REPORT ON GLOBAL WARMING AND ASSOCIATED IMPACTS

(PHASE II)

TATA ENERGY RESEARCH INSTITUTE
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ADAPTIVE STRATEGIES FOR INDIA IN THE PERSPECTIVE OF CLIMATE CHANGE

Dr. Ajay Mathur
Mr. O.N. Kaul
Ms. Amrita N Achanta
Ms. Sujata Gupta

Global warming is expected to result in the following climate changes by the middle of the next century:

(a) Increase in mean annual temperature of the order of 0.5 to 3°C, and increase in soil moisture by 5% (in winter) to 10% (in summer).

(b) Increase in discharge of glacier-fed rivers by 8 to 50% during peak flow periods.

(c) Increase in mean sea level by 20 to 55 cms.

The possible impacts of these changes would increase energy demand because of higher temperatures and because of the adaptive control strategies adopted, increased soil erosion and flooding due to increased peak flows of glacier-fed rivers, decreased biomass productivity, and submergence of coastal areas.

The consideration of climatic change response strategies presents immense difficulties as the information available to make correct policy options is inadequate because of the scientific uncertainties regarding, (i) the magnitude, timing, rate and regional consequences of potential climatic change; (ii) how effective specific response options or groups of options would be, in actually averting potential climatic change; and (iii) the costs, effects on economic growth, and other economic and social implications of specific response options or groups of options.

A prudent approach to climatic change would have to consider both Limitation and Adaptation Strategies, because even if concerted efforts are made, now, to limit emissions of GHGs through Limitation Strategies, some Adaptation Strategies would still be necessary. This is, firstly, due to the fact that climatic changes may be already under way as a result of past emissions into the atmosphere, and secondly, by the climatic changes that may occur before the options adopted under Limitation Strategy become effective.

It would, therefore, be necessary to consider Limitation and Adaptation strategies as an integrated package wherein the options adopted in the two cases compliment each other so as to minimise time and costs, should a significant adverse climatic change occur. In view of the scientific uncertainties and the difficulties of foretelling the effects of global warming,it is not possible to chalk out any precise strategies to counter such effects and we have to be content with some general strategies at present.

Adaptive strategies should, in general, aim at

(1) minimizing energy demand

(2) afforestation so as to minimize soil erosion and maximize absorption of surface water by the soil

(3) changes in cropping patterns and agricultural practices so as to minimize disruption to foodgrain production

(4) minimization to economic disruption due to sea level rise.

These strategies are discussed in some detail in the following pages.

Management of Energy Demand

Increased mean annual temperatures would lead to an increase in the demand of energy for refrigeration and cooling, as well as a decrease in the efficiency of most thermal and electrical devices owing to the higher ambient (sink) temperatures. However, increasing energy supply to meet this increased demand would lead to enhancement of the global warming phenomena owing to the increase in CO_2 emissions. Consequently response strategies would necessarily aim at increases in the efficiency of supply technologies and development of non-fossil fuel based technology (e.g., renewables). Similarly, energy efficiency and energy conservation on the demand side would be an essential component of the adaptive strategies. Efficiency in all sectors will have to be increased; major benefits accrue due to efficiency improvements in the vast and inefficient domestic energy sector and in the grossly inefficient transport sector.

Domestic Sector

The domestic sector accounts for nearly 40% of the total energy consumption in India, and about 80% of the total demand in rural areas. In the rural areas, 70-90% energy is consumed for cooking and water heating. Hence energy efficiency improvements in cooking play a critical role in managing rural energy demand. The main fuels used in rural areas for cooking are wood, crop residues and dung cakes; all of which are mostly collected. Presently in India, nearly 85 million rural households depend on biomass fuels for cooking.

These fuels are used in wood stoves with average efficiency of 8%. A major efficiency measure is the promotion of improved stoves.

The national programme on improved chullahs (NPIC) was initiated by the department of Non-Conventional Energy Sources (DNES) in December 1983. It is estimated that 4 million improved stoves were installed till 1988 at a cost of Rs. 287 million. Evaluation status have indicated that 50-80% installed improved stoves are being used at present with average fuel savings of about 25%. Given these statistics and an ultimate penetration of about 90% in the rural sector, some 70 million more improved stoves can be installed. These would result in an overall biomass saving of the order of 20 million tons. At present costs, this improved stove dissemination programme require an investment of nearly Rs. 7 billion in a comparatively short period of time.

