CLIMATE CHANGE & 12th FIVE YEAR PLAN

REPORT OF SUB-GROUP ON CLIMATE CHANGE

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Introduction

In July 2011, the Steering Committee on Environment, Forests & Wildlife and Animal Welfare for the Twelfth Five Year Plan of the Planning Commission formed a Sub-Group on Climate Change (as part of the Working Group on Environment & Climate Change). The Sub Group was asked to make recommendations on climate change for the 12th Five Year Plan, based on review of the existing programmes, policies and initiatives taken for adaptation and mitigation, including regulatory mechanism, research and development, infrastructure and institutional mechanism. The notification appointing the Sub-Group, its composition and its Terms of reference (ToRs) are annexed.

This was later supplemented by the "Approach to Climate Change" outlined by the Planning Commission in chapter V- Sustainable Management of Natural Resources of the Approach Paper for the 12th Five Year Plan.

The Sub-Group held three meetings over a period of two months in July and August 2011 and deliberated upon various aspects of the matter in the light of the ToRs. In course of its deliberations, the Sub group held wide ranging discussions with the members of the Working Group as well as other experts, scientists and policymakers to gather views and inputs on relevant issues.

The WG noted that detailed assessment of vulnerability of various sectors to climate change, and its impacts have been carried out recently by the Ministry of Environment & Forests. Indian Network for Climate Change Assessment (INCCA) has carried out 4X4 assessments of various regions and sectors and also published a GHG inventory 2007. The WG relied upon these assessments reports and also the analytical studies taken up in connection with preparation of the Second National Communication on climate change for its conclusions. The WG also made use of the status papers prepared by the Expert Committee on Climate Change impacts in India and other such inputs received from the representatives of industry and other stakeholders as members of the Working Group.

The Report of the Sub Group is organised in nine sections. First section presents the environmental, social-economic and political context in which climate change is to be addressed in India. The overall approach recommended by the Sub Group is outlined in the second section. In the third section, assessment of vulnerability to climate change in six critical sectors, namely agriculture, water, forests & other natural ecosystems, coastal areas, health, and infrastructure including trade and industry are described. This follows by a discussion of the National Action Plan on Climate Change and its strategy in relation to the identified vulnerable sectors. The cross cutting issues e.g. scientific capabilities for climate modeling and assessment, India's GHG emissions, mitigation strategy, state action plans on climate change and climate change finance are dealt with in subsequent sections. The concluding chapter summarises the recommendations that arise from the sectoral assessments and analysis of the cross-cutting issues.

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Section 1

Context

1 Climate change has emerged, in recent times, as an important area of both international as well as domestic policy making and development planning. The earth's climate has demonstrably changed on global and regional scales since the pre-industrial era, with some of these changes attributable to human activities. The changes observed in the regional climate have already affected many of the physical and biological systems and there are indications that social and economic systems have also been affected. The recent assessment report (AR4) of the Intergovernmental Panel on Climate Change (IPCC) has shown that climate change would have significant impact on myriad economic sectors and ecosystems.

2 Increasingly, the international and national studies have pointed towards damage to the environment due to anthropogenic causes including emissions of greenhouse gases, the various manifestation being increases in global average surface temperature, increases in global average sea level, and decrease in the northern hemisphere snow cover. These changes are likely to threaten food production, increase water stress and decrease its availability, result in sea-level rise that could flood crop fields and coastal settlements, and increase the occurrence of diseases, such as malaria.

3 It is recognized that India has hardly any historical contribution to the problem. Yet, climate change is a huge challenge because India is deeply vulnerable to its adverse impacts. In countries like India where climate variability has always existed in several forms, climate change is likely to put further pressures on this variability rendering several sectors more vulnerable.

4 In India, the climate and weather are dominated by the largest seasonal mode of precipitation in the world, due to the summer monsoon circulation. Over and above this seasonal mode, the precipitation variability has predominant inter-annual and intra-seasonal components, giving rise to extremes in seasonal anomalies resulting in large-scale droughts and floods and also short-period precipitation extremes in the form of heavy rainstorms or prolonged breaks on the synoptic scale. Further, the Indian climate is also marked by cold waves during winter in the north and heat waves during the pre-monsoon season over most parts of the country. Tropical cyclones, affecting the coastal regions through heavy rainfall, high wind speeds and storm surges, often leave behind widespread destruction and loss of life, and constitute a major natural disaster associated with climatic extremes. These extremes have visible impact on human activities and therefore deserve to receive greater attention by all sections of the society.

5 Although the science of climate change is still growing and is, at times, uncertain, a large body of scientific and social opinion believes that there is a need to enhance

actions at all levels to mitigate this threat. The observed changes in India's climate reveal that an increase of -0.4^{o}C in surface air temperatures over the past century (1901-2000) has been noticed in India as against the globally observed increase of 0.76^{o} C. However, there is no significant long term trend in monsoon rainfall or floods in the summer monsoon season at all India level. The total frequency of cyclonic storms forming over Bay of Bengal has also remained almost constant over 1887-1997. It is projected that, by the end of 21st century, rainfall in India may increase by 15-40% with high regional variability. Warming may be more pronounced over land areas with northern India experiencing maximum increase. The warming could be relatively greater in winter and post-monsoon seasons. The annual mean temperature could increase by 3°C to 6°C over the century.

6 The rise in sea level in the north Indian Ocean has been observed to be in the range of 1.06-1.75 millimeters per year in the past century. There is a threat of coastal inundation in some of the low lying coastal areas. On the other hand, the glaciers show a mixed behavior. While some of them are receding, some of them are growing. As the glaciers retreat, they become more fragmented and the smaller glaciers are more sensitive to global warming. While some of the glacial recession could be a part of natural cyclic process, the accelerated melting experienced by some of the glaciers as a result of the earth's warming may affect future water availability.

7 In view of the observed changes, India has reasons to be concerned about climate change. Its large population depends upon climate-sensitive sectors like agriculture and forestry for its livelihood. Any adverse impact on water availability due to recession of glaciers, decreases in rainfall and increased flooding in certain pockets would threaten food security, cause dieback of natural eco-systems including species that sustain the livelihood of rural households, and adversely impact the coastal system due to sea-level rise and increased extreme events. This aside, achievement of vital national development goals related to other systems such as habitats, health, energy demand and infrastructure investments would be adversely affected.

8 Climate variability and change can slow down the pace of development either through adverse impacts on natural ecosystems or erosion of the adaptive capacity of people and society. Climate change is, therefore, not only a major global environmental problem, but an issue of great concern to a developing country like India. Given the lack of resources, and access to technology and finances, developing countries such as India have limited capacity to develop and adopt strategies to reduce their vulnerability to changes in climate. India is compelled to spend almost 2.5 % of its GDP on development related programmes that help adaptation to climate change. The costs of adaptation will rise if the global climate change continues unchecked because of unsustainable historical concentration of human-induced GHG. The threat will persist and grow larger if the current international regime to address the problem of historical concentration is not implemented according to the existing mandate.

9 Although India's contribution to historical emissions of GHG gases of anthropogenic nature is hardly 4% and its per capita emissions are still amongst the lowest in the

world, there is increased pressure on developing countries like India to participate, through voluntary and nationally appropriate policies, in the global mitigation efforts aimed at stabilizing the climate.

10 Considering the existing and emerging challenges at the domestic and international level in the area of climate change, it is necessary, therefore, that India should develop a concerted response strategy that can help the country minimize its likely adverse impacts on livelihoods, natural ecosystems and growth potential of the country.

Section 2

Approach to Addressing Climate Change

Background

2.1 The Planning Commission has outlined its approach to the challenge of climate change in chapter V- Sustainable Management of Natural Resources of the Approach Paper for the 12th FY Plan. The Approach Paper calls for implementing the activities outlined under various Missions of the National Action Plan on Climate Change and a low carbon mitigation strategy.

Goal of Sustainable Development and National Action Plan on Climate Change

2.2 The National Action Plan on Climate Change launched in 2008 embodies the government's vision of addressing the challenge of climate change through a process of sustainable development. The goal of NAPCC is to enhance ecological sustainability of our development path. This is sought to be achieved through eight National Missions and several other specific initiatives in several sectors.

Domestic Mitigation Goal

2.3 In 2009, the goal of sustainable development was supplemented by a domestic mitigation goal of reducing emissions intensity of GDP that enjoins upon the government to endeavour to reduce emissions intensity of GDP by 20-25% by 2020 in comparison with 2005 level. This was an advance over the approach taken in the 11th Plan where concern on climate change was expressed in form of a limited reference to the objective of improving energy efficiency by 20% by 2016-17.

Strategy for 12th Five Year Plan

2.4 Considering the vulnerability of a large number of sectors to climate change and their adaptation needs, a well defined strategy should be adopted during the 12th five year Plan to achieve the objective of various Missions under the National Action Plan on Climate Change, and the goal of a low carbon inclusive growth strategy.

2.5 An effective strategy for addressing climate change should permeate the planning process at three levels. Firstly, in articulating the overall approach of the Five Year Plan, the considerations of sustainable development and lower carbon inclusive growth should be integrated in all sectors. Secondly, in specific sectors which are considered particularly vulnerable to climate change, a climate change adaptation strategy should be built into their respective plans. Lastly, in the Environment & Forests sector, specific schemes and programmes should be launched to strengthen the capacity for making scientific assessment, GHG measurement & monitoring, and achieve environmental protection through a coherent strategy of adaptation and mitigation actions.

2.6 An optimal way of achieving this would be to integrate the objectives of the NAPCC and the domestic mitigation goal in the development strategy of the respective sectors. In the area of adaptation, this calls for specific policy initiatives across a wide variety of sectors,

particularly in the areas of agriculture, water, health, coastal management, forests and other ecosystems, energy including renewable energy, and infrastructure and climate change assessment. The strategy, to be effective, must reflect the needs and priorities of the state governments who should be involved in the process. Further, an appropriate mitigation strategy will need to be drawn up at the national level. This should be implemented through an appropriate mechanism that should decide, finance and administer the process of achieving the domestic mitigation goal. The mechanism will need to involve the concerned Ministries and agencies which have the ability to influence the course of emissions emanating from consumption of fossil fuels and/or switch to alternative sources of energy or cleaner energy technologies. Considering the domestic needs and international obligations, other specific programmes and activities regarding scientific assessments and strategy will also be necessary to sustain the efforts scientifically and systematically over a longer term.

2.7 Amongst the key actions needed to achieve this objective are (i) establishing a framework of policy and institutional arrangements and provision of financial resources for implementation of national Missions under the NAPCC, (ii) preparation of a mitigation strategy and institution of an implementation mechanism for a lower carbon inclusive growth, (iii) building and strengthening the institutional capacity for scientific research into climate change including observation of ecological changes and assessment of climate change, and (iv) involving States in implementing Action Plans on Climate Change at the state level.

Integrating the NAPCC in the Sectoral Plans

2.8 As the specific Missions have already been approved by the PM's Council on Climate Change, the nodal Ministries will need to build the approved activities in the relevant sectoral plan of the Ministry. Specific areas included in the NAPCC are renewal energy/solar energy, enhanced energy efficiency, agriculture, urban habitat, water, Himalayan eco-system, forest cover, and strategic knowledge-base. Besides the eight specific Missions, there are several other initiatives in the area of research, energy, disaster management, coastal management etc. which, if implemented, will help achieve the objectives of the NAPCC. It is necessary to analyse the vulnerability of each of these sectors, and devise appropriate interventions at the scientific, policy and institutional level. The required resources for implementing the objectives of each of the National Missions also have to be projected and agreed as a part of the 12th Plan.

Lower carbon mitigation strategy for inclusive growth

2.9 With a view to enable the industry to grow sustainably while protecting the environment, a clear strategy for achieving the domestic mitigation goal has to be formulated during the 12th FY Plan. This requires that the potential of relevant sectors is studied through a well planned exercise to reduce emissions relative to output and the cost of implementing such policy measures and actions is assessed and provided for in course of the 12th Five Year Plan. To fulfill this objective, a set of nationally appropriate mitigation actions in various sectors will have to be identified and implemented through a nationally coordinated policy.

A national mechanism for identifying and financing such actions will be needed. Besides, a national system for GHG emissions monitoring and management will also have to be put in place. The existing system for preparing and reporting the national GHG inventory will need to be enhanced and suitably equipped in order to meet the international obligations to submit national Communications (NATCOMs) at periodical intervals. This will also include a process of periodical (biennial) update of inventories and evaluation and assessment of the impact of the mitigation actions on the national goal.

Strengthening scientific research capacity and strategic knowledge for climate change observation and assessment

2.10 Strengthening the capacity to assess vulnerability and impacts of climate change and conduct scientific studies of the ecological changes in different sectors such as agriculture, coastal areas, water etc. are critical to support the climate change related policy interventions. These require setting up of specific programmes and institutions by various Ministries. The 12th Plan will have to be geared to put in place scientific observation systems and launch specific programmes to build up and enhance such capacity.

Implementing climate change related actions at state level

2.11 The involvement of States in implementing the NAPCC through preparation of state level action plans is another important consideration in formulating a cross sectoral strategy. State Governments are currently preparing State level Action Plans for climate change (SAPCC) and adequate provisions will have to be made in the 12th Five Year Plan either through the developmental plans of the concerned State Governments or the nodal Ministries to support the SAPCCs.

SECTION 3

VULNERABILITY ASSESSMENT & ADAPTATION

3.1 AGRICULTURE

3.1.1 Systematic studies on climate change and Indian agriculture are relatively few and recent. But, the available studies indicate that adaptation challenges to Indian agriculture, arising from climate change are significant. Climate change is likely to further increase the ongoing stress of yield stagnation, land use, competition for land, water and other resources, and globalization that the Indian agriculture is going through.

3.1.2 Possible impacts

3.1.2.1 Studies done at the Indian Agricultural Research Institute indicate the possibility of loss of 4-5 million tons in wheat production with every rise of 1^{o}C temperature throughout the growing period even after considering carbon fertilization (but no adaptation benefits). Losses for other crops are still uncertain but are expected to be smaller, especially for kharif crops. It is, however, possible for farmers and other stakeholders to adapt to a limited extent and reduce the losses. Simple adaptations such as change in planting dates and crop varieties could help in reducing impacts of climate change to some extent. ICAR stud indicates that losses in wheat production can be reduced from 4-5 million tons to 1-2 million tons if a large percentage of farmers could change to timely planting. This may, however, not always be possible due to constraints in the cropping systems.

3.1.2.2 Probability of yield losses associated with frost damage in north-western India in crop such as potato, peas, and mustard is likely to decrease due to reduction in the occurrence of frost events.

3.1.2.3 Increasing glacier melt in Himalayas could affect availability of irrigation especially in the Indo-Gangetic plains, which, in turn, would have consequences on food production.

3.1.2.4 Small changes in temperature have significant effect on quality of rice and wheat. Pathogens and insect populations are strongly dependent upon temperature and humidity. Increases in these parameters will change their population dynamics.

3.1.2.5 Droughts, floods, tropical cyclones, heavy precipitation events, hot extremes, and heat waves are known to negatively impact agricultural production, and farmers' livelihood. The projected increase in these events could result in greater instability in food production and threaten livelihood security of farmers.

3.1.2.6 Increase in temperatures associated with global climate change can effect yield formation of temperate crops such as apple. This is illustrated by a significant

decrease observed in average productivity of apples in Kullu and Shimla in recent times. A key reason for this could be a trend of non-fulfillment of chilling requirement of apple in recent decades, crucial for good yields. This seems to have resulted in a shift of apple belt to higher elevations. The new areas of apple cultivation have appeared in Lahaul and Spitti and upper reaches of Kinnaur district of Himachal Pradesh.

3.1.2.7 Coconut yields are likely to be affected by global climate change. Plains of Karnataka, Eastern TN, coastal AP, Pondicherry, WB and Assam were found to be hot spots as per HadCM3 model scenarios of climate change; No change in productivity was projected due to climate change in coastal Karnataka and Kerala.

3.1.2.8 Preliminary estimates indicate that global warming is likely to lead to a loss of 1.5-2.0 million tones in milk production by 2020 and 15 million tones by 2050. A rise of 2-6 °C due to global warming by the end of this century will negatively impact growth, puberty and maturity of crossbreds and buffaloes and time to attain puberty of crossbreds and buffaloes will increase by one to two weeks due to their higher sensitivity to temperature than indigenous cattle.

3.1.2.9 Increasing sea and river water temperature is likely to affect fish breeding, migration, and harvests. Coral reefs in the Indian seas are predicted to decline from 2040. A rise in temperature as small as 1°C could have important and rapid effects on the mortality of fish and their geographical distributions, and hence climate change effects could be very significant for fisheries. Oil sardine fishery did not exist before 1976 in the northern latitudes and along the east coast as the resource was not available/and sea surface temperature (SST) were not congenial. With warming of sea surface, the oil sardine is able to find temperature to its preference especially in the northern latitudes and eastern longitudes, thereby extending the distributional boundaries and establishing fisheries in larger coastal areas.

3.1.2.10 Corals in Indian Ocean will be soon exposed to summer temperatures that will exceed the thermal thresholds observed over the last 20 years. Annual bleaching of corals will become almost a certainty from 2050. Given the implication that reefs will not be able to sustain catastrophic events more than 3 times a decade, reef-building corals are likely to start disappearing as dominant organisms on coral reefs between 2030 and 2040.

3.1.3 The most recent 4x4 assessments produced by Indian Network for Climate Change Assessment (INCCA) reveal the following likely impacts of climate change in four major sectors of India:-

Western Ghats

Rice: The productivity of irrigated rice is likely to reduce by 4% in most of the areas in this region. However, irrigated rice in parts of southern Karnataka and northern-most districts of Kerala is likely to gain. In case of rain-fed rice, all areas in the region are likely to lose yields by upto 10%. The results thus indicate that irrigated rice is able to benefit due to CO_2 fertilization effect as compared to the rain-fed rice, which is supplied with less amount of fertilizers.

Maize and sorghum: Climate change is likely to reduce yields of maize and sorghum by up to 50% depending upon the area in this region. These crops have C4 photosynthetic systems and hence do not have relative advantage at higher CO_2 concentrations.

Coconut: Coconut yields are projected to increase as much as 30% in the majority of the region by the 2030s. Increase in coconut yield may be mainly attributed to the projected increase in rainfall (~10%) and relatively less increase in temperature, apart from CO_2 fertilization benefits. However, some areas like south-west Karnataka, parts of Tamil Nadu and parts of Maharashtra may show reduction in yields by upto 24%.

Livestock productivity: The Temperature Humidity Index (THI) is likely to remain under highly stressful conditions in the 2030s. The heat-stress days per annum are likely to increase with THI above 80 in the 2030s in the Western Ghats, leading to severe thermal discomfort of the livestock and hence, negative impact on livestock productivity is expected.

Coastal Region

Rice: The yields of irrigated rice are projected to decrease by about 10% to 20% in this region. However, in some coastal districts of Maharashtra, northern Andhra Pradesh and Orissa, irrigated rice yields are projected to marginally increase by 5% with respect to the 1970s. On the other hand, rain-fed rice yields are projected to increase up to 15% in many districts in the east coast but reduce by up to 20% in west coast.

Maize and sorghum: Impacts of climate change on irrigated maize in coastal districts are projected to be much higher with projected yield loss between 15% and 50%, whereas in the case of rain-fed maize, the projected yield loss is up to 35%. In some districts of coastal Andhra Pradesh, rain-fed maize yields are likely to increase by 10%. Projected increase in seasonal maximum temperature in these areas is less than $1^{o}C$ in the 2030 scenario.

Coconut: Yields of coconut are projected to increase in the west coast of India by up to 30% (provided current level of water is made available in the future as well), while in the east coast, yields may increase by about 10% in the north coastal districts of Andhra Pradesh. All other coastal districts in eastern coast and those in the Gujarat coast are projected to lose coconut yields up to 40%.

Livestock productivity: The livestock in the Coastal regions are likely to be highly vulnerable with consequent adverse impacts on its productivity throughout the year in the 2030 scenario with THI above 80.

Fisheries: (a) Oil Sardines- An increase in recruitment and catches of oil sardine during the post-southwest monsoon season along the coastal region, especially along the Kerala coast, is expected in the future due to warming, elevated Sea Surface Temperature (SST), favorable wind (and perhaps current) and increasing Coastal Upwelling Index (CUI) inducing higher chlorophyll-a concentration during the southwest monsoon. (b) The

Indian mackerel is able to take advantage of the increase in temperatures of subsurface seawater. Therefore, with increase in global temperatures and sea surface temperatures, it is likely to move northwards and deeper into the seas surrounding it (c) The threadfin bream spawns optimally in SST between 27.5^{o}C and 28.0^{o}C and when the SST exceeds 28.0^{o}C, the fish shifts the spawning activity to seasons when the temperature is around the preferred optimum. Therefore in the climate change context, in the 2030s, if the SST exceeds 28^{o}C during April to September, an increase in catch might take place in the comparatively cooler months of October to March.

North-Eastern Region

Rice: Irrigated rice yields in this region may range between –10% and 5%, with respect to the 1970s, while the rain-fed rice yield may vary between–35% to 5% with respect to 1970s.

Maize: Maize crop yields are projected to reduce by about 40%.

Livestock productivity: In this region, the THI is likely to increase during April–October months with THI > 80.

Himalayan Region

Apples: Apple production in the Himachal Pradesh region has decreased between 1982 and 2005 as the increase in maximum temperature has led to a reduction in total chilling hours in the region—a decline of more than 9.1 units per year in last 23 years has taken place. This reduction was more during the months of November and February. With increasing temperature, it is anticipated that there may be an all-round decrease in apple production in the Himalayan region, and the line of production may shift to higher altitudes.

Livestock productivity: This is projected to rise in many parts of Himalayan region during March–September with a maximum rise during April–July in 2030s with respect to 1970s.

3.1.3 Adapting Indian agriculture to climate change

3.1.3.1 According to ICAR studies, the actions for adapting Indian agriculture to climate change should consist of:

- **Changes in land use and management:** Small changes in climatic parameters can often be managed reasonably well by altering dates of planting, spacing and input management. Development of alternate cultivars, and farming systems (such as mixed cropping, crop-livestock) that are more adapted to changed environment can further ease the pressure.

