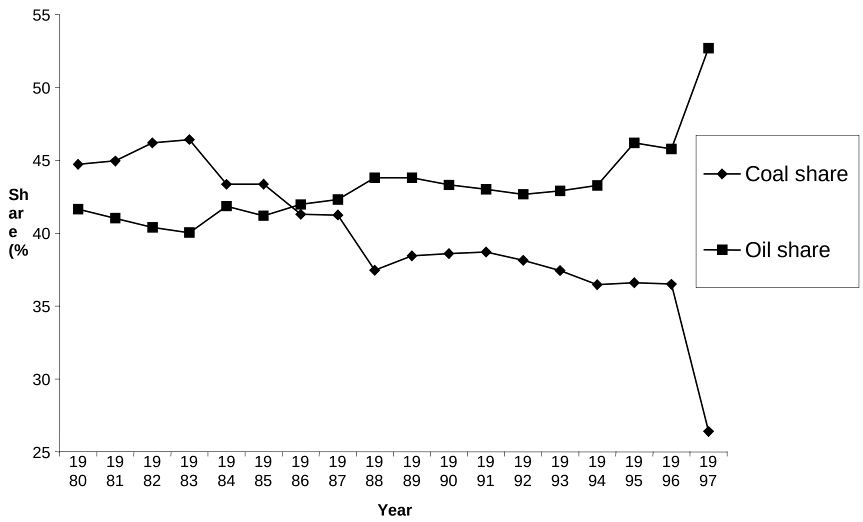


Source: Wholesale price indices, Office of Economic Advisor, 1995, GOI.
* Average prices charged to consumers in India.

4.6 Fuel Substitution

A major advance is in the area of coal substitution. First of all, due to liberalisation, use of oil and gas is permitted more freely compared to the days of controlled planning. Coal was initially the mainstay of commercial energy and use of oil and gas was not allowed for some sectors. More recently, many sectors have switched to the use of fuels other than coal. For example, the power sector is permitted to use natural gas. Coal-based fertiliser plants no longer function and coal use in railways is almost phased out. Figure 5 shows that due to consumers' preferences for clean and easily available fuel, oil is preferred in part because the distribution infrastructure for petroleum is better.

Figure 5. Changing Shares of Fuels in the Economy



Data Sources:
1. Coal Directory of India, 1993-94,Coal Controller of India (Ministry of Coal), Calcutta
2. Indian Petroleum and Natural Gas Statistics, 1993-94,(Ministry of Petroleum and Natural Gas), New Delhi

5. ISSUES IN CLIMATE CHANGE:

India should be an active and decisive partner, along with other developing countries, in climate change negotiations. We need to ask:

- What concentration levels, along with the associated risks, are acceptable to developing countries?
- How could it be ensured that the risks to the developing countries, and not just the costs to the developed countries, are minimised?
- If Annex-I countries postpone their commitments to reduce emissions, they use up limited carbon emission budgets available for future. How will it be available to the developing countries when they need it for their growth?
- How do we ensure that we have a fair share of the global environmental space?

The assumptions about greenhouse gas (GHG) concentration levels for stabilisation of atmospheric concentrations range from 450, 550 and even 1000 ppmv (for example, Wigley et.al., 1996). It should be noted that according to the IPCC third assessment report, increase of CO_2 concentrations in this range can lead to an equilibrium warming of between 2.0°C to 4.8°C (IPCC, 2001). The IPCC report probably specified a specific CO_2 concentration increase with which the warming of 2 – 4.8 degrees was associated? Each of these concentration levels permits different reduction strategies. Freedom to choose options is more limited in the case of 450 ppmv as carbon budgets are very low and therefore greater mitigation action is required in the nearer term. Integrated assessment models are currently being developed to consider these issues. Unfortunately, assumptions, premises and paradigms dictate the results of these models.

In the view of the authors, often the developed countries' perspectives are hardwired into the models in such a manner that even if many scenarios are generated, the basic theme and results do not change (J. Parikh, 1992). For example, these models focus on minimising costs to the developed countries and not the risks to the developing countries. Yet, the decision about what is an acceptable level of climate change should centre around the risks to the developing countries. In fact, the developing countries should have a greater say as they are more vulnerable to the impact of climate change, they have a very small share in the cumulated emissions and thus have less responsibility for the problem of global warming; they are also poor and their emission trajectories are likely to rise due to development. In no other environmental issue are large polluters given opportunities to decide what cost and efforts are acceptable to them without full consideration of the vulnerability of the others. The level of effort needed to address an environmental issue is decided on the basis of what is good for society. For climate change, this will depend upon what risks of climate change impacts are associated with different levels of emissions.