In urban areas, biomass fuels continue to be an important source of household energy. However, unlike in rural areas where most of the fuel required is collected by the poor, the poor in urban areas have to purchase the biomass required. These fuels are burnt in low-efficiency devices as in the rural sectors. In recent years, the urban poor are being squeezed in the energy market since it is becoming increasingly difficult to obtain adequate amounts of biomass fuel, and the supply of kerosene is also inadequate, particularly in small towns. It is essential that firewood and imported kerosene are replaced as cooking fuel for the urban poor. An alternative is the development of smokeless coal-based fuels such as briquette or gasifier systems for producing coal gas. At present, briquetting and gasifier technology in India is obsolete and expensive. These technologies need to be imported and indigenously developed. At the same time, emphasis on the development of high efficiency briquettes stoves also need to be taken up. Because of the higher end use efficiency, coal briquettes and gas use would lead to a decrease in the total CO_2 emissions as compared to those from biomass burning.

Refrigeration and Air Conditioning

Increased temperatures would lead to increased demand for refrigeration and air conditioning. At present, efficiency in this sector is lower than international norms, but improving. However, the phasing out of CFCs would lead to a decrease in energy efficiency, but nevertheless a 50% decrease in energy consumption is possible with the technology available in the international market today. This would imply additional investment of the order of 25-40%. It is imperative that efficient technologies are imported in the country at the earliest.

Transportation Sector

Transportation sector is the most inefficient energy consuming sector in the Indian economy. Average energy efficiency is less than 20%: road transportation efficiency is of the order of 15% and that of rail transportation between 24 and 30%. In addition, road transportation also emits nitrogen oxides a major green house gas - whose control has to be addressed in response strategies as well. Currently, international road transportation efficiencies are of the order of 30%, and improving. This implies that the state of the art technology can already reduce energy consumption in this subsector by as much as 50%. It is estimated that the price of individual energy-efficient cars and trucks would increase by 10 to 25%. In the case of rail transportation, efficiency improvement to 50% is possible.

In India, the major decrease in transportation energy requirement would result from a shift from private to public transportation. This implies the establishment of an efficient, reliable and comfortable public transportation system in urban areas. The high capital cost of public transportation systems has been a major deterrent in their establishment. It is estimated an efficient, reliable and comfortable public transportation systems for the Delhi would cost about Rs. 7,000 crores. Other specific suggestions include the development of urban buses (present buses are built on the chassis of long-distance trucks), and research and development towards commercialisation of electric vehicles, especially solar powered electric vehicles.

Industry

Industry (including thermal power generation) consumes about 45% of the total energy consumed in India. The average efficiency of thermal power generation (which alone amounts for about 50% of the energy used in this sector) is 28%. Of the other 50% of the energy consumed in this sector, roughly two-thirds is in the form of thermal energy (primarily for steam raising), while the remaining one-third is electric power (primarily for electrical drives such as motors). The average boiler efficiency is roughly 60%, while average motor efficiency is about 70%. Internationally the efficiencies for thermal power generation, steam -raising boilers, and electrical motors are in excess of 35%, 75% and 85% respectively. In general therefore, increases of the order of 7 to 10% are possible.

In the case of thermal power generation, advanced boiler design as well as new coal utilization technologies are required. In addition, better operation and maintenance of existing stock, and retrofits on aged boilers can lead to an increase of 2 to 3% in the overall efficiency. The major constraint is the lack of capital for renovation and retrofits, as well as for normal operation and maintenance. This is related to the pricing policy, as well as capital availability. International technology transfer in the long terms would be desirable for the power sector. In the short term availability of cheap capital for renovation and retrofits would go a long way in increasing the efficiency. However, the most important single factor is to place the electrical utilities on a sound fiscal basis.

Most steam raising boilers in India are 20-30 years old, and utilize outdated (stoked boilers) technology. However, in recent years, several Indian companies have started manufacturing and selling high efficiency fluidized bed boilers with efficiencies in excess of 70%. It is estimated that nearly two-thirds of new orders for boilers in India are for fluidized bed boilers. In spite of the success of fluidized bed boilers in India, penetration is slow owing to replacement of a boiler only after it is totally decrepit. It would accelerate the process of penetration if policies for the availability of cheap capital for the installation of energy-efficient boilers are introduced.

Technology transfer in the area of energy-efficient motors is also essential. The design and materials of construction of these motors needs to be upgraded so as to achieve energy savings.

Afforestation

Forests, because they offer a greater carbon storage capacity than either grasslands or croplands, represent an important opportunity for any mitigation strategy. They also offer additional social benefits such as erosion control, aesthetics, wildlife habitats, watershed protection, pollution control, reducing temperatures and the like.