- **Development of resource conserving technologies:** Surface seeding or zero-tillage establishment of upland crops after rice, gives similar yields to when planted under normal conventional tillage over a diverse set of soil conditions. In addition, such resource conserving technologies restrict release of soil carbon thus mitigating increase of CO_2 in the atmosphere. Greater emphasis on water

harvesting and improving the efficiency of regional as well as farm water use efficiency could help to face uncertain rainfall.

- **Improved land use and natural resource management policies and institutions:** Adaptation to environmental change could be in the form of crop insurance, subsidies, pricing policies, and change in land use. Necessary provisions need to be included in the development plans to address these issues of attaining twin objectives of containing environmental changes and improving resource use productivity. Policies are needed that would encourage farmers to conserve water, energy, and soil resources. For example, financial compensation/incentive for enriching soil carbon, and increasing the efficiency of irrigation water uses through drip and sprinkler methods could encourage farmers to improve soil health, manage with less water, and assist in overall sustainable development.

- **Improved risk management though early warning system and crop insurance:** The increasing probability of floods and droughts and other uncertainties in climate may seriously increase the vulnerability resource-poor farmers to global climate change. Early warning systems and contingency plans can provide support to regional and national administration, as well as to local bodies and farmers to adapt. Policies that encourage crop insurance can provide protection to the farmers in the event their farm production is reduced due to natural calamities.

- **Nutritional strategies for managing heat stress in dairy animals:** Nutritional modifications can help to maintain homeostasis in dairy animals or prevent nutrient deficiencies that result from heat stress, thereby minimizing the production losses associated with heat stress. The livestock owners, in several regions, based on their indigenous technical knowledge apply numerous nutritional modifications that are useful for hot weather feeding; however, many need further investigation to achieve specific recommendations.

3.1.4 GHG emissions from Indian Agriculture

3.1.4.1 The latest data from GHG emissions inventory of 2007 indicates that agriculture sector contributes 28% of the total GHG emissions from India. The emissions are primarily due to methane emission from rice paddies, enteric fermentation in ruminant animals, and nitrous oxides from application of manures and fertilizers to agricultural soils (Figure 1).

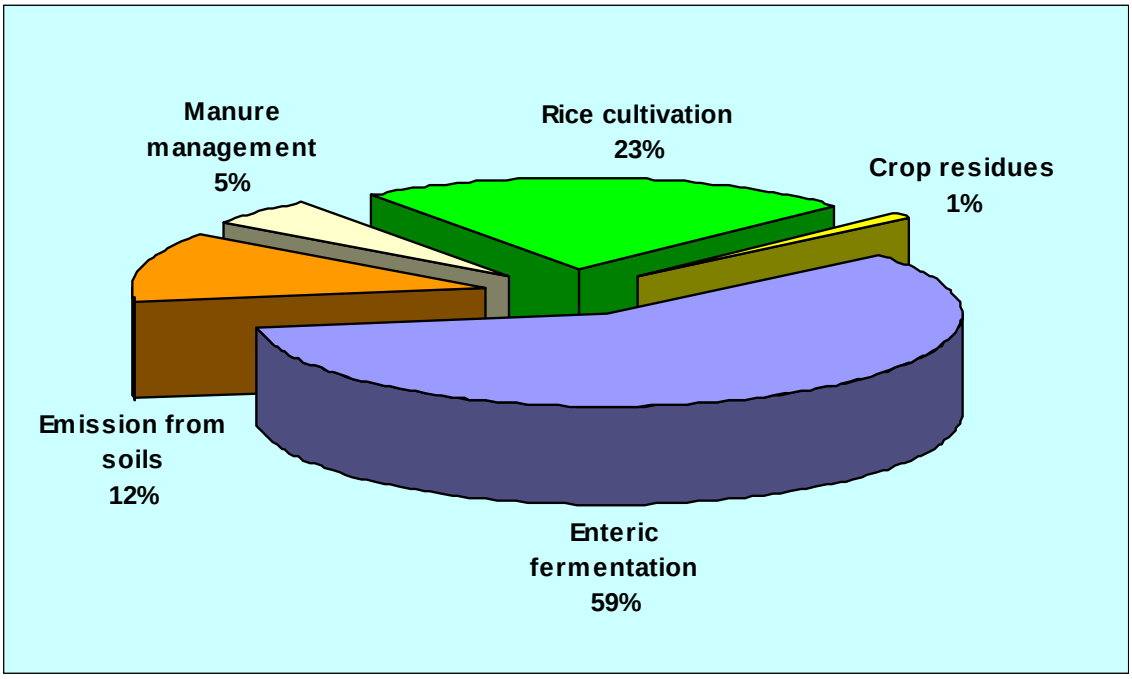


Figure 1. Sources of greenhouse gas emissions from Indian agriculture

3.1.4.2 The emissions from Indian agriculture are likely to increase significantly in future due to our need to increase food production. The latter would require greater emphasis on fertilizer application of fertilizers and other inputs. This in a globally warm environment leads to increased emissions of nitrous oxides and other GHGs. Increased temperatures would lead to higher emissions even at the current level of fertilizer consumption. Despite this, the relative proportion of emissions from agriculture in India is likely to show considerable reduction in future because of larger emission growth in other sectors compared to agriculture.

3.1.5 Reducing GHG emissions (mitigation) from Indian agriculture

3.1.5.1 As far as reducing GHG emissions (mitigation) from Indian agriculture is concerned, there are several approaches that have been tested at experimental scale to reduce emissions in Indian agriculture. However, these need large-scale testing from the mitigation perspective. Some of these that are relevant for Indian conditions are:

- Improved water and fertilizer management in rice paddies could reduce emissions of GHGs. There are possibilities for crop diversification as value added from different crops is gaining importance under globalization and supply chain management
- Improved management of livestock population and its diet could also assist in mitigation of GHGs.

- Approaches to increase soil carbon such as organic manures, minimal tillage, and residue management should be encouraged. These have synergies with sustainable development as well.
- Use of nitrification inhibitors, such as neem-coated urea, and fertilizer placement practices need further consideration for GHG mitigation.
- Improve the efficiency of energy use in agriculture by using better designs of machinery, and by conservation practices.

3.1.6 Methane emissions from Indian livestock

3.1.6.1 The share of Indian livestock in the GDP is about 7%. India is currently the top milk producer in the world. Besides milk, male cattle provide the much-needed power and fuel to Indian agriculture. However, the large ruminant population has also a role in emission of green house gases such as methane and nitrous oxide, which are major green house gases. Indian livestock are responsible for about 54% of total methane emission in India. Indian livestock emit about 10 Tg methane by consuming about 600 million tones of feed, consisting largely of crop residues and agro-industrial byproducts. Average methane emission/ kg milk from the lactating animals only, is 50.85 ± 3.67 g. [However, the value is 175.7 g when total livestock population (male and female) is considered.] The Indian livestock generates about 274.96 million tones dung (DM basis) and the total methane generated from this animal waste, as per the animal waste management systems being practiced in various Indian states, is 1.40 Tg.

3.1.6.2 For these reasons, India is often held responsible for producing large amount of methane, responsible for the global warming. However, there are a few fundamental differences in the approach to livestock emissions in India as contrasted with emissions from other sectors:

- Indian livestock is the major source of rural employment especially among small and landless farmers.
- Owing to the non-availability of grazing lands and green fodder, the cattle and buffaloes in majority of the states in India are raised, in general, under stall fed conditions, where the fodder is mainly crop residue-based. Concentrate ingredient/ mixture is provided only to the lactating cows.
- Indian livestock converts crop residues and inferior quality material, which do not have any other utility and may create a handling problem, into products such as milk, meat, farm power, and leather etc. Disposal of crop residues will affect the environment more critically.
- Cattle in India are also the source of power and fuel. Cattle population contributes to economy to the tune of 35000-mega watt energy, which is extremely difficult to replace keeping in view the length and breadth of the country and the additional infra-structure investments needed in rural area.
- Farming activities, if performed using diesel/petrol rather than animal power, will require huge investments and there will be greater pollution from these than from methane emission.
- Use of dung as fuel saves the forests, which are most powerful carbon dioxide sinks, another GHG and avoids the production of methane from the dung.

Electricity, coal and natural gas are the alternative fuels but their generation/collection, transportation, and distribution in the interior areas will be a gigantic task and require huge investments.

- Use of dung as manure saves the chemical fertilizers, whose production creates pollution and require large infrastructure for their production and distribution.
- Unlike western countries, which permit large emissions at all stages of animal waste and manure handling caused by anaerobic conditions, moisture and nitrogen contents in animal wastes, the fermentation of dung into methane does not take place because of animal waste management practices in India. These practices also restrict the nitrification and denitrification process due to their low nitrogen and moisture content, thereby leaving very limited scope for nitrous oxide emission.

3.1.6.3 Hence, methane emission from livestock in India has to be seen from the perspective of agriculture- animal husbandry system in the larger context. Removal of Indian cattle is neither possible nor desirable as livestock is the life line of common Indian and provides large benefits to the nation. Keeping in view the utility of Indian livestock population to national economy and food security as well as social needs, this emission is not a threat to the environment. Nevertheless, methods for the mitigation of methane emission from the livestock should be explored. Increasing the dietary energy level will not only improve their productivity but also mitigate the methane emission. Alternatively, some feed additives may be developed to control the methanogenic bacteria in the rumen.

3.1.7 Initiatives by ICAR

3.1.7.1 ICAR has launched in February 2011, a network project called 'National Initiative on Climate Resilient Agriculture (NICRA)' with a view to enhance resilience of Indian agriculture to climate change and climate vulnerability through strategic research and technology demonstration. The research on adaptation and mitigation covers crops, livestock, fisheries and natural resource management. The objectives of the scheme are as follows:

- To enhance the resilience of Indian agriculture covering crops, livestock and fisheries to climatic variability and climate change through development and application of improved production and risk management technologies.
- To demonstrate site specific technology packages on farmers' fields for adapting to current climate risks.
- To enhance the capacity of scientists and other stakeholders in climate resilient agricultural research and its application.

3.1.7.2 The project consists of four components are Strategic Research, Technology Demonstration, Capacity Building and Sponsored/Competitive Grants. The output of the project would be: Selection of crop genotypes and livestock breeds with greater tolerance to climatic stress, Existing best practices for climate resilience, Capacity Building including Infrastructure and trained man power.

The scheme will be implemented with the Central Research Institute for Dryland Agriculture (CRIDA), Hyderabad under the supervision of the Natural Resources Management (NRM) Division of ICAR. Currently, the outlay of the project is Rs. 350 crores for the 11th Five Year Plan, out of which Rs. 200 crores is allocated for 2010-11 and Rs. 15o crores for 2011-12.

3.1.8 Key recommendations : Keeping in view the above analysis, and the status of actions taken so far, it is recommended that the actions relating to adaptation and mitigation in agriculture should focus on the following:-

3.1.8.1 Adaptation: A programme for enhancing adaptation of agriculture could consist of adaptation projects/activities aimed at the following :

- Strengthening surveillance of pest and diseases. Increasing climatic variability and change could lead to rapid movement of pathogens and insect pests.

- Developing mechanisms for integrated management of rainwater, surface, and ground water. Augmentation of the water resources will be highly complimentary.

- Weather based insurance products should be provided to increasing number of farmers at an early date for management of enhanced temperature and rainfall risks.

- Establishing a science based *Agricultural Intelligence System* to facilitate understanding of impact of real-time weather and other inputs on production of important commodities.

- Establishing Weather Watch groups for climate sensitive commodities in ICAR commodity institutes for real-time monitoring of weather impacts and to enable appropriate policy response.

- Supporting community partnerships in developing food and forage banks to manage scarcity during projected increased periods of drought and floods.

3.1.8.2 Mitigation options: The efforts for making agricultural production more energy efficient should focus on:

- improving inventories of emission of greenhouse gases using state of art emission equipments coupled with simulation models, and GIS for upscaling,

- evaluating carbon sequestration potential of different land use systems including opportunities offered by conservation agriculture and agro-forestry,

- evaluating the mitigation potential of biofuels and their enhancement by their genetic improvement and use of engineered microbes,

- identification of cost-effective opportunities for reducing methane generation and emission in ruminants by modification of diet, and in rice paddies by water and nutrient management,

- renewing focus on nitrogen fertilizer use efficiency with added dimension of nitrous oxides mitigation, and (vi) assessing biophysical and socio-economic implications of mitigation of proposed GHG mitigating interventions before developing policy for their implementation.

3.1.8.3 Policy setting: The policy changes that will ensure quicker and more effective adaptation should cover the following aspects :

- Climate change impacts and adaptations should be considered in all major development planning activities.

- Develop new infrastructure, policies and institutions to support the new land use arrangements identified by science and technology.

- Enhance investment in water harvesting and conservation options; and promote small farm mechanization and efficient water use technologies.

- Facilitate greater adoption of scientific and economic pricing policies, especially for water, land, energy, and other resources.

- Explore international partnerships for joint food security.

- Consider financial incentives and package for improved land management including resource conservation/ enhancement (water, carbon, energy), and fertilizer use efficiency.

- Consider incentives for industry and farming community for producing and using slow release fertilizers and Green House Gas inhibitors.

- Establish 'Green Research Fund' for strengthening research on adaptation, mitigation and impact assessment.

3.1.8.4 Details of specific activities that should form part of an adaptation and mitigation strategy in of Indian agriculture, according to ICAR, are given in Annexure to this section. These cover areas of impact assessment', 'adaptation strategies', 'mitigation options', and 'capacity building'.

3.1.9 Conclusions

Continued population growth in our country is leading to increased demand for food. To meet these demands, crop yields would need to increase by almost 30-50% in the next 20

years. To address multifarious challenges of sustainable development, agriculture has to produce not only more food, but also contribute to increased employment and rural income while conserving natural resources. This will have to be achieved with relatively less water and land due to competition from other sectors. Global climatic changes and increasing climatic variability are likely to further exert pressure on agricultural systems and may constrain attainment of future food production targets. Urgent steps therefore need to be taken to increase our adaptive capacity. Several strategies for this are available and perhaps can be evolved in future. This would cost money although the precise costs of adaptation and mitigation in agriculture are not clearly known. It is, however, important to note that costs of inaction could be even higher. A win-win solution is to start with such adaptation strategies that are anyways needed for sustainable development.

Actions needed for adaptation and mitigation to climate change

Specific actions that need to be taken to improve research and development capabilities and address climate change in agriculture should cover areas of ' impact assessment', 'adaptation strategies', 'mitigation options', and 'capacity building'.

Impacts assessment

Research on impact assessment of climate change on production resources, crops, livestock, fisheries, and microbes needs to be strengthened using field and controlled environment facilities, and simulation models: The key aspects of such assessment should cover (i) spatial and temporal availability of surface and groundwater for irrigation, (ii) sensitive processes such as pollen germination, spikelet sterility and grain development, (iii) agricultural production (demand and supply of commodities, prices, trade, regional and societal differences), (iv) quality of produce, (v) germplasm variability and evolutionary trend, (vi) diversity and dynamics of key insects and microbes including fungi, bacteria and viral pathogens, (vii) livelihood of farmers and fishermen, and (viii) institutionalising the monitoring of phenology, especially of perennial crops, as a bio-indicator of climatic variability and change.

Adaptation strategies

The adaptation strategy in agriculture should include (i) development of new genotypes (ii) Intensification of search for genes for stress tolerance across plant and animal kingdom, (iii) Intensification of research efforts on marker aided selection and transgenic development for biotic and abiotic stress management, (iv) development of heat and drought tolerant genotypes. (v) attempting transformation of C3 plants to C4 plants, (vi) development of new land use systems and agronomy for climate change scenarios, (vii) exploring opportunities for maintenance /restoration/ enhancement of soil properties, (viii) use of multi-purpose adapted livestock species and breeds, (ix) enhancement of value-added weather management services, (x) development of spatially differentiated operational contingency plans for temperature and rainfall related risks, including supply management through market and non-market interventions in the event of adverse supply changes, (xi) enhancing research on applications of short, medium and long range weather forecasts for reducing production risks, (xii) development of knowledge based decision support system for translating weather information into operational management practices, (xiii) development of pests and disease forecasting system covering range of parameters for contingency planning and effective disease management, and (xiv) development of a compendium of indigenous traditional knowledge and explore opportunities for its utilization.

Mtigation options

In the area of mitigation options, it is recommended that efforts should be focused on (i) improving inventories of emission of greenhouse gases using state of art emission equipments coupled with simulation models, and GIS for upscaling, (ii) evaluating carbon sequestration potential of different land use systems including opportunities offered by conservation agriculture and agro-forestry, (iii) evaluating the mitigation potential of biofuels and their enhancement by their genetic improvement and use of engineered microbes, (iv) identification of cost-effective opportunities for reducing methane generation and emission in ruminants by modification of diet, and in rice paddies by water and nutrient management, (v) renewing focus on nitrogen fertilizer use efficiency with added dimension of nitrous oxides mitigation, and (vi) assessing biophysical and socio-economic implications of mitigation of proposed GHG mitigating interventions before developing policy for their implementation.

Capacity building

There is a need to establish automatic weather station in each Krishi Vikas Kendra (KVK) for agromet observations. A system for remote access of data at a central place and its on-line distribution to ICAR/SAU scientists should be developed, while weighing lysimeters should be established in key centers. Besides, the measures should include (i) developing specialized, state of art, climate control facilities (CO2, temperature, water and ozone). [Note: These are expensive, not available in the country, and hence international collaboration in this area, including research partnerships and training, should be developed], (ii) enhancing national capacity on decision support systems, especially on integrated, dynamic, agro-economic modelling based systems, (iii) enhancing national capacity on carbon trading in agriculture, and (iv) intensifying efforts for increasing climate literacy among all stakeholders of agriculture, including students, researchers, policy planners, science administrators, industry as well as farmers.

3.2 WATER RESOURCES

3.2.1 Projections of water demand made by the Ministry of Water Resources indicate that India will be able to meet her water requirements until the year 2050 by deploying integrated water management plans (NCIWRD, 1999). This may be an unrealistic picture since two crucial factors have not been taken into account: the impact of large number of ongoing and future water resources development projects of varied sizes and any possible impact on water resources due to climate change. Furthermore, there has been no attempt to enumerate the ecosystem services being provided by these freshwater ecosystems which if restored, shall add up to the existing water demand.

3.2.2 The National Water Policy

3.2.2.1 The National Water Policy was adopted in September 1987 and was reviewed and updated in April 2002. The National Water Policy provides for some of the amendments needed in the ISWD (Interstate Water Disputes) Act (Article-21.2). Some of the recommendations of the National Water Policy (NWP, 2002) that could address many of the problems in the water sector are:

- The National Water Policy provides for the formulation of the River Basin organisations, it states also that the "scope and powers of the river basin organisations shall be decided by the basin states themselves" (Article 4.2). In the case of interstate rivers, such a move has never been made because of the mistrust and also due to the absence of a facilitator. This role may have to be played by the Union government, if we want to manage the interstate rivers in the best possible manner. The first step in this direction has been taken in the form of the Ganga River Basin Management Authority formulated under the chairmanship of the Prime Minister.

- It provides for the creation of a standardised national information system promoting free exchange of data among various agencies (Articles 2.1 and 2.2). Here it might be mentioned that as per the Sarkaria commission recommendations , a data bank and information system at the national level has to be set up at the earliest and the states shall be required to compulsorily make the necessary data available. However the ground realities show that data accessibility is the major constraint for individual researchers as well as organisations.

- It provides for "adequate safe drinking water facilities" without mentioning the quantity of water in lpcd that should be provided in the urban and rural areas for various densities of population (Article 8). Although there is no mention of the quality of drinking water, Article 14 recommends regular water quality monitoring of surface and groundwater against the national water quality standards.

- The National Water Policy also recognises that water resource development should be planned for in hydrological units (river basins).

3.2.2.2 The National Commission for Integrated Water Resources Development Plan had recommended repealing the River Boards Act and enacting a new Act called the Integrated and Participatory Management Act. It is proposed that sustainability in the quantity and quality of water resources can be achieved by taking into account multi-sectoral factors such as groundwater, surface water and other environmental considerations. Although the Act has not been passed as recommended, it has been reflected in the Environment Policy (EP, 2006). The EP also addresses many other issues such as climate change and its impact on various sectors and the importance of exploring coping strategies.

3.2.3 Climate Change Impacts on Water

3.2.3.1 Climate change will affect the water balance, and particularly the amount of runoff and recharge, which in turn determines the water resources available for human and ecosystem uses. Some parts of the world will experience a reduction in resource availability, while others will see an increase. The impact of climate change on the major sectors and on the region of Asia have been predicted in the Fourth Assessment Report of the IPCC (SPM, 2007) made public in April 2007 in Brussels. Some relevant findings of the Fourth Assessment Report of IPCC are:

Water

- Runoff and water availability are very likely to increase at higher latitudes and in some wet tropics, including populous areas in East and Southeast Asia, and decrease over much of the mid-latitudes and dry tropics, which are presently water-stressed areas. (High confidence)
- Drought-affected areas will likely increase and extreme precipitation events, which are likely to increase in frequency and intensity, will augment flood risk. Increase of frequency and severity of floods and droughts will have implications on sustainable development. (High confidence)
- Water volumes stored in glaciers and snow cover are very likely to decline, reducing summer and autumn flows in regions where more than one sixth of the world population currently live (High confidence)

Ecosystems

- The resilience of many ecosystems is likely to be exceeded this century by an unprecedented combination of climate change, associated disturbances (e.g. wildfire, insects), and other global change drivers (High confidence)
- In the second half of this century terrestrial ecosystems are likely to become a net source of carbon, especially from previously under-estimated carbon stocks, thus amplifying climate change (High confidence)
- Roughly 20-30 per cent of species are likely to be at high risk of irreversible extinction if global average temperature exceeds 1.5-2.5°C (Medium confidence)

- For increases in global average temperature exceeding 1.5-2.5°C and in concomitant atmospheric CO2 concentrations, there are very likely to be major changes in ecosystem structure and function, species' ecological interactions, and species' geographic ranges, with predominantly negative consequences for goods and services (High confidence)

Coastal systems and low-lying areas

- Coasts are very likely to be exposed to increasing risks due to climate change and sea-level rise and the effect will be exacerbated by increasing human-induced pressures on coastal areas (Very high confidence)
- It is likely that corals will experience a major decline due to increased bleaching and mortality due to rising seawater temperatures. Salt marshes and mangroves will be negatively affected by sea-level rise (Very high confidence)
- Hundreds of millions of people are vulnerable to flooding due to sea-level rise, especially in densely populated and low-lying settlements where adaptive capacity is relatively low and which already face other challenges such as tropical storms or local coastal subsidence. The numbers affected will be largest in the mega-deltas of Asia but small islands face the highest relative increase in risk. (Very high confidence)

3.2.4. Climate Change impacts on water resources in India

3.2.4.1 It has been predicted that the drought-affected areas will likely increase creating more stress on already stressed ecosystems of India. Such a situation, in conjunction with manmade interventions, can cause a situation of river system closure. Such a situation shall arise due to the tendency of utilising/ exploiting every bit of the available flow without bothering for any environmental flow left in the river system other than present surplus flow. Any reduction in future flow shall be taken from this available surplus and shall thus encroach upon the environmental flows.