We have already discussed in the previous section some of the types of risks and cost implications of climate change for India. India is a large country with wide ranging soil climate and other natural conditions. The results for India are thus likely to represent developing countries as a whole. Such risks to poor countries should be the primary focus of the climate change analysis, rather than costs to the developed countries. To this extent, a paradigm shift is necessary from the cost-minimisation to risk-minimisation in the future analyses of IPCC.

Of course, the nature and extent of climate change and its impacts are uncertain. That, however, should not be grounds for inaction. We should find a way to deal with differing perspectives on uncertainty and risk. We offer a suggestion for this later.

5.1 Emission Reduction Responsibilities:

What are the implications of the differentiated responsibilities accepted under FCCC? If we look at the factors driving emissions, we get an idea. Parikh J (1994) modification of the Kaya identity states:

$$C = \frac{C}{E} \times \frac{E}{Y} \times \frac{Y}{N} \times N$$

Carbon Emissions	=	Carbon intensity of Energy systems	X	Energy intensity of GDP	x	GDP per Capita	X	Population

i.e.

Where C = Carbon emissions, E = Energy Use, Y = Gross domestic product and N=Population

It is clear that in the near future, population decrease or per capita GDP decrease are not plausible alternatives, especially for developing countries. Thus, carbon intensity of the energy system and energy intensity of GDP have to be also reduced to compensate for an increase in carbon due to an increase in GDP and population so as to reduce total emissions. The Parikh identity also suggests that in the long-term population reduction, GDP stabilisation and other such measures that may be considered drastic by today's standards, will be in the arena of desirable options, if the climate change problem turns out to be more serious than it appears today and if through technology development we are unable to decouple carbon from energy use. Parikh J (1994) gives a detailed plan about step by step reduction for both developing and developed countries.

To stabilise or reduce carbon emissions in a smooth transition, one has to proceed in steps. Thus, first reduce the rate at which carbon emissions are growing, then make this rate zero, i.e., stabilise carbon emissions and then make the rate negative, i.e., reduce emissions. These steps for Annex I and Non-Annex I countries would occur over different time periods. For example, fossil fuel growth rates in OECD countries used to be in the range of 3% to 7% in the 70s, which came down in the range of 0% or ± 1%. On the other hand, emission growth rates in developing countries increased until the 1990s, but are showing signs of deceleration in many major countries such as India and China due both to reduced population growth as well as to reduction in energy intensity of GDP (E/Y and to some extent in carbon intensities (C/E) due to substitution of coal with oil and gas) Yet these growth rates are at high level and further reduction in these growth rates is required after which they will also have to be stabilised of course, but that will take many decades. A possible "time table" of how the lead taken by Annex I countries could be followed up by Non-Annex I is indicated in Table 6.

Table 6. Implementing FCCC according to Differential Responsibility

Time Period	Annex I Countries	Non-Annex I Countries
Upto 1990	• Reduce Growth Rate	Unconstrained increase in emissions
1990-2000	• Stabilise emissions	Unconstrained increase in emissions
2001-2025	• Reduce emissions	Stabilise growth rate of emissions
2026-2050	• Reduce emissions	Reduce growth rate
Beyond 2050	• Further reduce to sustainable level	Stabilise or reduce emissions

C: Annual carbon dioxide emissions.
Source: Based on Parikh J. (1994)

This is a possible scenario. Carbon emissions in Annex 1 countries kept growing up to 1990 but at a decreasing rate. During the 1990's, emissions did not grow. From 2001 onwards, their emissions have to fall at an increasing rate. For non-Annex 1 countries, the table shows, carbon emissions will keep growing till 2050. The growth rate increases till 2000, remains stable from 2001 to 2025, and starts declining thereafter – becoming negative by 2050.

5.2 Discounting the Future

Behind the suggested reduction time frame in table 1, there is an implicit discount rate. It is often argued that the future generations would be richer and hence we can pass on the burden of emission mitigation on them. Some even suggested that they have to be similar to those used in any other investment strategy.

It is often argued by some Annex I countries that we should use a high discount rate in designing climate change mitigation strategies. In our view, this is not quite correct. Climate change, if it is permitted to happen, will impose a heavy burden on future generations in ALL countries not just on the citizens of Annex I countries. Even after 50 years, Indian nationals are likely to be poorer than those of the OECD are today. Thus, by not taking actions now the burden is transferred not just to rich citizens of the OECD of the next generation but also to poorer Indians of tomorrow who would be poorer than today's citizens of OECD. A low discount rate is more appropriate when assessing optimal mitigation strategies. Emission mitigation by Annex I countries is needed now.