Forests are net source or sinks for carbon depending upon net changes in biomass. To the extent forests expand through either the existing forests becoming more productive by better management or establishment of new plantations, additional atmospheric carbon is sequestered, thereby moderating the built up of atmospheric CO_2.

Improved management of existing forests would result in increased biomass and hence in the sequestering of additional carbon. However, establishment of large scale plantations would be required to offset a significant portion of the additional CO_2 currently accumulating in the atmosphere. Although this endeavor may seem monumental in scope, it is probably the do-able and may be least costly to deal with global warming over the next few decades.

In view of the above the following policy options are suggested.

1/ Identify major flow routes for flood water of snow-fed rivers and carry out afforestation along these routes. This afforestation should be carried out in a manner which reduces the kinetic energy of water flow and increases its traverse time across any terrain. This will minimize soil erosion and maximize replenishment of ground water reservoirs.

2/ Promotion of research and development activities in species development technologies - selection and breeding and biotechnology which will make plant species more adaptive to changing climatic conditions. Existing tree and shrub species will have to be scanned for resistance/tolerance to GHGs with a view to use these species on large scale in critical areas.

3/ Development and implementation of policies to reduce deforestation and forest degradation and to ensure the health and sustainable management of existing forests in order to enhance CO_2 sinks.

4/ Establishment of large scale plantations (preferably of mixed species) in conjunction with a dramatic decrease in the rate of deforestation, to be used as a mechanism to postpone the build-up of CO_2 and thus delay global warming.

5/ Conversion of marginal agricultural land to forests to enhance CO_2 sequestering.

6/ Reduction in forest biomass burning through improved and proper fire management practices and widespread use of alternative sources of energy to fuelwood.

7/ Encourage agroforestry and development management systems which may be less vulnerable to climatic change. Agriculture and forestry plans should be integrated in such a manner so that it reconciles the demands on our forests for expansion of agriculture.

8/ Develop inventories, data bases, monitoring systems and catalogues of the current state of resources and resource use and management practices through an all India coordinated schemes for making a realistic assessment of the problem and for arriving at realistic policy options to be adopted.

9/ Strengthening and enlarging protected natural areas and establishing conservation corridors to preserve biological and genetic diversity and to enhance the adaptation prospects for various ecosystems.

10/ Increased emphasis on the development and adoption of technologies - silvicultural and management and genetically improved trees - which may increase productivity or efficiency per unit area of land, consistent with sustainable economic growth and development to foster more carbon fixation, besides affecting high genetic diversity and high productivity.

11/ Increased promotion and strengthening of resource conservation and sustainable resource use, especially in highly vulnerable areas.

12/ Developing management system whereby the local population and resource users gain a stake in conservation and sustainable resource use.

13/ Increasing forest protection through incorporation of strategies for fire, insects and diseases into future management plans and through development of silvicultural practices and stress management strategies.

Agriculture

Climate change is likely to result in a significant impact on agriculture and related areas. It is important to consider what measures could be taken so as to respond to such a change. These measures would increase the ability of society and the ecosystem to adapt to a climate change. Given the scientific uncertainties of potential climate change, uncertainty regarding effectiveness of strategy adopted and uncertainty of both economic and social implications, policy decisions remain difficult.

While considering options, some of the aspects which must be considered are justifiability of adoption of option for reasons other than climate change, cost effectiveness, flexibility, sustainable development and the particular needs of the developing countries.

Some of the options which could be considered are:

Plant Genetic Improvement

According to the General Circulation Model predictions, it is expected that apart from an increase in carbon dioxide concentrations, a temperature rise of 1-4.5°C is likely. An average increase of 8-11% precipitation is expected globally, although the distribution of rainfall will be uneven.

This change in global climate will have an effect on agriculture due to:

1) increase in CO_2 concentration
2) changes in temperature
3) changes in the amounts and distribution of rainfall in different regions and in different seasons
4) changes in river flow
5) submergence or salinization of coastal areas and
6) increased ultra-violet radiation.

Such a climate change is likely to necessitate the development of cultivars which are better suited to the altered climatic conditions.

Development of heat and drought tolerant cultivars should be included in plant breeding objectives for the region. Plants which show a greater yield in response to higher CO_2 levels must be identified. Development of rice varieties with longer grainfilling period at temperatures 1-2°C warmer than present day temperature needs, to be undertaken by plant breeders.

Since salinization and flooding of coastal areas is one of the likely adverse effects of global warming, research to develop salt resistant varieties of important crops grown in these regions should be a priority area.

The germplasm collections for most of the important crops and the number of varieties tested under the All India Coordinated project trials are large. Suitable varieties may therefore, be available and identified for their suitability in the event of a climate change.