3.2.4.2 There are also some areas predicted to experience extreme precipitation events, with increased frequency and intensity, thus causing enhanced flood risk. In India, the northeastern systems of Mahanadi and Baitarni rivers are expected to come under this category (Gosain et. al, 2006). Increase of frequency and severity of floods and droughts will have implications on the functioning of the ecosystems.

3.2.4.3 Water volumes stored in glaciers and snow cover are very likely to decline, reducing summer and autumn flows in the Himalayan river systems in the long run. This shall be a major impact on the breadbasket of India since the Himalayan glaciers feed many major systems of India. There shall be a large number of implications such as glacier lake bursts, structural safety of the existing structures, etc. The climate change impacts are expected to influence the resilience of many ecosystems due to climate related disturbances such as wildfire, insects etc.

3.2.5 Some of the Indian Initiatives

3.2.5.1 India has been a very active participant in international climate change fora. India made its initial communication on climate change impact assessment, vulnerability to UNFCCC through the project known as NATCOM (National Communication) in 2004. This and subsequent NATCOM area specific reports remain the only significant national-level assessment of the impacts of climate change on water resources.

3.2.5.2 India has taken the climate change issue very seriously and has formulated the National Action Plan for Climate Change (NAPCC). The National Water Mission (NWM) which is one of the eight National Missions of NAPCC is expected to cover various aspects of the water sector for effective adaptation to climate change. Five goals proposed under the NWM are as under:

- Comprehensive water database in public domain and assessment of the impact of climate change on water resources
- Promotion of citizen and state actions for water conservation, augmentation and preservation
- Focused attention on vulnerable areas including over-exploited areas
- Increasing water use efficiency by 20%
- Promotion of basin level integrated water resources management.

3.2.5.3 In water sector, the first and foremost requirement for understanding and planning the adaptation measures it is important to assess the likely impacts of climate change on constituents of the hydrological cycle at basin/sub-basin level. Such assessments can be undertaken using available sophisticated mathematical modelling tools. As part of the NATCOM study such an exercise was undertaken for all the river basins of the country by deploying the SWAT hydrological model and using the international data on terrain, landuse, soil and meteorological series obtained from Regional Climate Models (RCM). The results of this study are available at http://gisserver.civil.iitd.ac.in/natcom. The present exercise has been done with data that is very coarse and also by making assumptions that there is no water resources development that has taken place in the basins. This had to be done since the data from the local organisations could not become available.

3.2.6 Recommendations for the water sector

3.2.6.1 The observed long term hydrological and meteorological data series along with the data on the water resources projects is essential for validating the models. It shall only then become possible to produce information/scenarios upto desired level of confidence which shall then be fit for taking planning and investment decisions. It is therefore recommended that review of data collection networks with a view for their utilisation in the development of mathematical models at appropriate scale should be undertaken for following parameters:

- o Rainfall;
- o Snowfall;

- Wind parameters (velocity, direction);
- Sun shine;
- Temperature;
- Humidity;
- Evaporation;
- River flows;
- Sediment flows through rivers;
- River geometry (cross-sections);
- Water bodies;
- Ground water levels.

3.2.6.2 In order to implement the strategy of integrated water resources management it is essential to create a framework which enables the mapping of hydrological units with the hierarchy of River Basin at the highest level of drainage system to catchment at the intermediate level and the watershed at the lowest level. Such a framework will need regular maintenance and updating to reflect fully the most accurate ground-truthed data or the infrastructure requirements for planning and management of the natural resources collected by the relevant departments. This framework, once available, could be used by all the line departments and updated by the relevant departments which have designated areas of jurisdiction over the data entry. The format should be made consistent with local to state and national level structures as well as the corresponding watershed, catchment and basin level structures.

3.2.6.3 Formulation of such framework can be undertaken by line department(s) including Central Water Commission, Indian Meteorological Department, Central Ground Water Board and Ministry of Earth Sciences by engaging academic and research organisations working in this area. An inventory (metadata) of available data series would also be created while doing the exercise. A tentative cost of Rs.150 cr. may be kept for this purpose.

3.2.6.4 Assessment of water utilization for various purposes linked with sources is also basic necessity for working out adaptation measures by examining purpose-wise water utilization upto village/Panchayat/municipal level for domestic use, small scale industry level for industrial use and minor irrigation projects for agricultural use. Such an exercise is essential for addressing the issues of inter-sectoral competition for water.

3.2.6.5 A GIS based "Water Resources Information System" has already been initiated during 11th Plan which needs to be enriched in terms of adding more layers to populate the system with available data and also by creating provision to update the system with current information on the additional projects taken up so as to have an updated baseline at all times. Converting available data in electronic form would be an enormous task which only can be performed by Public-Private partnership as one time activity. Updating the system with current data would require awareness and capacity improvement of the officials which can be undertaken by academic institutes as a continuing activity. Designing and standardization of formats, for the sake of uniformity, would also be a big exercise in itself so that every parameter of present and future importance be captured. It

shall require a comprehensive exercise of database design, implementation and processing. A tentative cost of Rs.200 cr. is proposed for this purpose.

3.2.6.6 A parallel action is needed for utilization of the data sets in converting to meaningful information as present scenarios and future scenarios considering impacts of climate change for planners and decision makers. This shall be achieved by adding a model base to the framework by consisting of modeling tools including MIKE Basin/RIBASIM for basin simulation and management, Soil and Water Assessment Tool (SWAT) for generating hydrological scenarios, MODFLOW for ground water, WEAP for water management etc. as a first cut deployment. A working level arrangement between academicians, research organizations with working professionals would be essential for both technology transfer or capacity building and generating knowledge products. The proposed working level arrangements can further be elaborated with consultation of the involved agencies and accordingly estimate can be firmed up. However, for the present an amount of Rs.300 cr. is considered appropriate for this activity.

3.2.7 Research Priorities

3.2.7.1 Suggested research priorities include research to support policy improvement, and in particular implementation, evaluation, linkages between policies and consideration of the effects on ecosystems. Research organisations and networks may be best placed to take the initiative on these issues, and in particular to communicate research information to policymakers in appropriate ways. Research priorities also include support for governance, particularly addressing the mismatch between hydrological health, environmental flows and the water demands of various sectors in an integrated manner. Research infrastructure should include a framework for integration, planning, monitoring and assessment. Within this, a series of components should also be suggested for addressing technical, environmental and social issues as well as support in negotiation and community participation.

3.3 Forests and other Natural Ecosystems

3.3.1 Forest sector is important in the context of climate change due to three reasons namely, (i) deforestation, forest degradation and land-use change contributes to about 20% of global CO_2 emissions, ii) forest sector provides a large and low-cost opportunity to mitigate climate change, and iii) forest ecosystems are projected to be adversely impacted by climate change, affecting biodiversity, biomass production and forest regeneration. Climate is one of the most important determinants of forest vegetation patterns and it is likely that changes in climate would alter the configuration of forest ecosystems in India.

3.3.2 In the context of climate change adaptation, the 11th Five Year Plan considered development to be the most important adaptation measure and achieving rapid economic growth to be a key element in adaptation. The National Action Plan on Climate Change (NAPCC) deals with the key vulnerabilities of India to Climate Change and, in particular, the impact on forests. As per State of Forest Report 2007 (FSI 2009) assessment, the forest cover of India is estimated to be 69.07 million hectare (Mha), which is 21.02% of the total geographical area of the country.

3.3.3 Analysis of climate change vulnerability and impacts

3.3.3.1 Forest ecosystems are intrinsically dynamic and are constantly influenced by climatic variations and are capable of adapting to the changes in the environment. However, climate change is expected to occur more rapidly than the rate at which ecosystems can adapt and reestablish themselves. It has been pointed out (Betts et al. 2008) that tropical forests are vulnerable to climate change and its impacts on them could be so severe as to threaten their structure, function and services. The fourth assessment report of IPCC (IPCC 2007) concluded that forest ecosystems could be seriously impacted by future climate change, even with moderate global warming of 1°C to 2°C.

3.3.3.2 Vulnerability is defined by the IPCC as *'The degree to which a system is susceptible to or unable to cope with, adverse effects of climate change, including climate variability and extremes'*. Impacts of climate change on forests have severe implications for the people who depend on forest resources for their livelihoods. With nearly 173,000 villages classified as forest villages, there is a large dependence of communities on forest resources in India.

3.3.3.3 Indian Institute of Science has conducted an assessment of the impact of climate change on forest ecosystems in India. A dynamic vegetation model IBIS (Integrated Biosphere Simulator) was used (Chaturvedi et al. 2011) to assess the impacts of climate change on forests in India. The study indicates that about 39% and 34% of the forested grids are likely to undergo shifts in vegetation type under A2 and B2 climate scenarios, respectively with a trend towards increased occurrence of the wetter forest types. Approximately 47% and 42% of tropical dry deciduous grids are projected to undergo shifts under A2 and B2 scenarios respectively, as opposed to less than 16% grids comprising of tropical wet evergreen forests. Similarly, the tropical thorny scrub forest is

projected to undergo shifts in majority of forested grids under A2 (more than 80%) as well as B2 scenarios (50% of grids). States such as Chhattisgarh, Karnataka and Andhra Pradesh are projected to experience change in 73%, 67% and 62% of the forested grids while in Madhya Pradesh it is about 50% under the A2 scenario. According to another study (Gopalakrishnan et al, 2011), projected impacts of climate change, using a moderate A1B scenario and IBIS vegetation model for the period of 2030s and 2080s, are projected in Figure 1, which show the impacts on current forested locations in India.

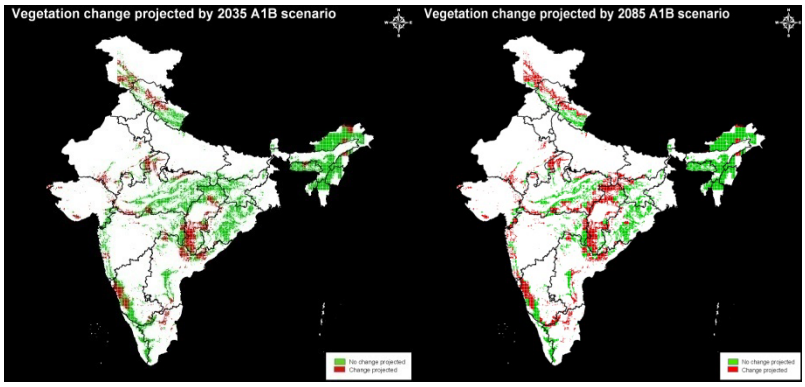


Figure 1. All forested grids in India are shown in color (red or green): red indicates that a change in vegetation is projected at that grid in the time-period of 2021-2050, and green indicates that no change in vegetation is projected by that period. The right panel is for the timeframe of 2071-2100.

3.3.4. Existing programmes, policies and initiatives

3.3.4.1 In tune with the nation's forest policy, the national strategy aims at enhancing and improving the forest and tree cover of the country thereby enhancing the quantum of forest ecosystem services that flow to the local communities. The services include fuelwood, timber, fodder, NTFP and also carbon sequestration. It is underlined that in the Indian context, carbon service from forest and plantations is one of the co-benefits and not the main or the sole benefit. Present initiatives like National Afforestation Programme (NAP) of the MoEF, together with programmes in sectors like agriculture and rural development are on an average adding or improving 1mha of forest and tree cover annually in our country. This annually adds about 1 million tonne of carbon incrementally, and combined with the accretion of biomass in our managed forests, protected areas, and in tree cover outside the government forests, the total carbon service at present is estimated at 138 mt CO_2 eq every year (Kishwan et al. 2009). The cost of the projected reforestation and afforestation activities contributing in mitigation and adaptation is estimated at Rs. 5,000 crores annually for the 12th Five Year Plan (FYP), or Rs. 25,000 crores for the entire FYP.

3.3.4.2 Both afforestation and reforestation in India are being carried out under various programmes, namely social forestry initiated in the early 1980s, Joint Forest Management Programme initiated in 1990, afforestation under National Afforestation and Eco-development Board (NAEB) programmes since 1992, and private farmer and industry

initiated plantation forestry. The "State Compensatory Afforestation Fund Management and Planning Authority" (State CAMPA) is intended as an instrument to accelerate activities for preservation of natural forests, management of wildlife, infrastructure development in the sector and other allied works.

3.3.4.3 National Afforestation Programme (NAP): The Centrally Sponsored Scheme, National Afforestation Programme (NAP) of National Afforestation and Eco-development Board (NAEB) assists rehabilitation of degraded forests through JFM Committees. The Programme was formulated by a merger of four 9th Plan centrally sponsored afforestation schemes of the Ministry of Environment & Forests, with a view to reducing multiplicity of schemes with similar objectives, ensuring uniformity in funding pattern and implementation mechanism, avoiding delays in availability of funds to the field level and *institutionalizing peoples participation in project formulation and its implementation*. The NAEB is responsible for promoting afforestation, tree planting, ecological restoration and eco-development activities in the country, with special attention to the degraded forest areas and lands adjoining the forest areas, national parks, sanctuaries and other protected areas as well as the ecologically fragile areas like the Western Himalayas, Aravallis, Western Ghats, etc. The scheme was envisaged to be implemented in a participatory mode, by involving two-tier set up namely the Forest Development Agencies (FDAs) and Joint Forest Management Committees (JFMCs).

3.3.4.4 Greening India Mission (GIM): The National Mission for a Green India, which is one of the eight Missions under the National Action Plan on Climate Change (NAPCC), recognizes the adverse impacts of climate change on the distribution, type and quality of natural biological resources of the country and associated livelihoods of the people. The Mission also referred to as GIM, recognizes the importance of forestry sector and its role in environmental amelioration though climate mitigation, food security, water security, biodiversity conservation and livelihood security of forest dependent communities. GIM puts "greening" in the context of climate change adaptation and mitigation. Greening is meant to enhance the ecosystem services such as carbon sequestration and storage (in forests and other ecosystems), hydrological services and biodiversity; as well as other provisioning services such as fuel, fodder, small timber and non-timber forest products (NTFPs). GIM aims to cover about 10 million hectares under different Sub-missions at a cost of Rs. 34,000 crores during the period 2011-2020. The Mission aims at responding to climate change by a combination of adaptation and mitigation measures, which would help in:

- enhancing carbon sinks in sustainably managed forests and other ecosystems;
- adaptation of vulnerable species/ecosystems to the changing climate; and
- adaptation of forest-dependent communities.

3.3.4.5 **Convergence with NREGA:** Inter-sectoral relationships between environment, forestry and rural development are recognized in the National Environment Policy 2006 and the National Forest Policy 1988. The national environmental goals are premised on the objectives of ensuring enhanced availability of environmental services, including recharge of surface and ground water, forest conservation, biodiversity conservation, soil

conservation, maintaining wildlife habitats, besides providing for the livelihoods of the poor.

There is also a realisation that the existing forestry institutions alone would not be able to meet the huge task of afforestation; they would require help of other existing institutions. NAP seeks to promote participatory process in rehabilitation of degraded forests through 30000 Joint Forest Management Committee (JFMC) at the village level. At the same time, MNREGA, implemented by the Ministry of Rural Development has, inter alia, an objective of strengthening the Natural Resource Management through the works that respond to drought, water scarcity, degradation of forests and depletion of soil productivity. MNREGA, therefore, provides an opportunity for developing productive natural resource base. Even more importantly, it generates co-benefits in terms of adaptation to climate change for the poorer sections of our population. .

Convergence between NREGA and NAP would be mutually beneficial and reinforcing. Implemented together in a manner that their operations converge will help minimize resources and optimize the results in terms of sustainable development. This would mean stronger inter-sectoral linkages. Moreover, public investment through sectoral allocation would not be sufficient. The central assistance for the afforestation per year is around Rs 350 crores. But, it is estimated that an investment of about Rs.1,50,000 Cr is needed to achieve 33% forest or tree cover from the present 23.39%. It is therefore felt that a convergence between NREGA and NAP is useful.

MoEF and the MoRD have already developed guidelines for convergence between NREGS and NAP, with the salient features being (i) an institutional mechanism in the form of District and Block level Resource Groups for facilitating knowledge sharing, planning, communication, training, technical support, resource pooling and monitoring and evaluation,(ii) preparation of perspective and annual plans on ecological basis, (iii) gap filling and value addition through NREGA for similar works under NAP, dovetailing inputs in to a common project, area based approach and technical support for execution of NREGA works, and (iv) treating Joint Forest Management Committees as implementing agencies. 18 Districts across the country have been selected for pilot implementation keeping in view representative bio-geographic zones and socio-economic situations. The experience gained will further inform and refine our strategy for convergence.

Convergence being an evolving process, the guidelines need to be considered as an instrument for realizing the synergy for common goals accommodating the situational nuances in implementation. Pooling of resources under forestry (either under NAP or Green India Mission) at the district and level with those of MoRD under MNREGA will enhance the impact of both programmes and contribute to adaptation of communities to climate change.

3.3.5. Recommendations

Mitigation and Adaptation are the two options for addressing climate change. Forest sector also provides opportunity for promoting synergy between mitigation and adaptation.

3.3.5.1 . Mitigation in the Forest sector : Climate change mitigation involves reducing GHG emissions or enhancing sinks in forests and soil. Forests can contribute to climate change mitigation (IPCC, 2007) by increasing carbon density of existing forests at both stand and landscape scales and reducing emissions from deforestation and degradation. According to the IPCC, the mitigation potential of forest sector is estimated to be in the range of 8.2 to 13.5% of the total mitigation potential, considering all sectors. Carbon stock enhancement involves restoring carbon stocks in degraded forests, or creating forests where none currently exist and approaches include afforestation, reforestation, restoration through natural regeneration, assisted natural regeneration or planting, rehabilitation, or forest landscape restoration (Miles et al., 2010). Mitigation in the forest sector is proposed using the following scenarios for the 12th Plan period:

1. **Business-as-usual (BAU) scenario:** According to Ravindranath et al (2008), assuming that the current trend in area under forests and afforestation continues, the area under forest cover is projected to reach 72 Mha by 2030. The estimate of carbon stock in Indian forests in both soil and vegetation is estimated to range from 8.58 to 9.57 GtC. The carbon stock in existing forests is projected to be nearly stable over the next 25 year period at 8.79 GtC. However, if the current rate of afforestation and reforestation is assumed to continue, the carbon stock could increase from 8.79 GtC in 2006 to 9.75 GtC by 2030 – an increase of 11%. The estimates made in this study do not include forest degradation and loss of carbon stocks due to biomass extraction, fire, grazing and other disturbances.

2. **Greening India Mission scenario:** The Greening India Mission targets 10 m ha of forest/non-forest lands and includes: a) qualitative improvement of forest cover/ecosystem in moderately dense forests (1.5 m ha), open degraded forests (3 m ha) , degraded grassland (0.4 m ha) and wetlands 0.1 m ha; b) eco-restoration/afforestation of scrub, shifting cultivation areas, cold deserts, mangroves, ravines and abandoned mining areas (2 m ha); c) bringing urban/ peri-urban lands under forest and tree cover (0.20 m ha); and d) agro-forestry /social forestry (3 m ha). The actual implementation period of the Mission will spread over 10 years, coinciding with the 12 and 13 five year plan periods. The incremental annual mitigation potential of the Mission interventions is estimated to be about 55 $MtCO_2$ in the year 2020, using moderate to conservative carbon accumulation rates.

3. **33% Forest cover scenario:** Government of India has set a long term goal of bringing 33% of geographic area under forest cover**.** The mitigation potential of afforestation policy in India for the forest sector over the period of 2010–2030 was assessed (Chaturvedi et al 2010), considering two scenarios:

   Rapid afforestation rate scenario-2020 (achieving the 33% goal by 2020) and a **moderate afforestation rate scenario-2030** (achieving the 33% goal by 2030). The

projected afforestation could mitigate 5.2 $GtCO_2$ under scenario-2020 over the 2010–2030 period, compared with 3.96 $GtCO_2$ under scenario-2030, over the same period. The aggregate mitigation potential in scenario-2020 is estimated to be approximately 3.2 $GtCO_2$ over the baseline, while in scenario-2030, the overall increase in mitigation potential is approximately 1.8 $GtCO_2$ which shows that rapid afforestation under scenario-2020 will lead to an incremental 1.4 $GtCO_2$ mitigation potential over scenario-2030.

3.3.5.2 Adaptation to climate change : The IPCC defines **adaptation** as *"Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities".* Adaptation to current climate variability can also increase resilience to long-term climate change and is required irrespective of the mitigation efforts at the global and national level due to the committed climate change. Forest ecosystems can be considered as vulnerable based on several ecological and socio-economic factors. Further, projected impacts for India indicate that 40% to 70% of the forested grids in different states are likely to experience change under a changed climate, resulting in forest die back and loss of biodiversity, which is irreversible (Gopalakrishnan et al. 2011). There is a large dependence on forests for fuelwood, fodder, non timber forest products and livelihoods. Thus, there is a need to consider adaptation to climate change in planning and implementation of all forest developmental programmes. Adaptation practices are likely to vary for different forest types and regions, depending on the current status of the forests, knowledge of the projected impacts and access to information on suitable silvicultural practices and forest management strategies. Some examples of the 'win-win' adaptation practices are as follows (Murthy et al 2011):

- Expand Protected Areas and link them wherever possible to promote migration of species
- Promote forest conservation since biodiversity rich forest are less vulnerable due to varying temperature tolerance of plant species
- Anticipatory planting of species along latitude and altitude
- Promote assisted natural regeneration
- Promote mixed species forestry
- Promote species mix adapted to different temperature tolerance regimes
- Develop and implement fire protection and management practices
- Adopt thinning, sanitation and other silvicultural practices
- Promote in situ and ex situ conservation of genetic diversity
- Develop temperature, drought and pest resistance in commercial tree species
- Develop and adopt sustainable forest management practices
- Conserve forests and reduce forest fragmentation to enable species migration
- Adoption of energy efficient fuelwood cooking devices to reduce pressure on forests.