5.3 Delay is Free Riding:

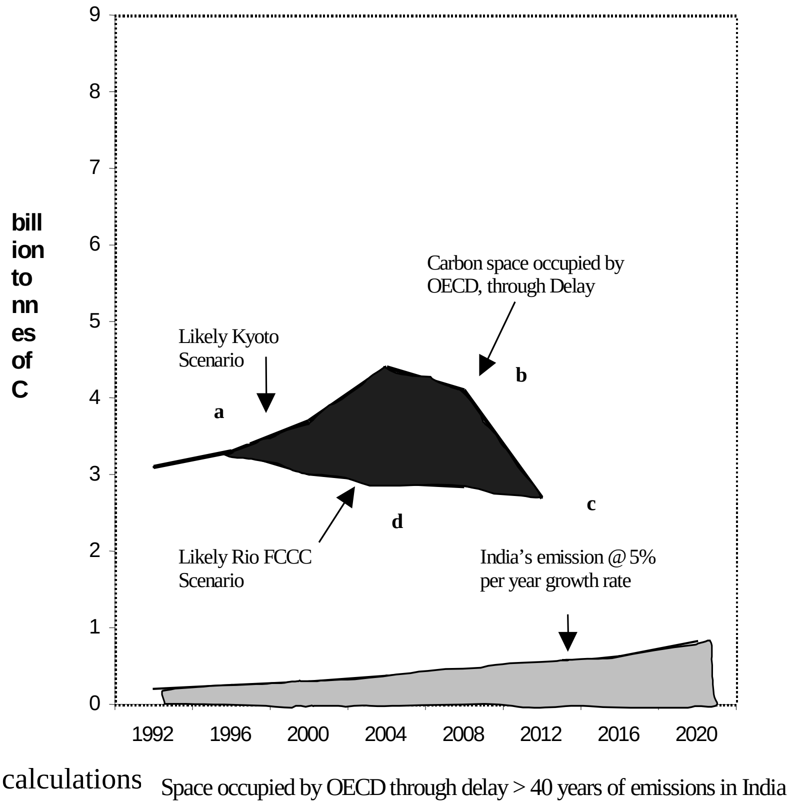
Despite the commitments made at Rio, the Annex I countries have taken little action to meet their commitments. At the Conference of Parties (COP) in Kyoto in 1997, too, Annex-I countries again delayed their commitments. On the whole the Annex-I countries are expected to reduce their emission by 5.2% in the next fifteen years over their 1990 levels. Of this, the USA is expected to reduce by 7%, the EU by 8% and Japan by 6%. Even what little they agreed has still to be ratified in their home countries. Annex-I countries need to take urgent actions through a consensus-building exercise to engage local decision-makers.

Through delays, rich OECD countries are occupying global environmental space. During 1990 to 2020 (during which period they were supposed to act, haven't acted and are not likely to act) OECD countries would have emitted more than India would emit in the next 30 years, assuming a 5% increase in India's GHG emission every year. This is seen in Figure 6.

Point a shows the present emission level, and point c the target emission level in the year 2010. The objective is to go from point a to point c. Path abc is the path that is likely to be followed if OECD countries were to fulfil their Kyoto obligations. Path adc, is the likely path of OECD emissions had they taken their FCCC commitment made at Rio seriously. While both the paths reach the same level, path abc puts much more CO_2 in the atmosphere. The shaded area shows the additional CO2 OECD countries have emitted and it would lead to higher temperature rise.

One can recognise that this delay is costing India and other developing countries opportunities to develop in the future. Through delay OECD countries are further occupying global environmental space, and since Kyoto they have asked for even more of a delay. Delaying Kyoto is really reneging on Rio.

Figure 6. Delayed Action Occupies Global Environmental Space



Source: Authors' calculations

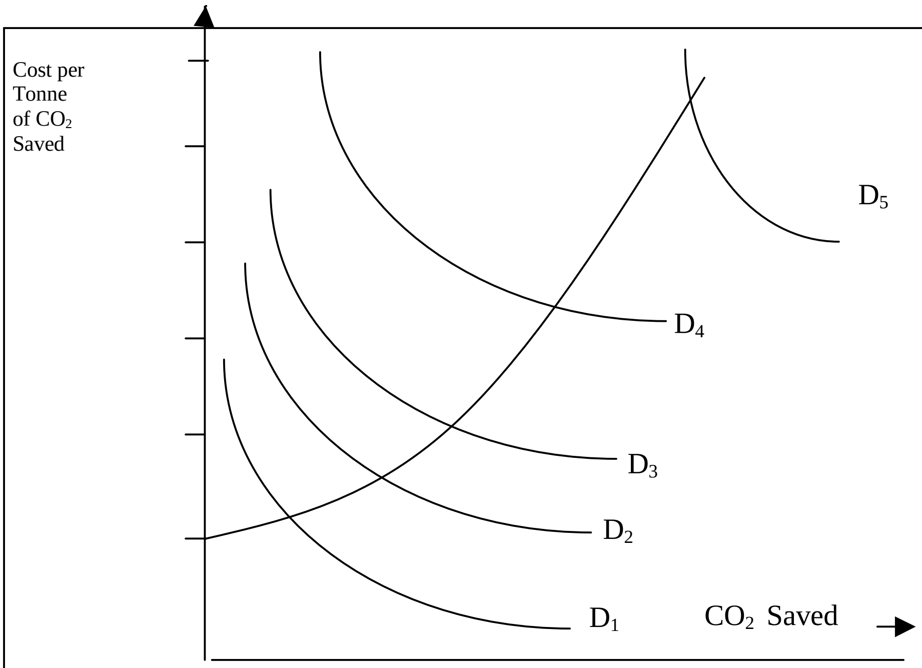
To discourage free riding during the negotiation period and beyond, we suggest that countries are accountable for their own emissions for a specific period, say after 1990 or 2000. That is, whatever decisions are arrived at, will be applicable retroactively from, say, 2000. That is, the clock starts ticking and all emissions are cumulated for each country even during negotiations. This way, negotiations will conclude faster and policy actions to reduce emissions will begin soon. Regardless of the outcome of the negotiations, these emissions will be shown against each country and that much less will be available to them in future. Thus, the countries taking actions in advance get their rewards and procrastinating countries will have to do more later.