Water Resource Management

Development of methods of water storage and conservation, particularly in the case of areas where rainfall is likely to be lower. This must be considered although most general circulation models predict an average 8-11% increase in precipitation, rainfall distribution is likely to be uneven.

The impact of global warming is likely to be less if water and fertilizer inputs are increased. An extension of areas with irrigation and higher fertilizer use must be an integral part of the plan.

Future Research

The effect of global warming on the monsoons is uncertain since temperature is one of the sixteen different factors which influence the south-west monsoon. The study of this area is of major importance. An increase in riverflow particularly of the snow-fed rivers, due to increased melting of snow, and greater precipitation in some regions is likely to lead to the necessity for flood control in several regions.

Minimization to Economic Disruption Due to Sea Level Rise

The various stages in adaptation of a response to sea level rise (SLR) are:

1. Assessing the vulnerability of an area to a sea level rise. As it is not possible to protect the entire coast line, it is necessary to prioritize areas which are more vulnerable to a SLR. For this an index of vulnerability can be established.
2. Research of the various adaptative options. Possible adaptation measures to combat sea level rise include

- construction of sea wall/flood barriers
- national flood insurance programme
- construction of reservoirs to combat increased salinity
- abandonment of developed regions in low lying area
- relocation of population away from vulnerable areas
- protection of coastal eco-systems and development of marine environments.

3. Choosing between alternative responses. The rise in the relative sea level and the consequent impacts are region or location specific. Thus, the response strategy is site specific and will depend on the resources, socio-economic characteristics of the region. For example, for Bangladesh, given the pressure of population on land, relocation of population may prove to be a difficult measure.

For a developing country like India with limited resources to adopt technical responses, natural resources to mitigate the effect of a potential, sea level rise seems a more viable option. Thus, eco-systems in the inter-tidal zones need to be taken into account when alternative development strategies are being considered.

4. Implementing the response. This will require a strong institutional set up and new/modified legislative measures.

Strategies for coastal zone management can be classified as follows:

1. Retreat - shift of people and eco-systems landward
2. Accommodation - continued habitation of the threatened area through adaptative measures like construction of flood shelters, buildings on elevated platforms, development of fishponds instead of agricultural fields, promotion of salt resistant species etc.
3. Protection - protecting land from sea by constructing dikes, bulkheads etc., through beach nourishment and nurturing of the natural vegetation. Marine environments besides having a commercial role also protect the coast by reducing the vulnerability of the coast line to erosion, storm surges and coastal flooding.

Wetlands. Regulatory protection alone cannot achieve the goal of zero net loss of coastal wetlands. A retreat strategy where the wetlands are allowed to migrate landwards as the sea level rises should not allow permanent development or 'hardening' of uplands in which wetlands would be expected to migrate if sea level rises.

There are two aspects to coastal zone planning:

1. An assessment of area which should be allowed to develop; those which should be sterilized; those which should be armoured by structural defenses and those which should be up- graded because of existing conditions that increase its vulnerability to sea level rise.
2. An assessment of coastal activities which are more vulnerable to sea level rise. It is necessary to assess the coastal dependency of human activity and classify them as "essential", "most desirable", "desirable", "beneficial", or "immaterial". Only "essential" activities should be promoted in threatened zones. "Most desirable" to "beneficial" should be evaluated, using the conventional criteria of feasibility, and cost effectiveness. For example, in a coastal area prone to greater erosion from SLR, the policy should be avoid siting a coast-dependent activity which is vulnerable to erosion but is not amenable to adaptation or retreat.

Thus it is necessary to consider the interaction between marine ecosystems and coastal uses and assess their impacts in the event of a SLR. The problem is then one of a choice between an optimal mix of preservation and development (or planned exploitation). The criterion of maximization of net present value of social returns from the area should be used to arrive at a decision.

Types of Adaptive Options

One can identify three main categories of responses to the SLR problem. These could be titled : (a) Biological (b) Technical (c) Institutional. Biological responses would concentrate on developing alternatives to lost or threatened resources and habitats or on enabling the development of species that are more tolerant to the changed environment. The emphasis in this set of responses would be to assist the ecological systems to adapt to an environment that changes faster than their natural ability to adapt to it. Technical responses are essentially engineering solutions and involve the building of structures that will protect the coast from submergence and overtopping. Such responses involve both 'hard' and 'soft' engineering options. Dikes, groynes, bulkheads, etc. are examples of the former. Beach nourishment is an example of the latter. The third category of responses is institutional. As information about SLR increases, coastal users and uses are allowed to respond to the potential threats either naturally or by the use of legal and policy means.