Forest planning and development programmes and policies may have to be altered to address the likely impacts of climate change and appropriately adopt various policy and management practices to minimize the adverse impacts and vulnerability.

3.3.6. Research and monitoring:

Climate change projections, impacts on forest sector, vulnerability of forest sector to climate change and adaptation strategies to cope with climate change are characterized by uncertainty and limited research and learning from the field. India should launch a long-term research and monitoring programme on various aspects of climate change and forests to enhance its ability to forecast and take preventive and adaptation measures.

3.3.6.1 Systematic observations: Currently, there is no systematic meteorological observations network to understand the "Forest and Climate". Forests observations should necessarily institute forest meteorological network, and soil moisture observations during 12 FYP. The data on a near real time should be monitored by a central research laboratory for data dissemination in public domain. The data collection should also enhance process-based modeling to understand the climate change scenarios and changing forests. The "Green India Mission" (GIM) should ensure 66% of forest cover in the hilly regions having 15% of slope and 33% of the geographical area in the gentle rolling lands. The monitoring mechanism and spatial and temporal performance of Green India activities should be imposed through high resolution IRS satellite image based monitoring and updating the progress on a geospatial context should become mandatory.

3.3.6.2 "Long Term Ecological Sites" (LTES) : Considering the lack of systematic climatic responses and observations on "**forest and climate"** it is prudent to implement "Long Term Ecological Sites" (LTES) their maintenance, measurements, monitoring the responses both in terms of structure and functions across the country of Indian Forest Vegetation. During the 12 FYP, at least 20 – 25 plots be developed each one with a plot size of 1 sq.km. These sites should be selected based on representativeness, geospatially mapable through satellite applications and the monitoring of variables with respect to LTES should be web enabled for research use and public access as per the protocols of MOEF. The implementation of such LTES areas in the Indian forests may provide, in the long term, the forest responses to the changing climate.

3.3.6.3 "Terrestrial Laser Scanners": Conventionally, Indian forestry practices maintain silvi cultural plots for assessing growth and productivity of the forest resources across the country. The long term monitoring of such forest metrics provide insights on the responses of forest vegetation to the changing climate. However, in India, there is no long term physically measured network of field plots representing all the 225 forest types of the country. It is imperative to reaugment the network and initiate a well coordinated, geo-referenced, well designed protocol-based silvi-cultural plot network in the country to begin during 12thFYP. The modern methods of "Terrestrial Laser Scanners" (TLS) should be employed for all the field plots and register from various corners the scanned images archived on an annual basis along with field mensuration and phyto-sociological data. This would go a long way in facilitating verification and implementing modern methods of forest mensuration. The long term data of such network measurements will provide **productivity indices** of the respective forest types as an indicator for climate change monitoring and to ascertain suitable thresholds for silvi culture interventions.

MoEN&F jointly with nearby university system is worked out to obtain scientifically managed measurements.

3.3.6.4 **Ecological hotspots:** The ecological hotspots in the country need to be given specific attention for eco system development and process understanding of the region. The climatically sensitive regions of India, in order of priority are: Himalayan glaciers, Alpine grass lands, coastal habitats, North eastern forest areas, Western ghats, Indo-gangetic plains and Andaman Nicobar Islands etc. India should undertake comprehensive understanding and resource auditing of these eco-systems both interms of physical, functional and dynamical changes that are happening in these regions need to be understood holistically. The 12 FYP should initiate a systematic action plan involving lead scientific departments, **corporate sector**, prominent NGOs for defining and planning for actionable programmes for the sustainability of these sensitive habitats as a priority.

3.4 Coastal Areas

3.4.1 Indian coast line is prone to undergo severe impact due to increased frequency of climatically induced extreme events like cyclones, storm surge, high-tides resulting in flooding of vast stretches of area all-along coast line. The coastlines of Andaman and Nicobar Islands in the Bay of Bengal and Lakshadweep Islands in the Arabian Sea is 7517 km of which 81% (6100 km) is along the Indian mainland surrounded by Arabian Sea in the west, Bay of Bengal in the east, and Indian Ocean in the south. More than 40 million people reside along this coastline. There are 13 Coastal States and union territories susceptible to sea level rise in the country, with about 84 coastal districts affected by tropical cyclones. Four States (Tamil Nadu, Andhra Pradesh, Orissa and West Bengal) and one UT (Puducherry) on the East Coast and one of the States on the West Coast, Gujarat, are the States that are the most affected by cyclonic activities. The mega cities of Mumbai, Chennai, Kolkata lie along this coastline. Additionally it is dotted with several major ports such as Kandla, Mumbai, Navasheva, Mangalore, Cochin, Chennai, Tuticorin, Vishakhapatnam, and Paradip.

3.4.2 A large portion of the population along the coastline is dependent on climate dependent activities such as marine fisheries and agriculture. Sea level changes and occurrence of extreme events such as cyclones and storm surges are of considerable significance for India as these adversely impact on human populations living in coastal regions and on islands as well as the sensitive ecosystems such as the mangroves (e.g. the Sundarbans). The flooding results in loss of coastal habitat and displacement of human habitations. The threatening consequence due to coastal inundation and to identify coastal vulnerability should, therefore, be attached high priority during 12th FYP.

3.4.3 Observations and Projections:

- The total frequency of cyclonic storms that form over north Indian Ocean does not show any significant trends during the period 1891-2008, but a slightly decreasing trend[1].

- An analysis of past tide gauge records of long duration for the Indian coastline regions gives an estimate of average sea-level-rise trend as 1.30 mm/year (Table 1)[2], which is consistent with the values reported elsewhere[3,4]. However, in the Indo-Gangetic deltaic region, for instance at Diamond Harbour (Kolkata), the record shows a trend of 5.74 mm/year, which is partly attributed to the subsidence in the delta[2].

- Future global projections for a moderate climate scenario A1B indicate an average sea-level rise of 0.35 m towards the end of the century (Table 2)[5].

- There is low confidence in the projections of tropical cyclones in the climate models. However, there is high confidence in studies that indicate that mean sea-level-rise can cause increased flood risks associated with storm surges[6].

Table 1: Mean-sea-level-rise trends along the Indian coast

Tide gauge Station	Number of years of available data	Trends (mm/yr)	Glacial Isostatic Adjustment (GIA) Corrections (mm/yr)	Net sea level rise (mm/yr) trends
Mumbai	113	0.77	-0.43	1.20
Kochi	54	1.31	-0.44	1.75
Vishakhapatnam	53	0.70	-0.39	1.09
Diamond Harbour (Kolkata)	55	5.22	-0.52	5.74

Table 2: Global sea-level-rise projections for different SRES scenarios

	Sea Level Rise in m (5 % and 95 % range)
	in 2090-2099 with respect to 1980-1999)
Case	**Model-based range excluding future**
	rapid dynamical changes in ice flow
Constant Year 2000 concentrations	NA
B1 scenario	0.18 – 0.38
A1T scenario	0.20 – 0.45
B2 scenario	0.20 – 0.43
A1B scenario	0.21 – 0.48
A2 scenario	0.23 – 0.51
A1FI scenario	0.26 – 0.59

[a] Year 2000 constant composition is derived from AOGCMs only.

Source: Meehl et al., 2007, IPCC WGI

3.4.3 Current knowledge on future vulnerabilities

- Sea-level rise would threaten coastal mangrove ecosystems and flora and fauna in nearshore regions, while increase in sea surface temperature would result in bleaching and death of coral reefs. This would compromise the livelihoods of people dependent on fisheries.

- There is low confidence in projections of tropical cyclones. However, there is high confidence in projections of mean sea-level rise which could cause increased flood risks from storm surges.

- Increase in sea surface temperature will cause probable decline of the coral reef ecosystem, affect fish breeding, migration and harvests.

- Salt water intrusion may take place into agricultural fields because of coastal inundation.

3.4.4 Institutional Mechanism

Protection and management of coastal areas is an area that is not specifically covered under any of the national missions. Indeed, scope exists for coastal zone-specific adaptation strategies being evolved under several Missions e.g. sustainable habitat, agriculture, water etc. This is however a gap that needs to be filled. The Integrated Coastal Zone Management (ICZM) policies are designed to afford protection against these vulnerabilities. Coastal zone regulations concerning construction activities have recently been modified to take into account the likely prospect of long-term sea-level rise.

3.4.5 Recommendations for Adaptation strategy for the Coastal zone

- Climate Change Impact Assessment needs to be integrated into the already existing practice of cumulative impact assessment of the environment

- ICZM must be accorded enhanced priority in the context of climate change.

- Flood inundation to be estimated for megacities and other vulnerable regions along the coast through modelling and GIS techniques

- Monitoring mechanisms need to be strengthened through the installation of tide gauges, HF radars for tides, early warning systems etc. along the coast. **T**he conventional mode of identifying vulnerable zones would miss the likelihood scenarios. Comprehensive modeling of the coastal processes incorporating all the necessary basic parameters is essential for undertaking mitigation and adaptation strategies. The existing capability of MOES and NRSC, ISRO may be employed during 12th FYP and suitably enhanced where necessary.

- Infrastructure development near the coast needs to be planned by considering sea level rise and Coastal Regulatory Zone rules.

- Planting of mangroves, which offer natural protection from extreme events.

- Land-use control and dissemination of information.

- Scientific evaluation of the potential changes in the coastal zone and development of appropriate advisories to stake holders.

3.5 Health impacts

3.5.1 Introduction

3.5.1.1 There is a growing concern in both medical and climatological communities that global climate changes are likely to effect human health. Global climate changes may adversely affect mortality and morbidity rates through the general warming. Rich countries produce most of the world's greenhouse gases, but it is the health of people in poor countries that suffers the most from global warming. The World Health Organization estimates warming and precipitation changes due to climate change claim 150,000 lives every year. The WHO warns that the risk of death and disease from climate change will double in the next 20 years. Thus global warming is no longer an environmental problem, but has become threat to public health. Diseases such as malaria, yellow fever, dengue and cholera are all sensitive to climate change. Many are spread by insects like mosquitoes, which prefer a wetter, warmer world. Deaths from heart diseases and respiratory illness during heat waves and malnutrition from crop failures add to the toll.

3.5.1.2 Due to growth in population in last few decades together with the rapid growth in industry and consequent higher energy consumption, there has been depletion of forest cover for converting into agricultural land, encroachment for settlement and increased harvesting of forest for biomass fuel. Similarly, in developing country such as India, rapid population growth, industrialization, increased energy consumption and degrading air and water quality may lead to major health impacts due to resulting climate change.

3.5.1.3 Increase in temperature, precipitation and extreme events are predicted to have an effect on the viability and the geographical distribution of the mosquitoes that transmit malaria. The Global warming is anticipated to increase the mosquito survival rates especially in temperate areas. In developing countries like India, rapid population growth and low incomes have resulted in large scale rural urban mitigation resulting in chaotic and unplanned urbanization. Besides, the combustion of fossil fuel and biomass will continue to be the dominant source for energy in India even in late 21^{st} century. The combustion of these fuels result in the emission of such as CO_2, CO, NO, SO_2, hydrocarbons, etc. The exposure to these pollutants can have a wide range of health effects. In metropolitan cities such as Delhi, with increase in the number of vehicles and subsequent release of pollutants cause considerable damage is caused to the respiratory system. Complex effects such as bronchitis, pulmonary edema, chronic bronchitis, cancer and eye related diseases are reported at higher doses.

3.5.2 Climate Change and Health Effects:

3.5.2.1 The health status of millions of people is projected to be affected through, for example, increases in malnutrition; increased deaths, diseases and injury due to extreme weather events; increased burden of diarrhoeal diseases; increased frequency of cardio-respiratory diseases due to higher concentrations of ground-level ozone in urban areas

related to climate change; and the altered spatial distribution of some infectious diseases. The climate change is projected to bring some benefits in temperate areas, such as fewer deaths from cold exposure, and some mixed effects such as changes in range and transmission potential of malaria in Africa. Overall it is expected that benefits will be outweighed by the negative health effects of rising temperatures, especially in developing countries. The change in stratospheric ozone and corresponding change in Ultra violet radiation over the years are correlated with eye diseases. Critically important will be factors that directly shape the health of populations such as education, health care, public health initiatives, and infrastructure and economic development (IPCC, Fourth Assessment Report,2007).

3.5.3 ICMR's Initiative on Global Environment and Health

3.5.3.1 ICMR has identified four areas of risks arising from climate change, such as (a) Climate Change and Vector Borne diseases, (b) Aerosols and Respiratory Diseases, (c) UV-A and UV-B and Corneal Damage and Cataract and (d) Environment and Heart Diseases. Following this assessment, the ICMR has constituted Task Force Groups such as (a) Vector Borne Diseases and Climate Change (b) Respiratory Diseases and Air Pollutants and (c) Eye Health and Environment with tasks as follows:-

- Under the Task Force on 'Vector Borne Diseases and Climate Change', the multi-centric study entitled "Evidence based assessment of biophysical determinants of malaria in the northeastern states of India and development of framework for adaptation measures for malaria control under climate change scenarios" is being conducted.

- Under the Task Force on Eye Health and Environment, the multi-centric proposal entitled," Multi-centric Collaborative Study on the impact of Global warming and Ultra Violet Radiation (UVR) exposure on ocular health in India," has been initiated.

- Under the Task Force on Respiratory Diseases, a multi centric study on, "Impact of Meteorological Changes and Air Pollution on Respiratory Health and Morbidity", is in the process of initiation.

3.5.3.2 Additional priority areas of research during 12^{th} plan are proposed in the areas of climate change variability and its effect on diarrheal and viral diseases, heat stress and certain types of cancer such as skin cancer. Other multi-disciplinary long term studies would be initiated in partnership with Indian Meteorological Department, Central Pollution Control Board and Indian Space Research Organizations.

3.6 Economic Impacts

Introduction

3.6.1 India's First National Communication (2004) had initiated a process of scientific assessment of the nature, quantum and spatial occurrence of extreme events to be experienced in the future against the climate change scenario. [The details of simulation exercises carried out in course of preparing India's Initial National Communication (2004), as may be relevant for knowledge of vulnerability of infrastructure, are available in the NATCOM 2004 and hence, are not reproduced here.] This assessment has been consolidated through the "Climate Change and India: A 4 x 4 Assessment" study. Model outputs of this assessment have enhanced the knowledge around assessment of extreme events to enable consolidation of the disaster management framework.

3.6.3 In the light of the "likely" enhanced impacts due to climate change and its manifestation in the form of occurrences of extreme weather events, both in frequency and intensity, it is imperative to enhance the understanding of such possible impacts in the future. Disaster management needs to be strengthened from the perspective of an enhanced understanding of the nature and magnitude of the occurrences of extreme weather events in the future and their projections. These would help in proactively identifying vulnerable regions/areas and acting appropriately thereof.

3.6.4 The National Action Plan on Climate Change (NAPCC) recognizes this need and the imperative to respond to extreme climatic events through two main approaches, namely; mainstreaming disaster risk reduction into infrastructure project design and strengthening of the communication and information networks and ensuring disaster management facilities at all levels. In the case of protecting coastal areas from impacts such as rise in sea-level, rise in the high-tide level, and cyclones and storms; the approach again is two pronged, namely; coastal zone protection and deployment and use of early warning systems.

Economic impact

3.6.4 Economic impacts of climate change on infrastructure and industry are generally measured as costs in terms of adaptation, prevention, damage, or palliation. While damage costs or losses are costs due to an adverse climate change impact, preventive adaptation costs are costs to prevent adverse impacts from occurring. On the other hand, palliative adaptation costs refer to full restoration costs after the climate change impacts have taken place. There may also be residual damage costs i.e. costs arising due to any uncovered risks.

3.6.5 Costs for preventive adaptation should be built into the 12^{th} FYP as a relevant factor for Plan allocation. NAPCC is the action plan and budgets of the 8 missions therein generally indicate the preventive costs of direct action for climate change adaptation and mitigation. However, there is a case for assessing, in particular, the costs of adaptation of infrastructure to climate change and building climate resilient infrastructure.

Climate Change & Infrastructure (including energy infrastructure)

3.6.6 Since infrastructure has a pivotal role to play in development, the large investments planned for future have to be protected against climate-change induced risks. These risks span beyond physical risks as strict mitigation regimes could jeopardize their profitability and even future existence. An integrated climate change risks management framework for infrastructures thus needs to be created including market and policy induced enforcements and adaptation strategies. The key to manage risks lies in identifying them and initiating appropriate risk management and adaptation initiatives.

3.6.7 Energy sector also requires creation of infrastructure for energy resource extraction, energy import and export, domestic handling and transport, conversion of primary to secondary energy forms, energy evacuation networks, distribution to end-users, and disposal of waste generated in the entire energy chain. These are covered under infrastructure discussions in this submission. Energy systems could also change due to voluntary and regulatory mitigation regimes for greenhouse gas emissions.

3.6.8 The total investment envisaged on infrastructure during the 11th Five Year Plan was about US$ 500 billion, which is likely to double during the 12th Plan period (Planning Commission, 2008). The latest trends in share of public and private sector investments in total infrastructure investments are around 70:30. There are sectoral and regional variations in this share.

3.6.9 Some estimates indicate that the costs of adaptation to climate change impacts for an existing infrastructure would be almost 2 to 3 times higher than those for a new infrastructure, since appropriate preventive measures could be adopted for new construction.

3.6.10 Detailed sectoral, regional and integrated studies need to be commissioned during the 12th Plan for uncertainty and risk assessment to Indian infrastructure due to climate change, especially to establish damage functions and costs.

3.6.11 Some early assessments for specific sectors and locations suggest that climate change adaptation costs for new infrastructure could generally be in the range of 3-10 per cent of total investment, although for certain sectors and locations this may be much higher. This however does not cover adaptation against all likely future damages due to climate change. These costs are termed as residual damage costs. These residual damage costs could be much higher for even very low probability events since risk coverage is not normally taken for these rare events. For instance, a super cyclone hitting a coastal refinery in Maharashtra at a place where such events have not occurred so far, and are therefore are very low probability events.

3.6.12 For existing assets, the adaptation costs could be up to 25% of present costs of creating similar assets. This does not include damage costs and residual damage costs.

Here again for very low probability extreme events, the residual damage costs may be much higher.

3.6.13 Small projects, such as a single residential building may not pose any viable threats to a natural ecosystem (such as lake) in the vicinity. However if many such buildings come up in the vicinity, then there could be serious adverse impacts on the lake due to combined impacts of all these buildings. This applies for all infrastructures in various sectors as well. Assessments by neutral third parties may therefore be conducted for all such upcoming infrastructure projects. Environmental Impacts Assessment of new infrastructure projects should also include impacts of climate change on the project in near, medium and long-terms.

3.6.14 Recommendations for climate resilient infrastructure

3.6.14.1 India has voluntarily committed to reduce national GHG intensity of GDP by 20-25% during 2005-2020 under the Copenhagen Accord. Creating low GHG infrastructure in energy intensive industries and transport sectors during the 12th and 13th Five Year Plans, while simultaneously reducing the GHG intensity of existing infrastructure, would therefore play an important role in meeting these goals and commitments. GHG emissions from construction and operation of each upcoming infrastructure project may therefore be estimated during the 12th and 13th Five Year Plans.Inclusive growth for the poor and vulnerable, especially for the vast rural populations, would require enhanced adaptation to climate change and would generally result in higher GHG emissions.

3.6.14.2 For instance, higher GHG emissions would occur for constructing rural infrastructure such as roads, schools and hospitals; extending irrigation facilities to dry and vulnerable farmers; providing modern cooking fuels such as LPG instead of traditional biomass and kerosene; and extending affordable electricity to each household in India. Therefore to meet India's commitment in reducing GHG intensity of GDP, Millennium Development Goals, and national sectoral targets; these additional emissions due to inclusive development have to be mitigated by sectors and regions that can do so at a relatively lower cost to the national economy.

3.6.14.3 Modern adaptation on the other hand could enhance resilience with relatively lower GHG emissions such as deploying micro irrigation systems, high yielding seeds that can withstand water scarcity, solar home systems, more modern bioenergy, etc.

3.6.14.4 The 12th Plan document should therefore focus on creating and analyzing alternate developmental pathways that would provide different combinations of GHG mitigation and adaptation. National Action Plan on Climate Change and the Missions thereof could be updated to include this.

Climate Change & Trade & Business

3.6.15 Climate change is seen as a strategic issue which requires special attention, and leading companies have begun to take action to mitigate the risks and take advantage of the opportunities arising from it to ensure a position for themselves in the emerging low-carbon global economy. The business risks associated with climate change have mainly four drivers:-

Public Concern	*Public concern and market pressures favouring "green" companies may affect ability to market products and ability to mobilize investment for perceived "dirty" industries.*
Governmental Action	*Governmental actions to reduce emissions intensity of greenhouse gases, varying in strength/emphasis/sector.*
Developments in Markets, Knowledge and Technology	*Recent and ongoing developments in markets, knowledge and technology enabling businesses to cut carbon emissions while increasing productivity.*
Climate Change	*Likely physical risks in form of disruption of supply chain, physical infrastructure and networks.*

3.6.16 There are many types of possible risks for business that could emanate from the four drivers mentioned above. An indicative list of climate change risks is provided below:

(a) Regulatory risk: Companies with significant GHG emissions face risks from new state, national and international regulations limiting carbon emissions and imposing a cost on the same. While the developed countries already have mandatory climate change legislation in place, the momentum for similar legislations in many countries is growing. California and ten North-eastern states in the USA have already taken regulatory action to ensure emission reductions. Japan, China and others have instituted GHG emission reduction targets, fuel emission standards and renewable energy mandates. Meanwhile, the entire EU is pushing to reduce GHG emissions under an ambitious cap-and-trade carbon emissions trading programme already valued at over US $30 billion a year. All major companies - from manufacturing and service sectors - will be impacted by the fast-spreading regulations.