5.4 Mitigation Costs and Benefits:

Reluctance to take action now implies a faith in technical progress to effectively deal with climate change later. This is a risky strategy which the poor and vulnerable will find hard to accept. Technical progress sometimes brings with it unanticipated consequences. When CFCs where introduced, they were hailed as a great technical innovation – but, as it known now, they had the side-effect of leading to ozone depletion. Thus, relying on technical solution alone can be risky. If dramatic technical progress does not take place, life style changes are inevitable if we want sustainable development.

Also if you recognise the benefits, the costs of mitigation would not look too high. Figure 8 shows this. It shows a mitigation supply curve and a set of mitigation demand curves. If one is interested primarily in removal of distorting subsidies then D_1 may be the demand curve. If in addition, the society cares to control local air pollution, the relevant demand curve would be D_2, and so on to D_5 , which adds an ethical dimension on species loss. A society's willingness would improve with greater awareness of its citizens. All countries need to put in efforts to increase it.

Figure 7. Benefits Justify Mitigation Cost



Demand for Abatement	If primary concern is
D_1	Removal of distorting subsidies
D_2	D_1 + local air pollution
D_3	D_2 + local externalities e.g. congestion
D_4	D_3 + ecosystem damage
D_5	D_4 + species loss

5.5 The CDM – A Step towards Equity?

The Clean Development Mechanism (CDM) proposed in the Kyoto Protocol offers developing countries finance and technology by allowing Annex-I countries to offset emissions through investing in emissions reduction in non-Annex-I countries. Apart from the generally recognized problems of appropriate determination of the base line, India's concerns relate to getting fair compensation for sink projects, ensuring real transfer of technology and an uneasiness about selling 'low hanging fruits', i.e. the exploitation of cheap emissions reduction early on in the process by developed countries.

5.5.1 Look Before you Leap – Sink Projects through CDM

It is generally believed that the sink projects such as growing trees for afforestation and so on are some of the most attractive options. India has some 100 million hectares of wasteland and degraded forests on which such projects may be started. However, several major considerations may be important.

a) The trees fix carbon only during the growing periods. After reaching maturity, they are carbon-neutral. Thus, the carbon sink projects can create liabilities for the host country through committed land use.
b) If at the end of maturity forests are removed, it may appear in the statistics of land use change of India. If the wood is burnt, will the CO_2 generated be the liability of India?
c) If the forests are left intact, it may have implications if the opportunity costs of land become high in the meantime. However, only if the country had taken a careful long term decision to create green cover on a permanent basis, may such projects be considered. In the cases where the forest is removed or burnt, the global environment does not benefit as it would have merely postponed the problem. The liabilities are reduced only if energy crops are grown that will replace fossil fuels, for example, for wood based methanol, or wood-based power generation. However, who claims the credit, the one who supported the plantation or the one who uses it to replace fossil fuels?
d) Another difficulty relates to the measurement of carbon sequestered. This is not an easy task. All kinds of fudging are possible and there would be incentives to do so. One may also note that afforestation projects involve very little technology and hence very little technology transfer. Technology transfer is claimed to be a major advantage of the CDM.

5.5.2 Technology Transfer (TT) and CDM

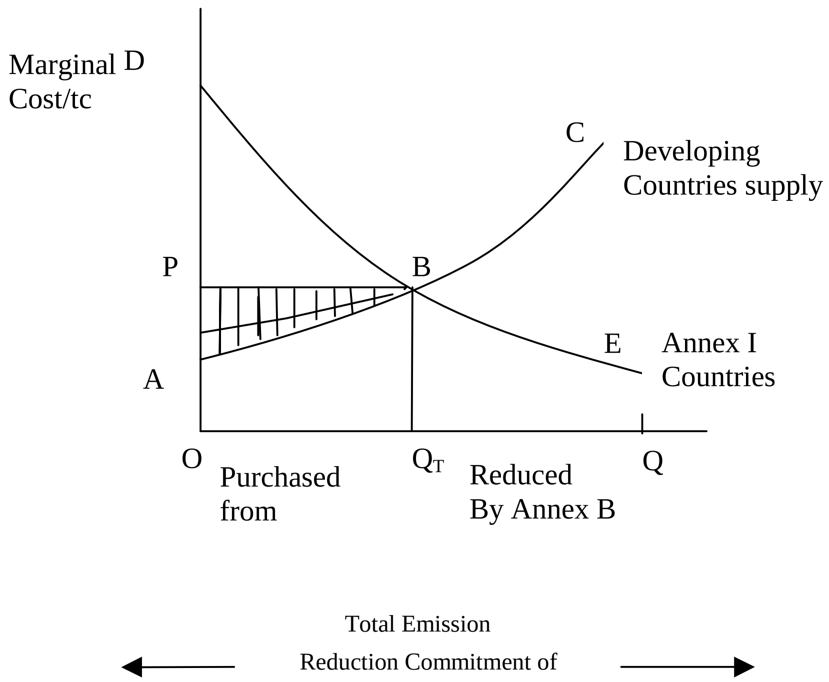
TT and CDM should be linked to ensure wider adoption of environmentally beneficial technologies beyond the CDM project. **India would like to see that a "CDM project" leads to real technology transfer giving the country the ability not only to operate the technology but also to replicate and innovate.**

Another concern of India is pricing of technology. There should be competition here. In a bilateral deal, the supplier of technology has monopoly power and the price charged for technology may be too high. Also projects such as sequestration projects do not involve technology transfer. One way to ensure that CDM projects involve technology transfer at competitive prices is to require that every CDM project, including sequestration projects, make a specific contribution to a technology acquisition fund with which the developing country is free to buy technology not necessarily related to the CDM project, from anywhere in the world. This can moderate excessively high charges for technology from a monopolist supplier.

5.5.3 Low Hanging Fruits and Pricing of Carbon

When carbon is traded, what developing countries gain would depend on whether the market is competitive, whether futures markets exist, or whether the carbon is bilaterally traded in a project-by-project basis, as is envisaged under CDM. Figure 10 illustrates who gains what from trading.

Figure 8. Carbon Trading : Who Gains What?



- Under a competitive market at B, Q_T will be traded at market price P
- Developing Countries would get producer surplus of AB/P
- Annex B countries will get consumer surplus of PDB
- In a bilateral project by project negotiation developing countries are likely to get only AA^1B. (see text)

As the developing countries have many low-cost opportunities to save GHG emissions (the low-hanging fruit) their marginal cost curve is relatively flat. Painuly (2000) has argued that developing countries are likely to get only about 20 % of the total surplus even under a competitive market.

Should the developing countries then not opt for such trading? That would be an erroneous conclusion. If technical progress in the future lowers the demand drastically these low-hanging fruits would bring developing countries even less in future. The low-hanging fruits would then appear to just have rotten. And in any case, since everybody tends to discount the future, money now is better than the same amount of money in future. However, developing countries can use these low-hanging fruits themselves in the future. So their long term opportunity cost may be higher than the short run marginal cost. To account for such opportunity costs, we should insist on the development of a futures market, so one can know how much the low-hanging fruits are going to be worth in the future.

India is concerned that in bilateral negotiations between project parties, Indian entrepreneurs might only look at their private gain and sell carbon at throw-away prices, getting only AA'B in figure 5. Developing countries should resist such trade. A well functioning market along with a futures market is the best way to ensure a good price. Development of such a market will take time. Meanwhile, a global carbon price floor should be announced for emissions trading and all developing countries should not trade below this price. India may want to do so unilaterally for its own projects.

5.6 Towards a Comprehensive Early Agreement:

Disappointing delays in the implementation of the Kyoto Protocol lead us to suggest a system where all countries should be accountable for their cumulated emissions, say after 1990. When final negotiations are concluded, those countries that have taken early action will be rewarded and the others will have to do a lot more later. We suggest the following:

- Despite the uncertainties surrounding climate change, the risks of potentially adverse impacts on the food system, coastal zones and increased occurrence of extreme events should be avoided by early action.

- Even during the negotiation period, an immediate decision to work from cumulative emissions for each country from a given year, say 1990 or 2000, should be taken. That is, whatever the final negotiated strategy, it will be applicable from the agreed reference year in the past to reward early actions by any country and perhaps to conclude negotiations faster. Delay to implement such a system only rewards current high emitters who do not take action to reduce emissions.