Many of the schemes introduced by the Govt. of India [e.g., PAT, RPO, REC] are already making Indian companies rethink their business strategies. It is also worthwhile to note that from 2012, all carriers flying in and out of Europe will be subject to a carbon tax under the EU-ETS scheme. This will include Indian carriers.

(b) Physical risk: Physical impacts of climate change, including the increased intensity and frequency of severe weather events such as prolonged droughts,

floods, storms and sea level rise, resulting in supply chain disruptions, all constitute a physical risk. With climate change impacts becoming more pronounced, an increasingly urbanised population may become vulnerable to new flood risks.

(c) ***Reputational and competitive risk***: Closely linked to the regulatory risk in the global and domestic market places, climate risk preparedness is a key driver in a company's ability to compete. General Electric, for example, sees huge growth opportunities from its many new climate-friendly product lines, such as wind turbines, high efficiency gas turbines, IGCC power plants and hybrid diesel-electric locomotives. India is already a production hub of small, fuel-efficient cars, and its potential has increased as most European and American auto manufacturers realise the competitive risk arising out of smaller cars.

Further, Indian credit rating agencies such as CRISIL and financial institutions such as SBI, ICICI Bank, IDBI Bank, IDFC, Yes Bank and others have started using information on disclosures by businesses in their assessment of a company's performance.

(d) ***Litigation Risk***: Global companies in carbon-intensive sectors, such as oil and gas, electric utilities and automobile manufacturing, have begun facing litigation concerning corporate contributions to global climate change. These are mostly seen in countries with carbon-related legislation. Car manufacturers exporting to the EU are impacted by stringent emission norms applicable in the European market. Similarly, large global cement manufacturers are now facing a litigation risk for high emissions during production. The potential liability is immense should the courts find companies guilty in such cases. Even if some of lawsuits are unsuccessful, the costs of litigation and the damage to reputation incurred will be detrimental.

(e) ***Disruptive Market Innovation***: Climate change threats will not be assuaged incrementally. New business models and innovations are more likely to catalyse transformational change, and sudden discontinuities may well topple many of today's market incumbents.

(f) ***General Risks*****:** General risks associated with climate change are those which arise due to energy and/or resource scarcity caused by a variety of scenarios. Price changes prompted by scarcity, changes in consumer attitude and demand, production and supply chain or supply process disruption are all feasible general risks.

The position of a company in the market-place as well as its profitability will be affected by the way in which it manages its risk. These risks can, on the other hand, be turned into opportunities benefiting both businesses and the environment in which they operate.

Climate Change & Industrial growth

3.6.17 The year-on-year growth of the overall Index of Industrial Production (IIP), which is a measure of the absolute level and percentage growth of industrial production, has been showing a steady increasing trend (Table 1).

Table 1: Industrial growth rate registered in India

Year	Growth Rate (%)	Year	Growth Rate (%)
1995-96	13	2001-02	2.8
1996-97	6.1	2002-03	5.8
1997-98	6.7	2003-04	6.9
1998-99	4.1	2004-05	8.4
1999-00	6.7	2005-06	8.2
2000-01	5	2006-07	10.6

3.6.18 Data released by the Central Statistical Organization (CSO) shows the growth of India's Gross Domestic Product (GDP) for 2006-07 at constant prices in 2006-07 at 9.6% [2]. The industrial sector contributed 26.8% of India's GDP for 2006-07 [3]. The implicit significance of this growth story is the amount of resources being used, and the consequent pollution levels, with special emphasis on the quantity of the Green House Gases (GHGs) emitted.

Table 2: Trends of GHG emission in India

GHG sources and sinks [4]	1990 (tCO_2e)	1994 (tCO_2e)	2000 (tCO_2e)	CAGR, % (1999-2000)
Total emissions	987,885	1,228,539	1,484,622	4.2
Industrial Processes	24,510	102,710	168,378	21.3
Per capita emissions	1.2	1.3	1.5	

CAGR = Compounded Annual Growth Rate

3.6.19 Inventorization of national GHG emissions related to various sectors like energy, industrial processes and product use, agriculture, forestry etc., would help analyse and implement opportunities for reducing the intensity of emissions, including energy management and product use efficiency initiatives. The Industrial Processes and Product Use (IPPU) sector includes GHG emissions produced as a direct by-product of non-energy industrial activities and the emissions involved during the non-energy use of materials which are produced by a process and used as a product in other processes. [In the Second National Communication (2012), Product Use sector is taken along with Industrial Processes sector.]

Initiatives taken by Industry

3.6.20 Industry has recently taken several voluntary initiatives in trying to adapt themselves to emerging challenges from climate change. These include both the manufacturing and service sectors. Some of these are evident in (i) development of fly-

ash cement concrete, (ii) green buildings movement, (iii) carbon foot-printing [using ISO 14064, WRI-WBCSD GHG Protocol, IPCC Guidelines, etc.], (iv) voluntary public disclosure of information relating to sustainability performance [e.g., sustainability reports using the Global Reporting Initiative [GRI] guidelines; submitting information in the Carbon Disclosure Project [CDP] in India, etc.], and (v) constituting and forming the Digital Energy Solutions Consortium [DESC] project, aimed at helping businesses strengthen the efforts of the Govt. of India in meeting the plans and objectives of the 8 National Missions under the NAPCC.

SECTION 4

National Action Plan on Climate Change

4.1 India released its National Action Plan on Climate Change (NAPCC) on 30th June 2008 to outline its strategy to meet the challenge of Climate Change. The National Action Plan advocates a strategy that promotes, firstly, the adaptation to Climate Change and secondly, further enhancement of the ecological sustainability of India's development path.

4.2 NAPCC stresses that maintaining a high growth rate is essential for increasing living standards of the vast majority of people of India and reducing their vulnerability of the impacts of climate change. Accordingly, the Action Plan identifies measures that promote the objectives of sustainable development of India while also yielding co-benefits for addressing climate change. Eight National Missions which form the core of the National Action Plan represent multi-pronged, long term and integrated strategies for achieving key goals in the context of climate change. The focus is on promoting understanding of Climate Change, adaptation and mitigation, energy efficiency and natural resource conservation. While, several of these programmes are already a part of the current actions, the Action Plan seeks to enhance them in scope, and effectiveness and implement them in an accelerated manner through time bound plans.

4.3 National Missions

4.3.1 The National Solar Mission aims at increasing the share of solar energy in the total energy mix through development of new solar technologies, while attempting to expand the scope of other renewable and non fossil options such as nuclear energy, wind energy and biomass.

4.3.2 The National Mission on Enhanced Energy Efficiency comprises of four initiatives, namely, a market based mechanism for trading in certified energy savings in energy-intensive large industries and facilities, accelerating the shift to energy efficient appliances in designated sectors, demand side management programmes in all sectors by capturing future energy savings, and developing fiscal instruments to promote energy efficiency.

4.3.3 The National Mission on Sustainable Habitat attempts to promote energy efficiency in buildings, management of solid waste and modal shift to public transport including transport options based on bio-diesel and hydrogen.

4.3.4 The National Water Mission has, as its objective, the conservation of water, minimizing wastage and ensuring more equitable distribution both across and within states.

4.3.5 The National Mission for sustaining the Himalayan Ecosystem is aimed at evolving management measures for sustaining and safeguarding the Himalayan glacier and mountain eco-system.

4.3.6 The National Mission for a Green India focusses on enhancing eco-system services and carbon sinks through afforestation on degraded forest land in line with the national policy of expanding the forest and tree cover to 33% of the total land area of the country.

4.3.7 The National Mission for Sustainable Agriculture would develop strategies to make Indian agriculture more resilient to climate change through development of new varieties of thermal resistant crops, new credit and insurance mechanisms and improving productivity of rainfed agriculture.

4.3.8 The National Mission on Strategic Knowledge for Climate Change is intended to identify the challenges of, and the responses to, climate change through research and technology development and ensure funding of high quality and focused research into various aspects of climate change.

4.4 Other Initiatives

4.4.1 Apart from the eight National Missions, the National Action Plan also envisages other initiatives aimed at enhancing mitigation and adaptation. These include:

- research & development in the area of ultra super critical boilers in coal-based thermal plants;
- integrated gasification combined cycle technology to make coal based power generation efficient;
- setting up more combined cycle natural gas plants; promotion of nuclear energy through adoption of fast breeder and thorium-based thermal reactor technology in nuclear power generation;
- adoption of high-voltage AC and high-voltage DC transmission to reduce technical losses during transmission and distribution;
- development of small and large scale hydro power;
- promotion of renewable energy technologies such as bio-mass combustion and gasification-based power generation;
- enhancements in the regulatory/tariff regimes to help mainstream renewable-based sources in the national power system; and
- renewable energy technologies for transportation and industrial fuels.

4.4.2 In addition, the Action Plan envisages:

- effective disaster management strategies that include mainstreaming disaster risk reduction into infrastructure project design,
- strengthening communication networks and disaster management facilities at all levels; protection of coastal areas,
- provision of enhanced public health care services, and assessment of increased burden of vector-borne diseases due to climate change.

- Increased role of Central Government, State Governments and local Bodies in putting in place appropriate delivery mechanisms and building adequate capacity and knowledge in the relevant institutions for effective adaptation and mitigation actions.

4.5 Institutional Mechanism

4.5.1 Government of India has set up an elaborate institutional mechanism to consider and address issues relating to climate change. A Council chaired by Prime Minister called 'Prime Minister's Council on Climate Change' was constituted in June 2007 to coordinate national action for assessment, adaptation and mitigation of climate change. The Council provides the overall guidance to climate change related actions taken by various Ministries in the Government and other agencies.

4.5.1 The National Missions have been institutionalized by the respective Ministries. Comprehensive Mission documents detailing objectives, strategies, plan of action, timelines and monitoring and evaluation criteria of all eight Missions and Other Initiatives have been developed by the nodal Ministries with approval of the Prime Minister's Council on Climate Change. Status of the approval and implementation of the Mission documents is attached at Annexure.

4.5.2 An effective strategy for implementing NAPCC has to take into account the sectoral plans being developed in course of 12th Five Year Plan. The objectives of the NAPCC should permeate the planning process at all levels. Specific sectors that are included in the NAPCC should have an adaptation and mitigation strategy that should be built into the respective sectoral plans. Particular mention, in this regard, may be made of the areas of agriculture, water, health, coastal management, forests and other ecosystems, energy including renewable energy, and infrastructure and climate change assessment. An optimal way of achieving this would be to integrate the Missions into the development strategy of the respective Ministries. This will however require large amount of resource mobilization. The assessment made by various Ministries for implementing their Missions is tabulated in the statement at Annexure to this Section . 12th Plan must take these requirements into account while finalizing sectoral outlays.

Annexure I to Section 4 (para 4.5.1)

Sl.No.	Name and Nodal agency of the National Missions	Salient features and status of the National Missions	Financial outlays of National Missions
1	**National Solar Mission** **Nodal agency:** **Ministry of New & Renewable Energy**	The Jawaharlal Nehru National Solar Mission has been launched by Prime Minister on January 11, 2010. The Union Cabinet has approved its implementation framework. This mission aims at increasing the share of solar energy in the total energy mix through development of new solar technologies, while attempting to expand the scope of other renewable and non fossil options such as nuclear energy, wind energy and biomass. The Solar Mission recommends the implementation in 3 stages leading up to an installed capacity of 20,000 MW by the end of 13th Five Year Plan in 2022. It is envisaged that as a result of rapid scale up as well as technological developments, the price of solar power will attain parity with grid power at the end of the Mission, enabling accelerated and large-scale expansion thereafter. The Mission will have a very focused R&D programme which seeks to address the India-specific challenges in promoting solar energy.	The total financial outlay during Phase 1 is estimated as Rs.4337 crore of which Rs. 2527 crore is for the remaining period of the 11th Plan. Requirement for Phase 2 will be assessed after review of implementation of Phase 1.
2.	**National Mission for Enhanced Energy Efficiency** **Nodal agency:** **Ministry of Power/Bureau of Energy Efficiency**	This mission is under implementation from 1st April 2010. The Union Cabinet approved its implementation framework on June 24, 2010. This Mission seeks to upscale efforts to create a market for energy efficiency which is estimated to be around Rs. 74,000 crores. This Mission will create a conducive regulatory and policy regime to foster innovative and sustainable business models to unlock this market. As a result of implementation of this Mission over the next five years, it is estimated that by about 2015, about 23 million tons of oil-equivalent of fuel savings – in coal, gas, and petroleum products, will be achieved every year along with an expected avoided capacity addition of over 19,000 MW. The consequential carbon dioxide emission reduction is estimated to be around 98.55 million tons annually.	The total requirement projected under the Mission between 2010- 2012 is Rs 425.35 crores. This is intended to attract private sector investment in energy efficiency market estimated at Rs.74,000/- crore.
3.	**National Mission on Sustainable Habitat** **Nodal agency:** **Ministry of Urban Development/Ministry of Housing and Urban Poverty/Alleviation**	Mission Document prepared by M/o Urban Development was approved by PM's Council on Climate Change on June 18, 2010. This mission attempts to promote energy efficiency in buildings, management of solid waste and modal shift to public transport including transport options based on bio-diesel and hydrogen. Main components of the Mission are (i) Development of National Sustainable Habitat Standards (Legal/ Regulatory) measures (ii) Incorporation of Principles of Sustainable Habitat in city and (iii) Complementary action such as support	The total cost estimate projected in the Mission Document is Rs.1000 crore. During 11th Plan, expenditure of Rs.50 crore is to be incurred and remaining Rs.950 crores is to be incurred during the 12th Five Year Plan.

		for building green demonstration projects and National outreach programme for creating consumer awareness.	
4.	**National Water Mission** **<u>Nodal agency:</u>** **Ministry of Water Resources**	Mission Document prepared by M/o Water Resources was approved by PM's Council on Climate Change on May 28, 2010. The Union Cabinet approved its implementation framework on April 6, 2011. This mission aims at to the conservation of water, minimizing wastage and ensuring more equitable distribution both across and within states. The key focus of the Mission document are (i) Intensive rain water harvesting and ground water charging to meet the demand of 1120 critical blocks during XI Plan and remaining blocks in XII Plan (March, 2017). Besides, 30% of the total urban areas would be covered by March, 2012 (ii) Increasing water use efficiency at least by 20% by 2012.	As per the Mission document, the total estimated additional fund required for implementing the Mission is Rs.89,101crore during the 11th and the 12th Five Year Plan period. This includes expenditure on schemes implemented through the State Plans and the Central Plan.
5.	**National Mission for Sustaining the Himalayan Ecosystem** **<u>Nodal agency:</u>** **Ministry of Science and Technology**	Mission Document prepared by M/o Science & Technology has been approved by PM's Council on Climate Change. This mission aims at evolving management measures for sustaining and safeguarding the Himalayan glacier and mountain eco-system. The mission attempts to address following key issues: Himalayan Glaciers and the associated hydrological consequences, Biodiversity conservation and protection, Wildlife conservation and protection, Traditional knowledge societies and their livelihood, Planning for sustaining for the Himalayan Ecosystem. The Government of India supports and facilitates a major research agenda to assess various climate change related issues. A special focus area is the study of Himalayan glaciers with a view to monitor the movement of glaciers and studies their link to climate change.	For implementing the activities, a total fund of Rs. 195 crore is required in the 11th Plan period. Provision of Rs. 1500 crore is to be made under 12th plan period for achieving the mission objectives.
6.	**National Mission for Green India** **<u>Nodal agency:</u>** **Ministry of Environment and Forests**	Mission Document prepared by M/o Environment and Forests was approved by PM's Council on Climate Change on February 23, 2011.This mission focuses on enhancing eco-system services and carbon sinks through afforestation on degraded forest land in line with the national policy of expanding the forest and tree cover to 33% of the total land area of the country.	An expenditure of Rs 46,000 crore is projected under the Mission for coverage of 10 million hectares over next 10 years.
7.	**National Mission for Sustainable Agriculture** **<u>Nodal agency:</u>** **Ministry of**	Mission Document prepared by M/o Agriculture was approved by PM's Council on Climate Change on September 23, 2010.This mission would develop strategies to make Indian agriculture more resilient to climate change new varieties of thermal resistant crops, new credit and insurance	The proposed adaptation and mitigation activities under the Mission require an additional budgetary support of Rs 1,08,000crore at current prices up to the end of the 12th plan.

	Agriculture and Cooperation/DARE	mechanisms and improving productivity of rain-fed agriculture. The main focus of the Mission would be food security and protecting land, water, biodiversity and genetic resources for sustainable production of food.	
8.	**National Mission on Strategic Knowledge on Climate Change** **<u>Nodal agency:</u>** **Ministry of Science and Technology**	Mission Document prepared by M/o Science & Technology has been approved by PM's Council. This mission is intended to identify the challenges of, and the responses to, climate change through research and technology development and ensure funding of high quality and focused research into various aspects of climate change.	Additional fund of Rs. 150 crores is required in the 11th plan period for implementing the Mission activities. Provision of Rs. 2500 crores is to be made under the 12th plan period for achieving mission/sub-mission programme initiatives.

Section 5
Climate Change Modelling And Assessment

5.1 Climate Change Modeling

5.1.1 The most fundamental requirement for narrowing the gaps between the state of knowledge and the policy response to the effects of climate change is the availability of reliable estimates of future climatic patterns on the regional scale. The estimates should be such that they can be readily used by different impact assessment groups. This needs a systematic validation of the climate model simulations and development of suitable regional climate change scenarios and estimations of the associated uncertainties.

Box 1: A description of IPCC IS92a* and A1B* SRES scenario
IS92a scenario –In this scenario GHG forcing is increased gradually to represent the observed changes in forcing due to all GHGs from 1860 to 1990 for future time period of 1990-2099, the forcing is increased at a compounded rate of 1 percent per year (relative to 1990 values).
A1B scenario – This scenario assumes significant innovations in energy technologies, which improve energy efficiency and reduce the cost of energy supply. Such improvements occur across the board and neither favor, nor penalize, particular groups of technologies. A1B assumes, in particular, drastic reductions in power-generation costs, through the use of solar, wind, and other modern renewable energies, and significant progress in gas exploration, production, and transport. This results in a balanced mix of technologies and supply sources with technology improvements and resource assumptions such that no single source of energy is overly dominant. *(Source: IPCC, 2000)

4.1.2 With the availability of a hierarchy of coupled atmosphere-ocean-sea-ice-land-surface global climate models (AOGCMs), having a resolution of 250-300 km, it has been possible to project the climate change scenarios for different regions in the world. The global models, however fail to simulate the finer regional features, and the changes in the climate arising over sub-seasonal and smaller spatial scales. This is more relevant in the case of India due to its unique climate system dominated by the monsoon, and the major physio-graphic features that drive this monsoon.

5.1.3 Initially, high-resolution simulations for India were based on the second generation Hadley Centre regional climate model (HadRM2). HadRM2 is a high-resolution climate model that covers a limited area of the globe, typically 5,000 km x 5,000 km. The typical horizontal resolution of HadRM2 is 50 km x 50 km. The regional model reproduces the large scale features of the GCM climate and adds realistic local detail. For example, the rain shadowing effect of the Western Ghats was found to be closer to the observations. The annual cycles of rainfall and surface air temperature were also remarkably close to the observed patterns, which demonstrate that the regional model is able to overcome the large biases of the GCM in portraying these features.

5.1.4 In order to assess the nature of the likely future climate in India at an all India level, eight AOGCMs (see Box 2) were run using the IS92a and SRES A2 and B2 scenarios.

Box 2. Coupled Atmosphere-Ocean General Circulation Models used for deriving climate change projections during INC

1. Canadian Center for Climate Modeling, Canada (CCC).
2. Center for Climate System Research, Japan (CCSR).
3. Commonwealth Scientific and Industrial Research Organization, Australia (CSIRO)
4. Deutsches Kilma Rechen Zentrum, Germany (DKRZ).
5. Geophysical Fluid Dynamics Laboratory, USA (GFDL).
6. Hadley Centere for Climate Prediction and Research, UK (HadCM3).
7. Max-Planck Institute, Germany (MPI).
8. National Center for Atmospheric Research, USA (NCAR).

5.1.5 The simulated climate approximately represented the period spanning nominal time scale of 1860-2099, but the individual model-years did not correspond to any specific years or events in this period. Considering all the land-points in India according to the resolution of each AOGCM, the arithmetic averages of rainfall and temperature fields were worked out to generate all-India monthly data for the entire duration of model simulations and for different experiments. These monthly data were then used to compute the seasonal totals/means of rainfall/temperature. Taking 1961-90 as the baseline period, the seasonal quantities were then converted into anomalies (percentage departures in the case of rainfall). The resulting time series were examined for their likely future changes into the 21st century.

5.1.6 The GHG simulations with IS92a scenarios showed marked increase in both rainfall and temperature by the end of 21st century relative to the baseline. There was a considerable spread among the models in the magnitudes of both precipitation and temperature projections, but more conspicuously in the case of summer monsoon rainfall. The increase in rainfall from the baseline period (1961-90) to the end of 21st century ranged between 15 and 40% among the models. In case of mean annual temperature, the increase was found to be of the order of 3 to 6ºC. At a glance one could realize that the change in rainfall under A2 and B2 scenarios was not as high as that noted earlier in IS92a scenarios. Compared to A2 scenario, the B2 simulations showed much subdued trends into the future. The temperature however shows comparable increasing trends in IS92a and A2 but B2 shows slightly lower trends.

5.1.7 Keeping in view the limitations of the global climate models, high- resolution simulations for India were carried out using the second generation Hadley Centre Regional Climate Model (HadRM2). It was envisaged to add new scenarios from the bouquet of emission scenarios available from the IPCC Special Report on Emission Scenarios. Subsequently, the A1B Scenario was chosen as the most appropriate scenario as it represents high technological development, with the infusion of renewable energy technologies following a sustainable growth trajectory (See Box 1). Subsequently new development in regional models has taken place. India now has access to PRECIS - the latest generation of regional model from the Hadley center. The PRECIS is an atmospheric and land surface model having 50 km x 50 km horizontal resolution over the

South Asian domain and is run by Indian Institute of Tropical Meteorology (IITM), Pune. PRECIS is forced at its lateral boundaries by a high-resolution GCM (150 km) called HadAM3H in so called 'time slice' experiments. Presently, using the outputs from PRECIS runs; sectoral impact assessment is being carried out.