- Suppose we agree to limit climate change to 2°C of temperature increase. To give countries some leeway to deal with uncertainties involved and their differing perspectives of risk, countries must be held accountable for the damages caused due to their cumulative emissions over the most pessimistic scenario (i.e., one which restricts the atmospheric CO2 level to the lower value for such a temperature increase). However, a country may be permitted to emit up to their quotas as per the scenarios they consider reasonable. *Over time with research and better understanding of the global climate system the uncertainty will reduce and estimates of* the range of emissions *required* to restrict warming to 2°C will narrow. Participating countries would be held responsible for the emissions that correspond to narrowed range. For greater flexibility quotas should be leaseable. There are many desirable consequences of such a system. It will optimise response and reduce free-riding through delay. We have observed that the cost of delay in emission reduction (by the North) in terms of the South's foregone opportunities to development is substantial. This will impose many constraints on the way the South decides on policy options regarding issues such as how to generate power, how to use land, and what crops to grow and so on. Moreover, the South is highly vulnerable to the impact of climate change. Hence, unless the North acts now, North-South transfers of large amounts will be needed to compensate the South for the development opportunities foregone or for direct economic losses stemming from climate change.

- The risks to poor countries should be the primary focus of the climate change analysis, rather than costs to the developed countries. To this extent, a paradigm shift is necessary from the cost-minimization in the future analyses of IPCC.

6. SUMMARY AND CONCLUSIONS:

Our main arguments are as follows:

- India and other developing countries feel strongly that they are not responsible for the threat of climate change that has been created. Unsustainable consumption patterns of the rich industrialised nations in the world are responsible for it.

- Yet, India and other developing country economies may be highly vulnerable to climate change. India's food production would be adversely affected. Sea level rise would displace a large number of people. The developing countries are particularly vulnerable to the likely increase in the incidence of extreme events. The impacts of climate change could hinder development and delay progress in eradicating poverty, potentially aggravating social and environmental conditions in these countries.

- An analysis of India's emissions show that its per capita emission of carbon is one fourth of the global average. Even the top 10% of urban population emits well below the global average per capita emission.

- India, and other similar types of developing countries, are making significant progress in limiting GHG emissions through normal policy developments such as those aiming to improve energy and economic efficiency of the energy and industrial production capacity, as well as energy development, both conventional and renewable, which target improved environmental quality and limit human health hazards from air pollution.

- India's energy intensity in industry and transport sector has come down. It has installed 2300 MW of generating capacity based on various renewables. Deforestation is arrested and the vast potential of afforestation on wasteland is increasingly utilised.

- India and many developing countries have carried out price reforms and removed subsidies. These have resulted in substantial energy savings and reduction in emissions through greater use efficiency and fuel substitution.

- An equitable climate regime will focus on limiting the risks from climate change impacts to poor developing countries rather than on limiting the costs of mitigation per se. Options that improve economic efficiency of mitigation also need to address the distribution of economic costs associated with climate change. Such a system needs to be guided by a better understanding of the potential economic impacts and other risk to developing countries which emanate from the climate change problem. One must also recognise the need for economic growth of developing countries.

- With differentiated responsibility, Annex I countries have to take the lead. For a smooth transition, they should first stabilise their carbon emissions as soon as possible and then reduce them to sustainable levels over the coming decades. Emission of developing countries will need to grow even at increasing rates for some time. They would have to stabilize them somewhat later in the future and then reduce them.

- Unfortunately, Annex I countries are delaying action. By their delay, they are occupying global environmental space and are free riding on developing countries. Compared to the carbon emission that OECD countries would have made had they followed the FCCC agreed on at Rio, they have emitted much more. In fact, even if they were to meet the Kyoto targets by 2012, the additional emission of OECD countries between 1992 and 2012, exceeds the emission India is likely to make over 40 years assuming a 5% growth rate of emission.

- Delay cannot be justified on the ground that the future generations would be richer and should, therefore, bear higher costs of mitigation. Annex I countries should use a low discount rate when assessing optimal mitigation strategies as postponing action now would put a larger burden of future population of developing countries – who would be poorer than what the citizens of Annex I countries are today.

- If countries recognise the environmental, societal and ecosystem benefits of mitigation and value them properly, it would justify incurring large mitigation costs. We need to increase awareness of citizens.

- One promising option for organising mitigation over the long term is to hold countries accountable for all emissions from some fixed date in time, say 1990 or 2000. This provides incentives for early conclusion of negotiation.

- The CDM could be risky for developing countries because of perverse incentives to exaggerate valid credits (e.g. through exaggerated baselines) and because of likely imbalances in the power among the investor and host parties who will need to negotiate about important variables (e.g. type of project, baseline, credit sharing and possibly price or other terms of reference for the investor). To equitably share the gains from CDM projects, we may start with fixing a global carbon price floor.

- A major attraction of the CDM for developing counties is technology transfer. However, carbon sequestration projects do not involve any significant technology. Also the price at which monopolist suppliers provide technology may vary. We suggest a technology acquisition fund in which every CDM project, including sequestration project, is required to make a contribution to technology funds with which technology catering to specific needs of developing countries can be developed (for example, 2 wheelers transport with 4 stroke engines or certain cheap cooling equipment). Moreover, the developing country should be free to choose technology, not necessarily from the country that brings the CDM project, but from anywhere in the world.

- A more interesting option over the longer term could be to go to a fully fledged emission trading system, which would increase the economic efficiency of long term mitigation and, if emission quotas are allocated in an equitable way, begin to compensate developing countries for any costs that significant mitigation might impose on their developing economies.

- Many persons in India and other developing countries are concerned about selling off their cheap mitigation options (the 'low-hanging fruits'). One should weigh the price one gets today, the worth of such fruits in the future and the possibilities of their 'rotting' if unused.

- The need for an approach to mitigating the threat of climate change that is equitable and one that can accommodate differing perspectives on risk need to be elaborated. To initiate action now even with differing perspectives of uncertainties and risks that different countries have, we suggest a scheme where a global trading system of carbon emissions with futures market is introduced. The allocations of quotas are made on an equitable basis. However, the total quota will depend upon each country's subjective trajectory that restricts global temperature change to a desired limit, say 2°C. Countries, however, are responsible for their cumulative emissions in carbon-ton-years that they have made and the range of permissible trajectories narrows as our knowledge and understanding improve.

7. CONCLUDING REMARKS

In the context of the current debate about climate change, it is necessary to show that far from being inactive, the developing countries, especially India, are taking considerable actions in terms of policies, programmes and projects.

Technology transfer can speed up the modernisation process and additional funds can accelerate Government initiatives in energy conservation. However, policies for poverty alleviation must take priority.

It is shown that savings in GHG emissions by the poor should not be expected at the expense of development. Yet, other savings by developing countries can be increased by technology transfer, investment in better infrastructure, and efforts for modernisation, all of which require financial support. Encouragement to conservation and good practices would result in lower emissions. Far from free riding, low GHG emissions in developing countries have made it possible to sustain the high pattern of energy consumption by the industrialised countries for decades in the past, at present and in the future too.

REFERENCES

Asian Development Bank (1995)
Climate Change in Asia, Article by V. Asthana.

Bolin B., (editor), (1995)
IPCC Guidelines for Estimating National Greenhouse Gas Inventories, Vol. I, II and III, published by UNEP, OECD, IEA and IPCC, 1995.

Carbon Dioxide Information Analysis Center (1993),
Trends '91 *A Compendium of Data on Global Changes*, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Cline W.R. (1992)
Economics of Global Warming, Institute of International Economics, Washington D.C.

Forest Survey of India (1988)
The state of forest report 1987. Forest Survey of India, Dehra Dun.

Forest Survey of India (1996)
The state of forest report 1995. Forest Survey of India, Dehra Dun.

IPCC, (Intergovernmental Panel for Climate Change), (1992)
The First Assessment Report, Cambridge University Press, Cambridge.

IPCC, (Intergovernmental Panel on Climate Change), (1996)
The Science of Climate Change, Vol. 1 of Climate Change 1995: IPCC second assessment report, Cambridge University Press, Cambridge.

Kumar, K.S. Kavi and Jyoti Parikh, (1997)
"Potential impacts of global climate change on Indian agriculture", presented at the workshop, Measuring the impacts of Climate Change on Indian and Brazilian agriculture, held at the World Bank, Washington D.C., 5-7 May.

Kumar, K.S. Kavi and Jyoti Parikh, (1998)
"Climate change impacts on Indian agriculture: The Ricardian approach". in Dinar et.al., Measuring the impacts of Climate Change on Indian Agriculture, World Bank Technical Paper No.402, 1998.

Kumar, K.S.Kavi, Parikh, J., 2001a.
'Socio-economic Impacts of Climate Change on Indian Agriculture', *International Review for Environmental Strategies*, 2(2).

Kumar, K.S.Kavi, Parikh, J., 2001b.
'Indian Agriculture and Climate Sensitivity', *Global Environmental Change*, 11, pp. 147-154.

Manne, A.S. and Richels, R.G., (1993)
Buying Greenhouse Insurance, Cambridge, Mass: M.I.T. Press.

Mitra A.P. (Ed.), (1992)
Global Change: Greenhouse Gas Emissions in India – 1991 Methane Campaign, Scientific Report No. 2, NPL, Publication and Information Directorate, CSIR, New Delhi, India, June 1992.