5.2 Climate Change Assessment: Sectoral and Regional Perspective

5.2.1 Ministry of Environment and Forests, Government of India, launched, in 2008, a network-based scientific programme i.e. the Indian Network of Climate Change Assessment (INCCA), which has conducted an assessment to review the impacts of climate variability in the four major climate sensitive regions in India, namely; the Himalayan region, the North-Eastern region, the Western Ghats and the Coastal region. This attempt was a significant step towards an approach so as to design, develop and devise policies that help in appropriately addressing the impacts of climate change in the most vulnerable regions and in the key sectors. Such a scientific analysis was one of its kind attempt to look at the climate change projections in the near to mid-term. This has contextual importance as most of the climate change projections are made keeping the longer term view point. It is for the first time that an assessment has been made for the 2030s (all previous assessments were for the period 2070s and beyond).

5.2.2 The climate change scenarios were derived from PRECIS model (a version of HadRM3 developed by the Hadley Centre, UK) with a resolution of 50km x 50km and forced by a greenhouse gas (GHG) emission scenario emanating from A1B IPCC SRES. The 2030s is the average of the period between 2021 and 2050. All the changes in the 2030s are with respect to the average of the period 1961 to 1990s, also referred to as the 1970s or the baseline.

5.2.3 The model projects the following changes in 2030s:

• The assessment projects around 10% increase in the Indian monsoon rainfall over central and peninsular India in 2030s. The expected change in the rainfall is within the current monsoon variability and there are large model to model differences making these projected changes to be lesser confident.

• The assessment projects 1.5-2^{o}C warming in the annual mean temperature over the Indian landmass while Winter (Jan-Feb) and Spring (Mar-Apr-May) seasons show higher warming.

• The projections of PRECIS in 2030s indicate 3-7% increase in all-India summer monsoon rainfall.

• The annual mean surface air temperature may rise from 1.7°C to 2°C by 2030s as indicated by the simulations

• The regional climate model simulations indicate that the cyclonic disturbances over Indian Oceans during summer monsoon are likely to be more intense and the systems may form slightly to the south of normal locations.

- The ensemble mean changes in the monsoon rainfall are in the range of 2 to 12% while the annual temperature changes are of the order of 1.4 to 1.9^{o}C, however the individual simulations show large differences.

- The key findings of the assessment in terms of agriculture, water and fisheries are mentioned in Section 3.1 of the Report.

5.3 Indian Network for Climate Change Assessment (INCCA)

5.3.1 There has been a significant leap in the understanding of the "science" of climate change and its impacts on socio-economic systems and sectors from the Third Assessment Report (TAR) of the IPCC. With a view to enhance knowledge about the impacts of climate change, the Ministry of Environment and Forests launched Indian Network for Climate Change Assessment (INCCA) on October 14, 2009. The INCAA has been conceptualised as a Network-based Scientific Programme designed to (a) assess the drivers and implications of climate change through scientific research; (b) prepare climate change assessments once every two years (GHG estimations and impacts of climate change, associated vulnerabilities and adaptation); (c) develop decision support systems and (d) build capacity towards management of climate change related risks and opportunities. The INCAA is visualised as a mechanism to create new institutions and engage existing knowledge institutions already working with the Ministry of Environment and Forests (MoEF) as well as other agencies.

5.3.2 Building on the network of institutions and scientists created during the operationalization of INCCA, it is envisaged to strengthen and utilise the existing system of network -based institutions to a more systematic and credible institutional arrangement so as to continuously enhance the understanding of the “science" of climate change, make regular assessments of the impacts due to changes in the climate system and also assess the extent and nature of key vulnerabilities. Moreover it is also envisaged, through appropriate institutional arrangement, to systematize the preparation and publication of GHG inventory on a regular basis. This institutional arrangement is envisaged to form a nodal mechanism for policy advice regarding climate change, apart from being a key assessment resource. This effort would also enable streamlining preparation of NATCOMs, as per the international obligations and would facilitate the implementation of related activities for the same. The aforementioned institutional arrangement would be an enabling factor in mainstreaming climate change related studies in the context of its significance.

5.4 Recommendations

In the light of the foregoing, following research programmes and institutional innovations are suggested to strengthen scientific research, assessment, planning and management capability in the area of climate change and fulfill related domestic and international obligations-

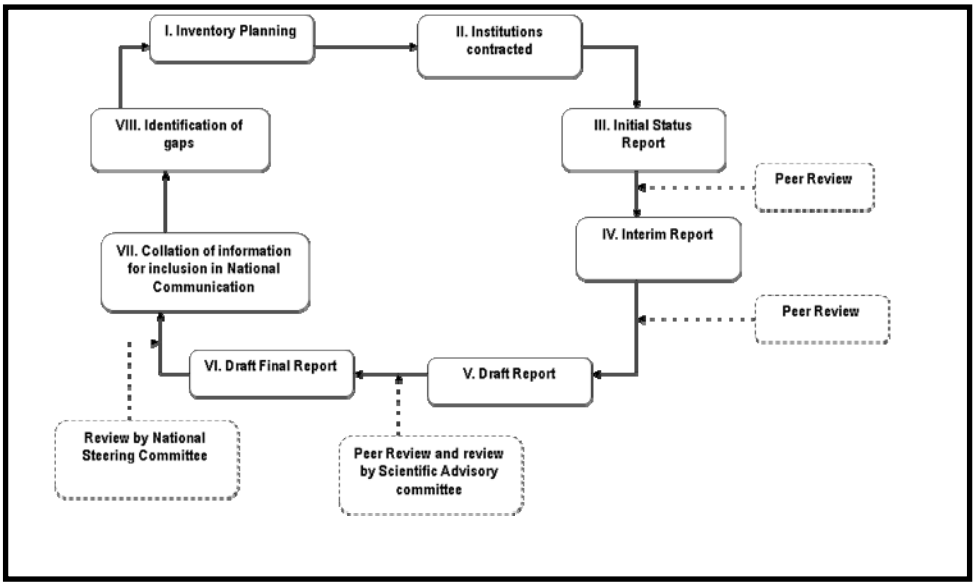
5.4.1 GHG Inventory Management System (GHG – IMS)

5.4.1.1 GHG inventory preparation is an important exercise for any country. It helps in assessing the nature and quantum of emissions intensity of the economy and also helps in identifying key emitting sources. This in turn helps the policy makers to identify and

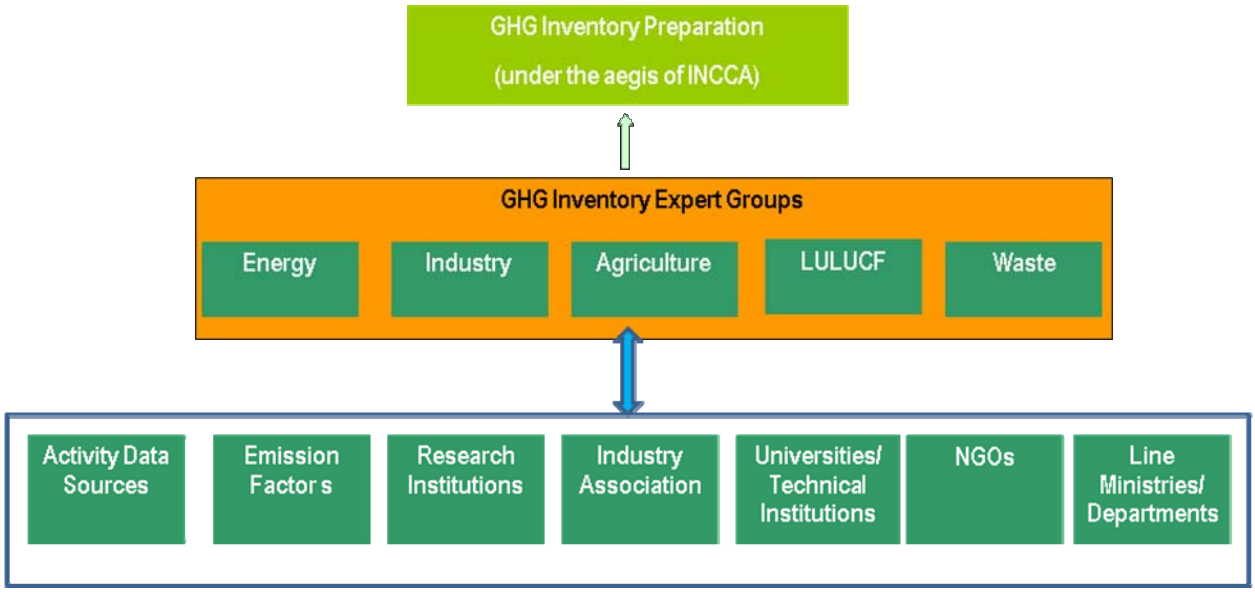
frame appropriate policy response to mitigate GHG emission from a particular source. GHG inventory between two time periods helps in assessing the nature and quantum of increase/decrease in emissions intensity and therefore would help in assessing the progress made in the direction of de-intensification of emissions. In the present context, future GHG inventory would help the country to gauge the progress made in the direction of achieving the emissions reduction pledge to the UNFCCC.

5.4.1.2 GHG inventories for the Initial National Communication and the Second National Communication were and are being prepared through a network of institutions, specially organised in a project mode. These network of institutions spread across the entire length and breadth of the country, comprising of nearly 60 institutions. GHG emission assessment for 2007 was carried out under the aegis of the Indian Network for Climate Change Assessment (INCCA). This is an initiative coordinated by the Ministry of Environment and Forests. The GHG inventory was prepared by scientists and experts drawn from a network of a diverse mix of institutions across the country having the capacity to generate information on the GHG emission inventories by sources and removals by sinks from Energy, Industry, Agriculture, Land use Land-use Change and Forestry and Waste sectors on a regular basis. These institutions comprise of national research institutions, technical institutions, universities, industry associations, non-Governmental Organizations and the private sector. Other than estimating the GHG inventories, these institutions also collected activity data from relevant sources, and are also involved in the process of generating country specific emission factors. Developing country specific emission factors has been the thrust since the First National Communication process begun, especially for the key emitting sources, as it makes the inventory more representative of the circumstances under which the emissions take place and the estimates more scientifically robust. In this effort, the support of key line ministries such as the Ministries of Power, Coal, Petroleum and Natural Gas, Surface Transport, Shipping, Aviation, Heavy Industries, Iron and Steel, Agriculture, Environment and Forests, Urban Development and Ministry of Statistics and Programme Implementation is recognized. These ministries constituted the source of activity data for majority of the source categories.

5.4.1.3 This program needs to be systematically institutionalised, as India would require publishing its GHG inventory after every two years. The program is initially to be planned in the same manner as the Climate Change Assessment Centre, to be housed under INCCA and operationalized at the MoEF. The management program would coordinate the entire system of coordinating with network agencies for regular publication of GHG inventory of India. The nodal centre at MoEF would also act as a data repository and analysis centre for GHG inventory related issues and would support policy makers in feeding information pertaining to development of response strategies to the climate change challenge. The total budgetary support for initiating this activity as well ensuring its regular functioning would be INR 20 crore for the initial period of 5 years and thereafter, regular budgetary support would be required to ensure its continuity.



The Inventory Preparation Cycle and Arrangement



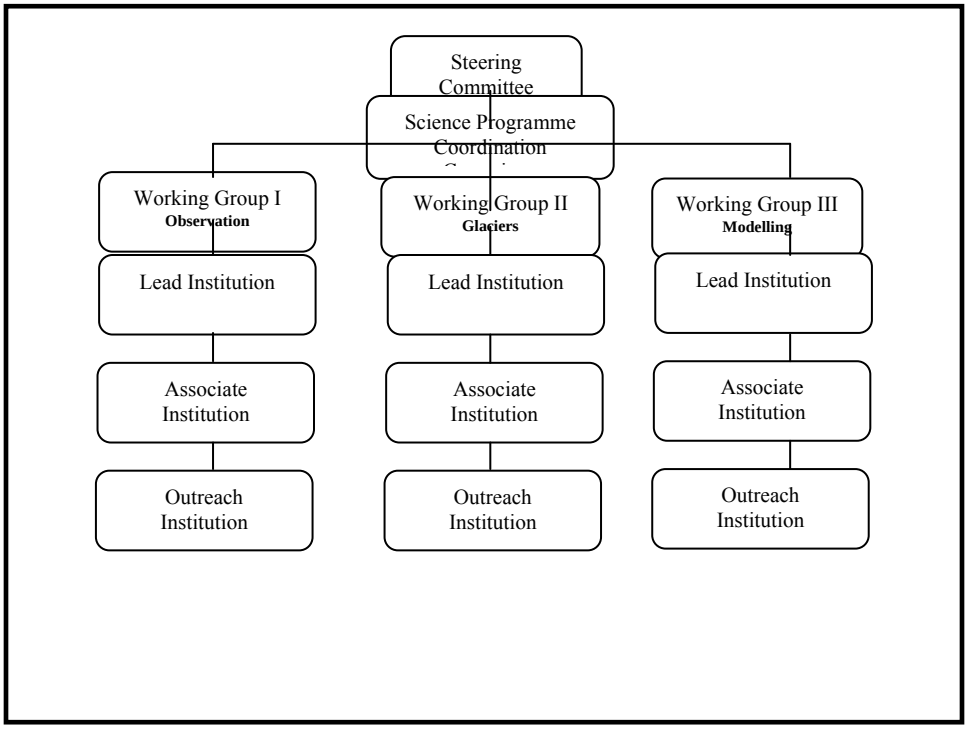
The Implementation Arrangement for Preparing GHG Inventory

5.4.2 Black Carbon Research Initiative (National Carbonaceous Aerosols Programme) BCRI-NCAP

4.4.2.1 Aerosols are suspended particulates in the atmosphere that can modify local climate through different mechanisms. Aerosols alter climate directly by modifying the radiative fluxes and indirectly through their ability to alter clouds. Among the various aerosol types, Black Carbon (BC) aerosols absorb solar radiation directly and hence influence earth's circulation and climate. An initial study of black carbon and its impact on environment in Indian cities has been carried out. The initial findings of the study are

given in **Annexure I** of this section. However, our understanding of the impact of aerosols on climate is not as good as our understanding of the impact of greenhouse gases (such as carbon dioxide) on climate. The science plan and the approach of the research initiative include: long-term monitoring of aerosols, assessment of impact of aerosols on Himalayan glaciers, modelling of black carbon emissions inventory over India, development of an Indian emission inventory for carbonaceous aerosols, identify the sources influencing carbonaceous aerosols through inverse modelling exercises, quantify the regional atmospheric abundance of carbonaceous aerosols through Chemical transport modelling, understanding the influence of carbonaceous aerosols on regional climate change and climate futures through General Circulation Modelling.

5.4.2.2 The program is visualised as a multi-institutional and multi-agency project. The four major departments associated with the studies include MoEF, Ministry of Earth Sciences, ISRO, Ministry of Science and Technology and the Department of Space with its institutions. Council of Scientific and Industrial Research (CSIR) will also participate in the program through their existing institutional network. The other institutions identified include universities, research institutions, premier scientific establishments, colleges and non-governmental agencies to undertake the work on various components of the programme which principally consists of aerosol observations and modelling of the impacts of carbonaceous aerosols (black carbon). This research program is envisaged to comprise of 65 observatories and 101 institutions and the budgeted expenditure for this initiative would be INR 200 crores over a 5-year period. Please see the box below for a schematic implementation arrangement and coordination initiative.



5.4.3 Long term Ecological Research Observatory (LTERO) for Climate Change

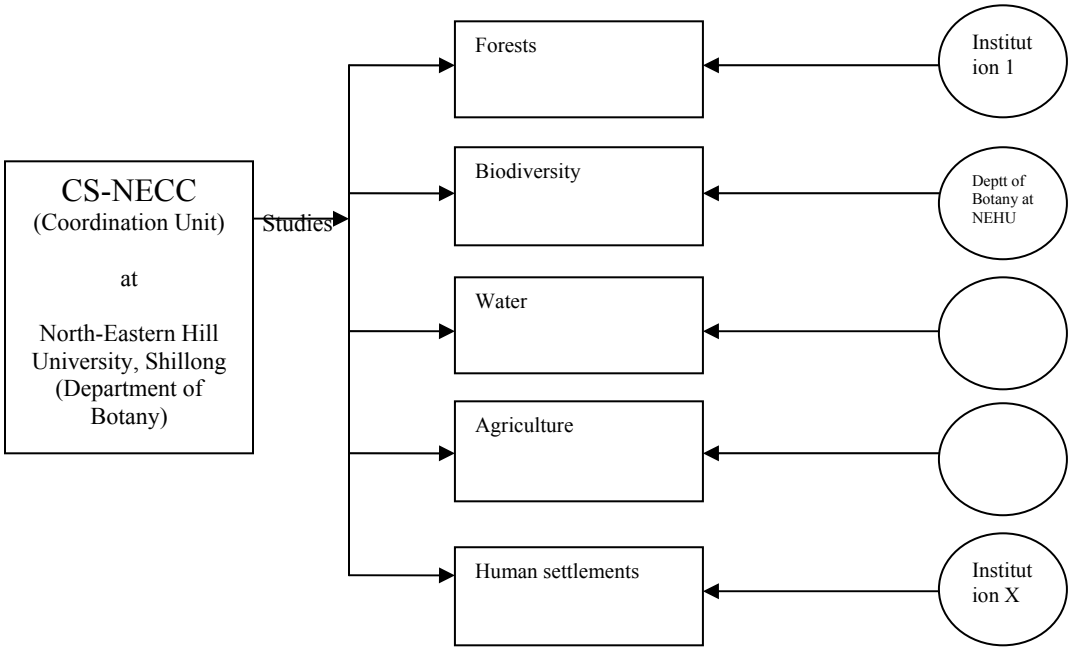
5.4.3.1 The challenges of conserving India's rich biological diversity, amidst past and present environmental degradation in addition to the threats of future climate change, make it imperative for us to have a more holistic understanding of the structure and function of our biota, population trends and possible responses to climate variability and change. India's flora and fauna is relatively well documented as a result of work carried out by agencies such as the Botanical Survey of India and Zoological Survey of India. What we lack however is any depth in our understanding of ecological processes of our major biomes and their components, ether at a scale of landscapes, communities or individual species. such an understanding on not just the functional dynamics of plants and animals but also the soil and hydrology in relation to climatic factors and human influences is essential if we are to plan for adaptation to changing climate and anthropogenic pressures. Targeted, collaborative, multi-disciplinary and long-term research is needed if we are gain such an understanding. a long term ecological, social and economic monitoring program is required not only to identify patterns and drives o f change, but also to meet UN's MDGs because in a country like India millions of people rely on natural ecosystems to sustain their livelihoods. Further monitoring is required to meet the requirements and obligations respectively from enactment of national policies and signing of international treaties and conventions such as UNFCCC.

5.4.3.2 Accordingly it is proposed to establish a network of long-term ecological research observatories in India, which would also be the field sites used by several institutions and scientists with expertise in various disciplines from climate to geology, hydrology, soil science, plant and animal ecology, landscape ecology, functional ecology, and even social sciences. These sites would also be used as locations for experimental research in ecology. The need for experimental work is essential for understanding a number of urgent questions with management implications; these include the ecology of fire and invasive plants, and sustainable use of non-timber forest products (esp. in the context of livelihoods of tribal and other forest dwelling communities). This program is planned to comprise of 25 institutions and 10 observatories and would cost INR 100 crores over the 5-year period. This estimate is based on estimates needed for setting up the program. However, in order to sustain the initiative for years to come; this program would require budgetary support on a continuous basis.

5.4.3.3 It is proposed to select 10-12 sites across the country that represents the different biomes and geographical regions. Ministry of Environment and Forests will be the nodal agency for development and implementation of the programme. The institutional network will cover other Ministries, State Government, Private sector and Non-governmental Organisations as well. Centre for Ecological Sciences is proposed to act as the coordinating agency for the scientific programme and the overall management at the National level.

5.4.4 Co-ordinated Studies (CS) in the North Eastern Region on Climate Change (NECC) (CS-NECC)

5.4.4.1 In order to streamline the process of understanding the impacts of climate change on a regional basis, a sectoral and regional climate change assessment has been made under the aegis of INCCA. Specifically, sectoral analysis for the North-Eastern region has been conducted in the assessment which points towards significant changes in the precipitation and temperature patterns and perceptible impacts on various sectors such as agriculture, and also impacts on biodiversity and human health. The key results encourages to undertake further studies on observational impacts on forests, biodiversity, water, agriculture and human settlements and to identify key vulnerabilities and thereafter, develop suitable adaptation and mitigation responses for the North-Eastern region. Considering these special circumstances of the North-Eastern region, it is envisaged to undertake studies on Climate Change in the North-East Region under the aegis of INCCA. The main objectives of the studies would comprise of (a) acting as the repository of data, information and knowledge regarding all aspects of climate change, ecosystem functioning and socio-economic aspects of the region; (b) undertaking activities to collect, collate and synthesize data and prepare reports for dissemination; and (c) undertaking coordination of research activities in the short-, medium- and long-terms for the region. The scientific program shall broadly focus on two aspects of research. The first will be concerned with the filling of gaps in data/information related to the baseline and status of research concerning the identified sectors in the region. The second will be to study the impacts, adaptation and vulnerability of the sectors that are likely to be affected by projected climate change induced changes in the temperature and rainfall patterns. The initial budgeted expenditure for setting up the unit would be of the order of INR 25 crore. Provisional schematic of the institutional arrangement is indicated below.



Provisional Schematic of the Institutional Arrangement

5.4.5 Climate Change Assessment Studies (CCAS)

5.4.5.1 The ability to predict future climatic patterns is essential for assessing the nature and magnitude of the impacts on sectors, population, regions and nation. Climate change has enormous implications to the natural resources and livelihoods of the people. The assessment of climate change impacts, and vulnerability and adaptation to climate change, therefore, require a wide-range of physical, biological and socio-economic models, methods, tools and data. An assessment of the impact of projected climate change on natural and socio-economic systems is central to the whole issue of climate change. Climate change impact assessment involves (i) identifying, analyzing and evaluating the impact of climate variability and change on natural ecosystems, socio-economic systems and human health, and (ii) assessing the vulnerabilities of the affected communities and sectors, such as farmers, forest dwellers and fishermen and assessing the potential adaptation responses.

5.4.5.2 The methods for assessing the vulnerability, impact and adaptation are gradually improving and have significantly improved year after year. This improvement has facilitated a much deeper analysis of the impacts due to climate change on the various sectors. However, due to uncertainties in regional climate projections, unpredictable response of natural and socio-economic systems and the inability to foresee the future technological developments do provide some limits to the exercise.

5.4.5.3 "Climate Change in India: 4x4 Assessment in the 2030s" undertaken by INCCA has assessed the impacts on four key sectors in the four key ecological zones of the country. This assessment attempts to bring together what is known as four major regions in India, namely, Himalayan region, the North-Eastern region, the Western Ghats and the Coastal Region with regards to the observed and future climate for the year 2030s and the impacts on sectors, such as agriculture, water, natural ecosystem, biodiversity and health.

5.4.5.4 Development of these assessments should be seen as a process of regular improvement commensurate with the needs of quality, scale, accuracy and consistency. This initiative needs to be sustained and translated into a full-fledged assessment activity, wherein the immediate next step would be to expand and improve the earlier assessment for the entire set of "agro-climatic" zones of the country and make an assessment initially for the medium-term (2030s) and also extend it to long-term (2050s and 2100s). This activity would also serve as the co-ordinating and synthesis agency for devising various scenarios (either in line with the IPCC SRES scenarios or India specific future scenarios). The assessment on the basis of agro-climatic zones would underscore the importance of planning for the key sectors on this overarching basis rather than identifying policies/options on the basis of physical boundaries. This is important in the context of the fact that environmental issues/problems recognise no political boundaries.

5.4.5.5 It is proposed that this programme is initially conceptualised within the MoEF (as a part of INCCA), with a Director and at least 5 scientists; wherein the entire planning, collation and coordination would take place. Thereafter an appropriate institutional

arrangement would need to be devised which would need regular budgetary support. To sustain this activity and maintain this initiative initially for a period of five years, a grant of INR 25 crore will be required. The activity is already operational and two assessments have already been brought out by INCCA within the existing constraints.

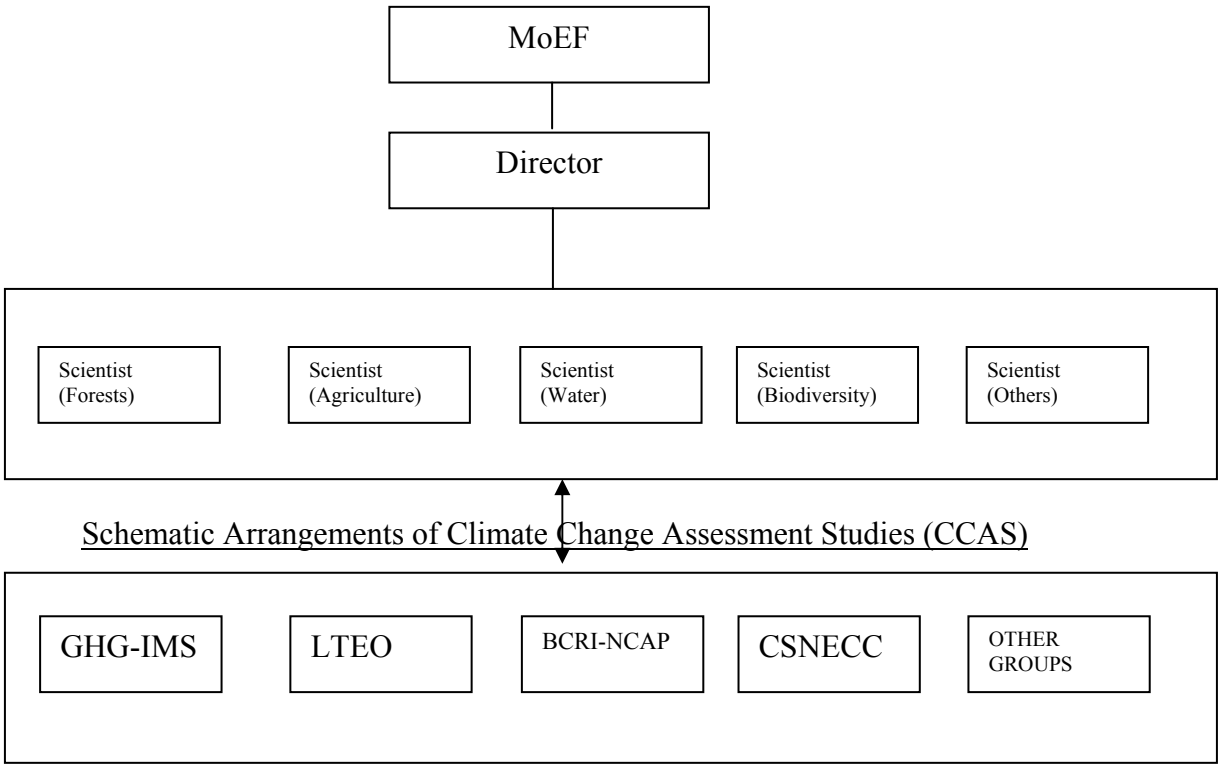
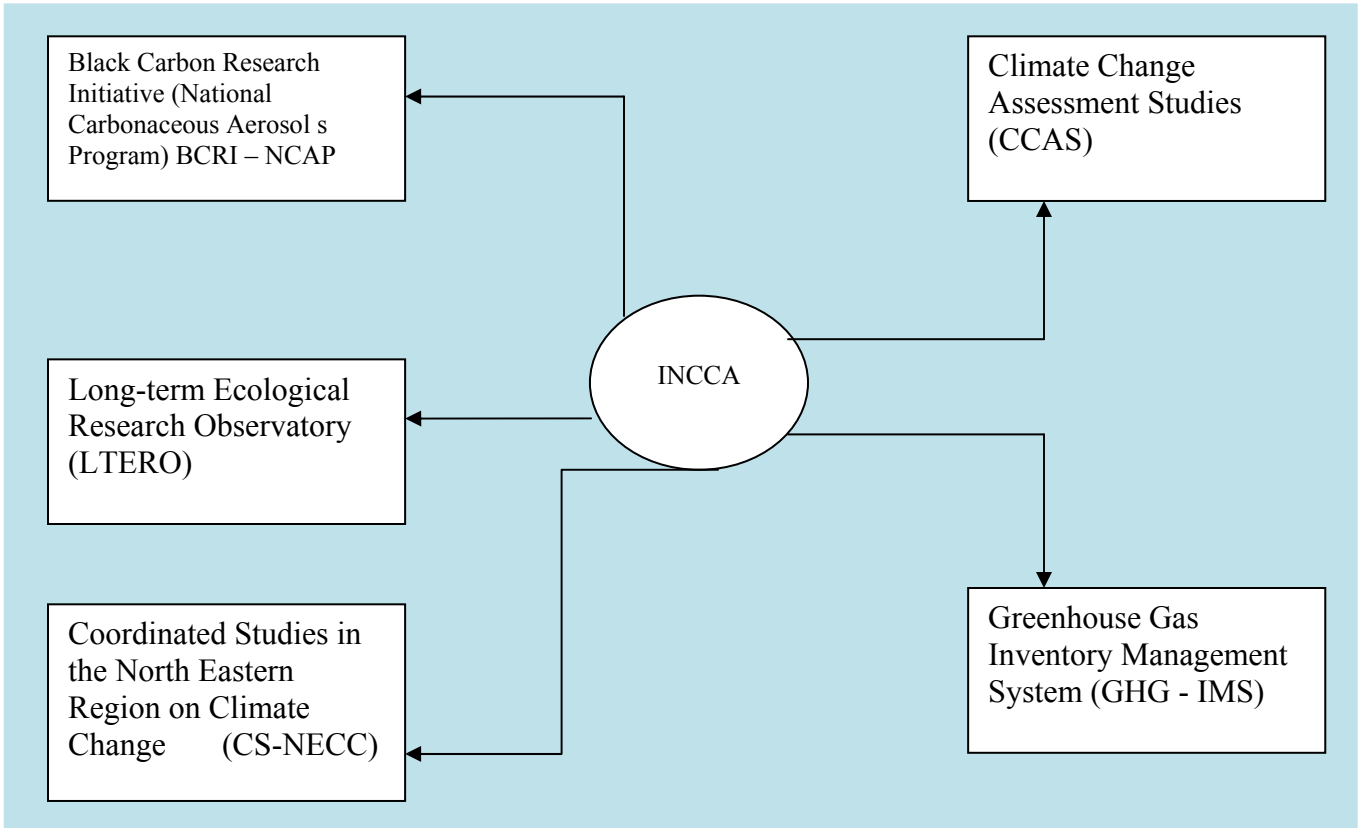


Fig 1: 12th Plan Programme Elements



5.4.5.6 The tentative financial outlay for the proposed arrangements is estimated as follows:-

Table: Programmes and Proposed Outlays for the 12th Plan

Programme	**Proposed outlays (INR in crores)**
GHG Inventory Management System (GHG – IMS)	20
Black Carbon Research Initiative-National Carbonaceous Aerosols Programme (BCRI-NCAP)	200
Long term Ecological Research Observatory (LTERO) for Climate Change	100
Coordinated Studies in the North Eastern Region on Climate Change (CS-NECC)	25
Climate Change Assessment Studies (CCAS)	25
G.Total	**370**

Black Carbon

1. Aerosols are suspended particulates in the atmosphere and have implications for climate and health through different mechanisms. Several studies have suggested that aerosols may be mitigating global warming by increasing the planetary albedo, although the sign and magnitude of aerosol effects on climate are still uncertain as outlined in the International Panel of Climate Change (IPCC) reports. Compounding to the complexity of this problem is the interaction of aerosols with clouds. Aerosols change cloud properties, alter precipitation patterns and have serious consequences for altering the hydrological balance of the Earth-atmosphere system.

2. Among the various aerosol types, black carbon aerosols assume importance due to its high absorption characteristics, which in turn depends on their production mechanism. In addition to exerting its own radiative impact, black carbon aerosol can substantially contaminate other aerosol species thereby alter the radiaitve properties of entire aerosol system and in fact their ability to act as cloud condensation nuclei. There have been several inferences on the climate impact of BC aerosols. Some examples are: "Black Carbon contributes to droughts and floods in China" (Menon et al., 2002); "Soot Intensifies flooding and droughts in India" (Luo et al., 2006); "Soot blocks sunlight and results in reduced crop yields" (Chameides et al., 1999) and so on. These results are not validated adequately and hence there are several issues to be considered before reaching conclusions on BC climate impact.

Elemental Carbon (EC), Organic Carbon (OC) in Indian cities

3. In a recently concluded study on source apportionment study in six cities namely Delhi, Mumbai, Kanpur, Pune and Chennai by CPCB/ MOEF, the elemental carbon (EC), Organic Carbon (OC), Sulphate and Nitrate in PM 10 and Pm 2.5 samples have been analysed. These parameters constitute important fraction both from public health point of view and as indicators for source group contribution at a particular location of sampling. The results correspond to PM10 samples of 20/30 days and PM2.5 samples of one week.

4. The following important information and interpretations can be obtained from the EC- OC plots.

- In all cities, OC (organic carbon) levels are always much higher (2 - 4.5 times) than EC levels. The ratio of EC/OC is variable from one location to another, indicating that sources, those contribute to particulate pollution, are variable.
- In general EC and OC levels relate well with PM10 levels. It can be seen that Delhi and Kanpur showed the high pollution levels for PM10 and these two cities also show high EC and OC levels. EC levels: 15-20 µg/m3 at Delhi and 15- 40 µg/m3 at Kanpur; OC Levels: 50 – 100 µg/m3 in Delhi and 35 – 105 µg/m3 at Kanpur. The levels in other cities range 5 – 20 µg/m3 for EC and 10 – 45 µg/m3 for OC.
- EC and OC almost account for 20-45 percent of PM10, inclusive of all cities which are quite high and reflect as to how badly the cities are affected because of combustion and/or fuel related emissions (mainly vehicular emission).
- High EC to OC ratio represents freshly contributed diesel/petrol/coal combustion particles. Many cities have shown this ratio to be high at kerbside and industrial locations.
- There are significant quantities of SO42 – and NO3–, (10-15% in most cities and 20-30% in Kanpur) in PM10 indicating contribution of secondary particles. These contributions are even high at the background upwind direction in all cities. It signifies long-range transport of particles in the city as well as formation of secondary particles in the city. Any control strategy for reduction of secondary particulate will have to consider control of SO2, NOx and NH3.
- NO32- concentrations at background sites are generally lower as compared to other sites. The instances of its higher concentrations are due to reported local activities and contribution from nearby settlements.
- EC and OC contribution to PM2.5 is even more than what it is to PM10, and it varies from one city to another. Chennai has shown a very high EC and OC content (60-75% in PM2.5), followed by Bangalore (35-50%), Delhi (30-45%), Mumbai (30-40%), Pune (25-40%) and Kanpur (25-35%). It signifies an important point that PM2.5 has much higher component of toxic EC and OC and that mostly come from combustion sources like vehicles, coal, biomass, and others

Section 6

GHG emissions and mitigation actions

6.1 India's per capita GHG emissions at 1.7 ton are lower than most countries (including the developed and developing countries) in the world of comparable economic size and structure. Its CO_2 intensity, particularly when measured using PPP GDP, is among the lowest amongst countries with a significant share of coal (the most carbon-intensive fossil fuel) in the energy mix. This is significant when it is seen that India has (i) an intensity of emissions per unit of GDP that is at par with the world average (ii) per capita emissions that are among the lowest in the world and (iii) a forest cover that has stabilized. Further, India's emissions modeling exercises show that, by 2030, India's per capita emissions will still be in the range of 3.7 ton of GHG emissions and India will have less than 10 percent of the global emissions despite having 20 percent of the world population. India has been able to offset the growth in emissions attributable to increased GDP and population, through improvements in energy intensity, fossil fuel mix, and fossil fuel share in total energy consumption.

Table 1: 2008 Emissions Data for Selected Countries

Region / Country	Population (million)	GDP (billion 2000 US$)	GDP ppp (billion 2000 US$)	Energy Cons. (MTOE)	CO_2 Emissions MT CO_2	Per-capita Energy Cons. (kgOE)	Energy Intensity KgOE/ $GDPppp	Kg CO_2/ $GDP ppp	Per-capita Electricity Cons. (kwh)	Per-Capita CO_2 Emission (tonnes)
World	6609	39493	61428	12029	28962	1.82	0.20	0.47	2752	4.38
China	1327	2623	10156	1970	6071	1.48	0.19	0.60	2346	4.58
Brazil	192	808.95	1561	235.56	347	1.23	0.15	0.22	2154	1.80
India	1123	771	4025	421	1146	0.53	0.10	0.28	543	1.18
Japan	128	5205	3620	513.5	1236	4.02	0.14	0.34	8475	9.68
S. Africa	48	178	517	134.3	346	2.82	0.26	0.67	5013	7.27
Thailand	64	173	548	104	226	1.63	0.19	0.41	2157	3.54
Turkey	74	372	821	100	265	1.35	0.12	0.32	2210	3.59
UK	61	1766	1833	211	523	3.48	0.12	0.29	6142	8.60
USA	302	11468	11468	2340	5769	7.75	0.20	0.50	13616	19.10
France	64	1506	1738	264	369	4.15	0.15	0.21	7573	5.81
Germany	82	2065	2315	331	798	4.03	0.14	0.34	7185	9.71
Russia	141.79	429.55	1651.17	786	1593.83	5.54	0.48	0.97	6443	11.24

Source: International Energy Agency 2009

6.2 GHG Emission Measurement

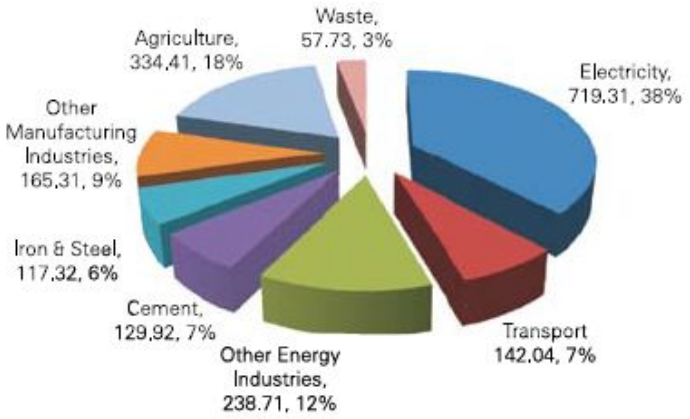
5.2.1 India's first GHG emissions inventory was made in 2004 as part of its National Communication. India has now proactively estimated its GHG inventory for the year 2007 in view of the need for GHG emission assessment to be made on a scientific and regular basis. The assessment for 2007 was carried out under the aegis of the Indian Network for Climate Change Assessment (INCCA). The GHG inventory has been

prepared by scientists and experts drawn from a network of a diverse mix of institutions across the country having the capacity to generate information on the GHG emission inventories by sources and removals by sinks from Energy, Industry, Agriculture, Land use Land-use Change and Forestry and Waste sectors on a regular basis. These institutions comprise of national research institutions, technical institutions, universities, industry associations, non-Governmental Organizations and the private sector. Other than estimating the GHG inventories, these institutions also collected activity data from relevant sources, and are also involved in the process of generating country specific emission factors. Developing country specific emission factors has been the thrust since the First National Communication process begun, especially for the key emitting sources, as it makes the inventory more representative of the circumstances under which the emissions take place and the estimates more scientifically robust.

6.3 GHG emissions in 2007

6.3.1 India's GHG emissions are heavily influenced by the structure of its large and expanding economy, the limitations on its energy resources, as also its current status in terms of energy access. In 2007, India's greenhouse gas (GHG) emissions by sources and removal by sinks were 1727.71 million tons of CO2 equivalents (or 1904.73 million tons of CO2 equivalents without land use, land use change and forestry), with the largest shares from electricity generation (38%), agriculture (18%) and other energy industries (12%)[1].

Figure 1: Greenhouse Gas Emissions Distribution across Sectors, 2007



[1] India emitted 1994456.20 Gg of CO_2 eq., of which CO_2 was 1425672.86 Gg, CH_4 was 20896.35 Gg, N_2O emissions were 320.86 Gg. The total CO_2 equivalent emissions were 1964088.77 Gg. The rest of emissions were as HFC 134a (1.67 Gg), HFC 23 (1.24 Gg), CF_4 (1.47 Gg), C_2F_6 (0.15 GG), and SF_6 (0.12 Gg). The energy sector emitted 1374267.43 Gg of CO_2 eq., of which 1271587.83 Gg was emitted as CO_2, 4065.47 Gg as CH_4 and 55.82 Gg was emitted as N_2O. The Industrial process sector emitted 189987.86 Gg of CO_2 eq. The CO_2 emissions from this sector were 154085.03 Gg, CH_4 emission was 10.65 Gg, N_2O emissions were 17.13 Gg. The Agriculture sector emitted 372653.07 Gg of CO_2 eq., off which CH_4 was 14310.68 Gg, and N_2O was 232.67 Gg. The waste sector emitted 57726.81 Gg of CO_2 eq., of which CH_4 was 2515.15 Gg and the N_2O emission were 15.81 Gg.

6.4 Energy emissions

6.4.1 Although a number of analyses establish that India has a low energy consumption level on a per capita basis and is following a path of low-emissions growth, the energy related emissions are expected to grow in the coming decades. India's CO2 emissions from fuel use in 2007 were less than 5 percent of the world total, according to the International Energy Agency (IEA 2009), but its share of the global emissions is likely to increase with economic development.

6.4.2 Economic growth, increasing urbanization, rise in per capita consumption, and spread of energy access are the factors likely to substantially increase the total demand for electricity. This is likely to be so in spite of several substantial initiatives taken to reduce energy intensity of growth through measures such as energy efficiency standards, labels, building codes, and introduction of market mechanisms for energy intensive industries. As per Planning Commission, energy elasticity of GDP growth between 1991 and 2004 was 0.82[2]. Actual values in a regime free of energy constraints (that India has been traditionally facing) could be higher as more and more consumers come into the fold of commercial energy consumption[3].

6.4.3 Coal is the mainstay of India's generation in the past and is likely to continue to be the primary fuel source, as India lacks sufficient alternate sources of domestic energy. Hydro projects have contributed to the generation mix substantially. However both these resources are increasingly facing challenges. In spite of adoption of more efficient coal technologies there is a risk that domestic coal supplies may get constrained within the next few decades. There could be shortfalls in achieving hydro power development in the 11th Five Year Plan (2007-12). High transmission and distribution losses on account of inadequacies in network infrastructure add to these difficulties. The resultant electricity supply shortages cause increasing consumption of quantities of diesel and furnace oil being used by all sectors – industrial, commercial, institutional or residential. The lack of rural lighting is leading to large-scale use of kerosene. Biomass is still the fuel of choice for a large portion of the rural population.

6.4.4 India's urban population is likely to increase from 288 million in 2000 to 590 million by 2030, a 2.4% annual increase. Rapid urbanization is expected to place substantial stress on existing—often insufficient—transport infrastructure, both for long-distance freight and the movement of people within cities. The transport sector is the second largest contributor to energy related GHG emissions in India, and its share in national GHG emissions has increased from 6.4 percent to 7.5 percent between 1994 and 2007 [INCCA 2010]. Moreover, India imports about 80 percent of its petroleum requirements, a significant part of which is used for transport. Despite the efforts already

[2] Source: Planning Commission of India, http://planningcommission.nic.in/sectors/index.php?sectors=energy

[3] As per the Integrated Energy Policy, 2006, about 43 percent of India's energy requirements are met through non-commercial energy – wood, biomass, agricultural residues, etc. As consumers switch to various forms of commercial energy with economic and social advancement, the demand on commercial energy will increase further. Large scale use of grid and off-grid captive power (primarily on furnace oil and diesel) also indicates that the energy elasticity data could be understated to some extent.

undertaken, emissions from the transport sector are expected to experience among the fastest growth of any sector. In order to meet this challenge, extensive and better mass transit systems in cities will need to be developed. Investment in efficient modes of freight transport, and improvement of vehicle efficiency should be a priority.