Mitra A.P., (Ed.) (1996)
Global Change Greenhouse Gas Emission in India – Methane Budget Estimates from Rice Fields based on Data available upto 1995, Scientific Report No.10, Publication and Information Directorate, CSIR, New Delhi, India, July 1996.

Murthy, N. S., Manoj Panda and Jyoti Parikh (1997a)
"Economic Development, Poverty Reduction and Carbon Emissions in India", *Energy Economics*, Vol.19, No.3.

Murthy, N. S., Manoj Panda and Jyoti Parikh (1997b)
"Economic Growth, Energy Demand and Carbon Dioxide Emissions in India: 1990-2020", *Environment and Development Economics*, Vol. 2, No. 2 (forthcoming).

Murthy N.S., Manoj Panda and Kirit Parikh, (2000)
"CO2 Emissions Reduction Strategies and Economic Development of India", IGIDR Discussion paper.

Nag, Barnali and Jyoti Parikh (2000)
Indicators of Carbon Emission Intensity from Commercial Energy Use in India, *Energy Economics*, Vol. 22, pp. 441-461.

National Accounts Statistics, 1993-94
Economic and Political Weekly Research Foundation.

Painuly J.P. (2000)
"Kyoto Protocol and Voluntary Commitments: What are the Risks to Developing Countries" Invited Paper, International Symposium on Development Policies for the New Millennium in Honour of Professor Kirit S. Parikh, IGIDR, July 12-14, 2000.

Parikh Jyoti, and Gokarn S. (1992)
"Climate Change and India's Energy Policy Options:New Perspectives on Sectoral CO2 Emissions and Incremental Costs", Global Environmental Change, Sept. 1993.

Parikh Jyoti and Gokarn S., (1993)
Climate Change and India's Energy Policy Options, *Global Environmental Change*, Vol. 3(3), 276 - 291.

Parikh Jyoti (1992)
"IPCC Response Strategies Unfair to the South", *Nature*, Vol. 360, pp. 507-508, 10th December.

Parikh Jyoti, (1993)
"Joint Implementation and Sharing Commitments: A Southern Perspective". *Proceedings of a workshop held on Oct. 16-18, 1994 on Integrated Assessment for Climate Change* at International Institute for Applied Systems Analysis (IIASA), Laxenburg, Austria.

Parikh Jyoti, (1994)
"North-South Issues for Climate Change", *Economic and Political Weekly,* pp.2940-2943, November 5-12.

Parikh Jyoti, (1998)
"Linking Technology Transfer with Clean Developoment Mechanism (CDM): A Developing Country Perspective", Presented at Columbia University.

Parikh Jyoti, and Kirit Parikh (1998)
"Free Ride through Delay: Risk and Accountability for Climate Change", *Journal of Environment and Development Economics,* Vol.3, Part 3, 1998.

Parikh Jyoti, Kirit Parikh, Subir Gokarn, J.P. Painuly, Bibhas Saha and Vibhooti Shukla (1991)
"Consumption Patterns: The Driving Force of Environmental Stress", IGIDR prepared for the United Nations Conference on Environment and Development (UNCED), IGIDR Monograph.

Parikh Jyoti, Roy Culpeper and Davis Runnalls, J.P. Painuly (Eds.), (1997)
Climate Change and North-South Cooperation, Tata McGraw Hills Publishing Co.Ltd., New Delhi.

PCRA Report (1994),
A Pursuit with a Purpose, Petroleum Conservation and Research Association, New Delhi.

Reddy B.S. and Jyoti K. Parikh, (1997)
"Economic and Environmental Impacts of Demand Side Management Programmes", *Energy Policy*, Vol.25, No.3.

Report of Task Force on Wastelands Development in the IX Five Year Plan (May 1996)
Ministry of Rural Areas and Employment, Government of India, New Delhi.

Rosenzweig, C. and M.L. Parry. 1994
"Potential impact of climate change on world food supply", *Nature*, 367(6450), pp.133-138.

Schelling, T.C. (1993), Nakicenovic et.al (ed),
Proceedings of a workshop held on Oct. 16-18, 1994 on Integrated Assessment for Climate Change at International Institute for Applied Systems Analysis (IIASA), Laxenburg, Austria.

Sundaraman N., (1997),
Reference Manual and Workbook of the IPCC 1996, Revised Guidelines for National Greenhouse Gas Inventories, Published by IPCC, 1997.

United Nations (1992)
Framework Convention on Climate Change, United Nations, New York.

Wholesale price indices, Office of Economic Advisor, 1995, GOI.

Wigley, T., R.Richels and J.Edmonds, (1996)
"Economic and evnironmental choices in the stabilization of atmospheric CO2 concentrations", Nature, 379, pp.240-243.

World Bank, (1992)
World Development Report (1992), World Bank, Washington D.C.

Yohe, G., (1990)
"The Cost of Not Holding Back the Sea", Coastal Management, 18, pp.403-431.