6.5 Low carbon growth

6.5.1 India has followed a conservative and low carbon policy despite its rising energy demand and continued supply constraints. These include promotion of renewable energy, innovative mechanisms to boost energy efficiency, and high energy prices. The Integrated Energy Policy (2006) aimed at maximizing the development of renewable and other cleaner energy options. The 11th Plan had laid down a target of increasing the energy efficiency by 20% by 2016-17. India has now announced that it will endeavour to reduce the emissions intensity of its GDP by 20 to 25% by 2020 in comparison with 2005 level. [These exclude the methane emissions which arise primarily in agriculture and livestock sector.] With its relatively low carbon footprint and steadily declining energy intensity over the last decade, the goal of voluntary mitigation goal can be achieved through a predetermined strategy.

6.5.2 With an expectation of a substantial increase in energy use, reduction in the growth in total CO2 emissions will depend on the extent to which total growth in energy use is offset by a combination of (a) further reduction in energy intensity of GDP, allowing growth and development goals to be met with less growth in energy use and associated CO2 emissions than anticipated; and (b) further reduction in the CO2 intensity of energy use, through greater increases where possible in the share of energy demand met by lower-carbon or even carbon-neutral energy resources.

6.5.3 12th Five Year Plan will therefore need to evolve a viable and effective strategy of improvement in emissions intensity of power sector and other energy-intensive sectors of economy. The strategy should look at the mitigation options, choice of policy and possible actions, and financial and technological resources needed to implement the strategy within a specific timeframe. The financial outlays and technological support should accordingly be identified and provided through the 12th Plan or other identified sources to achieve the objectives of the strategy.

6.5.4 Green growth: In the context of climate change and domestic mitigation strategy, a reference is often made to the need to adopt policies and measures aimed at promoting green growth. The objective of 'green growth' or 'greening the economy' need not be reduction of GHG emissions in absolute or relative sense; it must be squarely placed in the context of sustainable development. An effective mitigation strategy should essentially focus on increased productivity and development through conservation of resources, and not on low carbon development. A mitigation strategy can at best have an objective of having lower carbon development so that there is no need to draw an artificial or imagined trajectory of Business As Usual (BAU) carbon emissions. A BAU for emissions growth, a concept implicit in the objective of low carbon growth, is not only difficult to draw but also not desirable for a growing economy where the energy

needs are largely unmet and an appropriate level of development is neither within reach nor defined with reference to the available energy resources. Moreover, greening of economy should cover sustainable use of all resources and not just carbon. The aim of green growth should therefore be achieved through a lower carbon strategy relative to a desired level of output and emissions, the use of improved technologies and systems, and should be accompanied by the goal of improving energy access and energy security in the long run.

6.5.5.1 **Green technologies:** In this pursuit, technologies which offer opportunities to build local and global leadership need to be promoted. There is a need to identify climate friendly technologies that can help inclusive growth with least energy resources. Diffusion and deployment of available technologies with the required financial and technical resources is a big challenge; these need to be scaled up through a special programme that should have both a financial and capacity building component. At the same time, development of and access to new technologies in this area should receive highest attention. Global agreement on creation of Climate Technology Centre and Network notwithstanding, there should be a national network of such centres that promote diffusion and development of climate friendly technologies. Efforts are being made with the help of Global environmental Facility to create a Partial Risk Guarantee Fund that will support the PAT scheme of the Bureau of Energy Efficiency. However, a clearly planned strategy and mechanism for supporting diffusion, deployment and adoption of climate friendly technologies should be launched during the 12th Plan.

6.5.5.2 The goal of National Manufacturing Policy (NMP) in support of deployment of green technologies should be harmonized with the overall mitigation strategy for climate change. In identifying and classifying green technologies under the NMP, the policy should be consistent with the objective of the national action plan on climate change. While there may be a case for promoting or incentivizing technologies through regulatory as well as market based policy interventions, the overall objective must be to achieve inclusive and sustainable development. Benchmarking or standardisation of technologies should be avoided in this exercise and the thrust of domestic actions should be on development of best, most efficient and affordable technologies.

6.6 Sector Identification

6.6.1 Government of India has already identified a range of initiatives that form a core part of its mitigation strategy. National Missions have been launched with specific goals and programmes aimed at achieving the objective of sustainable development. Two of the NAPCC missions are aimed at augmenting the clean energy supply base, while simultaneously promoting energy efficiency. Within the clean energy space, the overwhelming focus of the Jawaharlal Nehru National Solar Mission is on expanding the reach of solar energy for energy generation (both grid based and decentralized) as well as other applications related to lighting, space heating and cooling, and cooking applications. In the area of energy efficiency, the National Mission for Enhanced Energy Efficiency intends to introduce commercial incentives and market based arrangements to encourage consumers to reduce the extent of energy use without compromising on the

economic and social priorities of the country. In addition, the National Water Mission and the National Mission for Sustaining the Himalayan Ecosystem have a bearing of energy generation and consumption in a sustainable manner.

6.6.2 While the identification of mitigation potential of various sectors will need to be decided and finalised through inter-sectoral consultations with concerned Ministries, a preliminary analysis of the possible sectors and actions is in order.

Power:

6.6.2.1 For achieving transition to clean energy and higher energy efficiency, power sector is the foremost sector deserving attention. Various modeling projections indicate that the largest share of greenhouse gas emissions in India will continue to be from the power sector (captive generation and grid supply) by 2032. The Expert Group appointed by the Planning Commission has indicated that India will need to increase its installed capacity to 377 GW (from current levels of 172 GW) if it has to sustain 9 percent economic growth until 2020. According to these projections, emission from the power sector could be in the range of 1452 to 1620 million tonnes of CO2 equivalents by 2020 (from the current 719 million tones of CO2 equivalent). Hence, any effort in this sector, has the potential to significantly reduce the total quantity of emissions against a business as usual scenario.

6.6.2.2 Ensuring minimum efficiency of new coal-fired power plants that are being built could be an important component of the strategy in power sector. Rehabilitation of existing lowest efficiency coal-fired units and their replacement by more energy efficient plants including super critical coal plants is another "low hanging fruit". On the supply side, this may be deepened through the reduction of electricity Transmission and Distribution (T&D) losses. If T&D losses are reduced from the current estimated level of 29.3% to 15.05% in 2025-26 (as planned by Ministry of Power), the energy supplied through the grid is likely to decrease by a total of 16% of supplied power over the 25-year period. An ambitious programme (restructured Accelerated Power Distribution Reforms Programme, or r-APDRP) launched to reduce electricity transmission and distribution losses by 50% (to a level of 15% from the current level of 30%) will obviously be a necessary component of this strategy.

Energy Efficiency:

6.6.2.3 Energy Efficiency (EE) measures have a high impact on low carbon growth and energy security. The 11th Five Year Plan targets an increase in energy efficiency of 20% by 2016-17 through implementation of a set of energy efficiency interventions. Energy efficiency is the focus of one of the eight missions under the NAPCC. Under the NAPCC, the PAT (Perform, Achieve and Trade) mechanism has already been launched that will achieve enhanced reduction in the energy intensity of the most energy-intensive industrial units. The scheme will enable the trading of Energy Savings Certificates earned by the industrial units through the achievement of reduction in their specific energy consumption (SEC) which is in excess of their mandated SEC reduction target. Achieving a further improvement to reach 50% by 2031-32 would reduce the growth

factor of energy supply from 4 to 3.5 with an additional savings of 1,850 million tons CO_2 over this 25-period (equivalent to 74 million tons CO_2 on average per year).

6.6.2.4 On the demand side, introducing a labeling and standards programme to increase the energy efficiency of energy-using equipment and appliances (including cars and other vehicles) could be a useful addition to the measures planned to optimise energy demand. Significant reductions in CO2 can be achieved through investments and expenditures by adopting mandatory minimum energy efficiency standards for lighting, entertainment appliances, kitchen appliances, and heating/cooling purposes. A market based mechanism for **high / super efficient appliances** could be introduced on the lines of the Bachat Lamp Yojana. This can yield savings in the order of 75 million tons CO2 annually, or 1,875 million tons over 25 years. Due regard could be given to the design of such standards to ensure that they remain eligible to a number of financing mechanisms that are emerging in the international arena to promote lower carbon growth. Adoption of such standards could limit household electricity consumption in 2031-32 to only 2.7 times 2007-8 levels[4].

6.6.2.5 Use of energy in commercial and residential buildings has a huge potential of reducing emissions. It is expected that two-thirds of the commercial buildings in 2020 will be built between 2005 and 2020. Implementing the Energy Conservation Building Code to reduce the energy use in new, large commercial buildings aggressively should be a priority. This needs effective integration of the ECBC with the building bye laws implemented by the local governments. Adoption of ECBC could lead to a decline of 30% in the energy intensity of the commercial-buildings sector.

Renewable energy:

6.6.2.6 Even as coal based generation will continue to be the mainstay for quite some time, alternative approaches for catering to the growing energy demand need to be promoted on a large scale. The share of renewable energy technologies in electricity production is small, but the installed base has been steadily growing. With an average installed capacity of close to 2000 MW per annum in the last few years, renewable energy technology (RET) installations have shown commendable growth. Despite poor wind resources, wind energy capacity has grown at about 26 percent annually, due to the favorable policies followed in the renewable energy sector. Wind energy has contributed almost a third of new capacity of renewable energy.

6.6.2.7 The Solar Mission under the NAPCC has the objective of addiing 20,000 MW of grid-connected solar power by 2020. Specific generation and financial targets for this Mission have to be laid down and converted into an action plan.

6.6.2. Existing policies already mandate procurement of electricity from renewable sources of energy. Renewable Purchase Obligations already exist in 19 states. Addition of renewable energy to the grid through the introduction of Renewable Energy Certificates will enable states that are rich in renewable-energy resources to recover costs of additional renewable-energy procurement from other states that are deficient in these

[4] World Bank study for low carbon growth in India, 2009

resources. This is expected to lead to further addition of renewable–based electricity generating capacity during the 12th Plan period. However, it is critical that the RPO enforcement mechanism across the states is made effective, with severe penalties for failure or non-compliance. The recent revision (downgrading) of REC prices has created a negative sentiment within the investor community. A mechanism for continuous engagement with the financial institutions and investors needs to be evolved in order to sustain high investor interest in RE projects.

Forests as carbon sinks:

6.6.2.9 Forests act as a major carbon sink. More than a fifth of India's land area is under forest cover. 6-7% of India's annual emissions will continue to be absorbed by the forests in 2020. India is one of the few developing countries in the world where the forest cover is increasing, despite the pressures of population growth and rapid economic development.

6.6.2.10 The current plan aims at increasing in forest cover @ almost 0.8 mn hectares (0.25% of India's land area) every year. It is proposed to be raised to 2.3 mn hectares p.a. through the new afforestation initiatives. A Green India Mission has been launched to promote additional afforestation in 10 million hectares. This can be augmented through the following promoted through green bonuses to state governments through financial allocations (through finance commission awards) of $1 billion approx. for eco-friendly and sustainable forestry development over a 5-year period. CAMPA can provide an additional $2 billion (Rs 17,000 crs approx.) to state governments for compensatory afforestation activities.

Transport sector:

6.6.2.11 **A**ggressive fuel efficiency standards need to be considered to make substantial impact on emissions in this sector. Fuel efficiency measures alone will make marginal impact on total emissions unless policies are enacted to promote fast and efficient public transport over private transport, and corresponding infrastructure is developed. Introduction of electric vehicles could have some impact on the quality of emissions. Development of bio-fuels and other alternative fuels should be an essential part of this inter-sectoral strategy. National Mission on sustainable habitat should aggressively take these steps forward.

International Market Mechanisms:

6.6.2.12 Clean development Mechanism (CDM) of the Kyoto protocol helps developed countries meet their quantified emission limitation and reduction commitments through greenhouse gas reduction projects set up in developing countries like India. CDM has helped the developing countries enhance their sustainable development and at the same time facilitated emissions reduction at the national level. With around 25% of total globally registered CDM projects, India represents a significant component of the global carbon market. CDM has the potential of creating an additional financial flow of about US$ 6 bn that may help in reducing CO_2 emissions in sectors of energy efficiency, fuel switching, industrial processes, municipal solid waste and renewable energy. National CDM Authority (NCDMA) in India has accorded Host

Country Approval to about 2033 projects having a potential to facilitate an overall inflow of approximately US $ 7.07 billion in the country by the year 2012 if all the projects get registered. The potential of total emissions reduction amounts to about 10% of our emissions. With new forms of market mechanisms that are under discussion in the climate change negotiations, it may be necessary to scale up the capacity building efforts in this sector to help India industry utilize the emerging opportunities and meet the challenges.

6.6.2.13 Use of ICT in the Mitigation-related National Missions

CII has recommended that ICT solutions can potentially lead to GHG emission savings of about 320-450 million tCO2 per annum in 2030, which is approximately 8-10% of the estimated GHG emissions in 2030. Details of these proposed measures given in Annexure to this section.

6.7 Nationally Appropriate Mitigation Actions (NAMAs):

6.7.1 It is important to ensure that a formal strategy for mitigation is evolved and implemented through a comprehensive programs of Nationally Appropriate Mitigation Actions, as feasible and financially viable, and in a manner that does not compromise the ultimate goal of sustainable development. 12th Plan should therefore launch a formal process for development of a mitigation strategy and identification of NAMAs in consultation with the concerned Ministries and stakeholders. The MoEF should take a lead role in piloting this process since the legal and political responsibility of implementing the domestic mitigation goal vests with the Ministry.

6.7.2 To aid this exercise, the Planning Commission has constituted an Expert Group on Low Carbon Strategies for Inclusive Growth. The Group is currently working to provide inputs on identification of sectors and possible mitigation actions. [It has come out with an Interim Report that is available at http://planningcommission.nic.in/reports/genrep/Inter_Exp.pdf]. The formal process to be launched under the 12th Plan should take into account the Report of the Group and hold widest possible consultation with the concerned Ministries and stakeholders before recommending a set of actions.

6.7.3 Under the recently agreed Cancun decisions, there is possibility of creating a set of NAMAs that can be funded either from international sources or linked to markets. A national authority for preparing and implementing NAMAs should, therefore, be set up with clear responsibility of implementing NAMAs and finding the required resources from the national and international sources. The Agency should also have the responsibility of monitoring the emissions reduction outcomes relative to the national goals under international agreements. Under the CDM, such a designated national authority (inter-ministerial body) already functions in the MoEF to consider, examine and approve the projects which are validated and verified by accredited third party entities known as Designated Operating Entities (DOEs). The national authority for NAMAs can function on the basis of similar objectives and nationally developed MRV protocols. It

will however need to be strengthened institutionally. Financial resources will need to be provided and mobilized through a national fund to empower the Authority to administer the strategy and ensure its implementation.

National Mission on Enhanced Energy Efficiency (NMEEE): Of the 90-100 million tCO2 emission reduction target of this mission by 2016-7, the adoption of ICT in buildings, transport and the nine sectors identified under the PAT scheme has the potential of contributing approximately 31 million tonnes. The projected GHG emissions from the sectors under the NMEEE is about **1.55 billion tCO2 in 2020, and 3.2 billion tCO2 in 2030.** The ICT solutions available for enhancing energy efficiency can be categorized into Level-0 to Level-5, with every level corresponding to more sophistication and better functionalities as compared to the previous level. The DESC project analysis reveals that implementation of the identified ICT-based energy efficiency solutions can potentially save energy to the tune of about 221-465 PJ per annum in the year 2020 and 887-1,452 PJ per annum in the year 2030, assuming moderate and high penetration of the identified ICT solutions is achieved by then. The energy savings will translate into **GHG savings** of about **17-29 million tCO2 per annum in the year 2020 and 69-114 million tCO2 per annum in the year 2030. O**ut of this, power (transmission & distribution), railways (traction) and iron and steel will together account for more than 90% of the total energy saving potential.

National Mission on Sustainable Habitat (NMSH): Both commercial and residential construction contribute significantly to the economy, approximately 6.5% of the GDP. These sectors, in turn, consume substantial quantum of energy throughout the lifecycle of buildings, contributing to around 6% of India's total GHG emissions. Energy consumption during the operation phase of buildings is driven by two factors: energy intensity, and floor area. ICT-enabled monitoring, feedback and optimisation tools can be used to reduce both these factors at every stage of a building's lifecycle. Some of these tools include energy modelling software, building management systems, lighting and HVAC controls. ICT solutions also enable real-time information sharing on energy consumption of every energy-consuming appliance in a building, empowering users to take informed decisions, resulting in energy savings. Similarly, ICT-enabled intelligent waste management systems can provide significant cost benefits for municipal solid waste sector. For achieving habitat mission objectives, the use of ICT should involve:

- defining the strategic roadmap for ICT adoption towards NAPCC / NMSH and setting up a mechanism for effective execution and monitoring,
- Providing supply and demand side fiscal incentives to reduce the high cost of ICT solutions.
- Promoting education, research and outreach to increase the awareness and availability of skilled resources.
- Promoting standardization and localization of technologies to reduce the initial and running cost of ICT solutions.
- In certain focus areas, taking the regulatory recourse for higher ICT adoption.
- Applying ICT for implementation of habitat mission and to increase information availability for policy makers and end users.

National Solar Mission (NSM): ICT-based solutions will play a critical role in ensuring effective implementation of NSM. Currently the penetration of ICT for solar power is very limited and much needs to be done to promote existing technologies and also to develop new technologies. The recommendations for achieving Solar Mission objectives through the use of ICT can be categorized into the following key areas:

- **Promotion of Solar Information and Monitoring Network:** Link all solar installations of the country through a communication channel with the state and national-level monitoring centre. Such an infrastructure will aid in effective ground level tracking of the JNNSM initiatives and will provide the policy makers with a one-stop source for gathering all the information on solar power generation in the country,
- **Establishment of Knowledge Network for Solar Power:** Leveraging ICT, a knowledge network for solar power can be established that can focus on activities relating to information availability, education and outreach. One of the focus areas of the knowledge network can be promoting use of ICT for solar power generation and transmission.
- **Specific R&D support to "ICT for solar":** ICT for solar power is still evolving and there is no detailed research on leveraging ICT for solar power in domestic context. These challenges can be addressed through focused R&D funding and establishment of CoE for "ICT for Solar". The CoE can also adopt a pilot project based model to demonstrate the use of ICT for solar power.
- **Overall proliferation of smart grids:** To ensure that the interfacing with grid do not become a hurdle for promotion of solar power, it is essential that the implementation of smart grids is fast-tracked. The ability to integrate the distributed solar power generation into the grid will depend on the maturity of grids to enable two-way power flow, dynamic pricing and accurate metering.

Section 7

State Action Plan on Climate Change

7.1 National Action Plan (para 4.6) recognizes that role of state governments and local governments in implementation of the Action Plan is crucial. With climate change becoming increasingly central to policy and actions of central Government at various levels, there is need for coherence between climate change strategies at national and state level. It is also clear that climate change (both mitigation and adaptation) will only be addressed at the ground level, if the state governments get involved in planning and implementing actions in pursuance of the goals of NAPCC.

7.2 MoEF has initiated a process of preparation of State Action Plans on Climate Change (SAPCC) as a follow-up to the announcement made by Prime Minister in the Conference of State Environment Ministers held on August 18, 2009. SAPCCs are to be prepared according to a common and generic framework while providing scope for incorporating state specific contexts and situations. SAPCCs are expected to build on the existing policies of the state Government by taking into consideration the ongoing programmes and schemes being implemented at the state level as well as the NAPCC.

7.3 The SAPCCs have to be integrated into the state level planning process so that the resource allocation for the implementation of the identified adaptation / mitigation measures can be defined with an objective to achieve the development goals of the state Governments. As it may not be possible to include complete array of measures to address climate change, the SAPCC should be seen as a dynamic document which will follow a continuous interactive process to reflect the changes and developments happening at the national, state and local level.

Template for SAPCC

7.4 While the content of State Action Plans will vary according to regional and local adaptation needs, the states would require orientation as to the methodological steps on the preparation of SAPCC. MoEF has, therefore, prepared and recommended a common template for preparation of SAPCCS to all states with focus being on the following elements:-

- *Impacts and Vulnerability assessment:* Methodological steps and common guidelines for analyzing impacts of climate change as well as vulnerability assessment at the regional and local level should be a part of SAPCC. Reference for this may be drawn from the national exercises conducted for impacts and vulnerability assessment e.g. India's National Communication to UNFCCC.
- *Identify Adaptation/Mitigation options*: The Mission documents under the NAPCC will provide the guiding framework to the states in identifying adaptation / mitigation options[5] suiting to regional or local requirements. Various ongoing

[5] Draft National Water Mission (http://wrmin.nic.in/index2.asp?sublinkid=579&langid=1&slid=794)
National Solar Mission (http://mnes.nic.in/)

programmes and schemes should be included and their relevance to complement adaptation / mitigation needs to be examined. This will also include additional interventions and cross cutting issues which are not covered under the eight Missions.

- *Prioritize Adaptation/Mitigation options*: The states require inputs about the national level priorities to align the actions at the local level. Adaptation/ mitigation options will need to be prioritized in terms of time horizon (matching the plan period) and the resources available.

- *Financing Adaptation/Mitigation options*: Additional resources as well as policy shifts will be required to implement the adaptation/mitigation options. States will require active guidance to identify potential financial sources as well as appropriate technology. They may also require support to design the feedback mechanism to the national level missions.

Institutional Mechanism

7.5 A National Steering Committee under the Chairmanship of Secretary, Ministry of Environment and Forests has been set up to consider and approve/recommend the SAPCC. An Expert Committee under the Chairmanship of Adviser, Climate Change Division, MoEF, with members from various Nodal Ministries/ Departments functions to screen the SAPCCs and recommend them to the Steering Committee for consideration. The expert committee has the task of reviewing the draft documents and provide suggestions/recommendations to States for incorporation in their final SAPCC reports.

Financing of State Action Plans

7.6 SAPCC will need to be funded in course of implementation of State Plan in various sectors and the resources may be mobilised/provided through budgetary and/or bilateral/multilateral financing channels including the central plan. Various activities under SAPCC will, therefore, need to be part of a central plan scheme. In addition, State Government may receive bilateral and multilateral support for implementation of various activities depending on the priorities set by these States.

7.7 12th Plan should, accordingly, set up a formal mechanism for recognizing and financing the SAPCCs. MoEF should launch a programme for this purpose and specific provisions for this purpose should be made in its sectoral budget, as the Nodal Ministry for Climate Change. MoEF will monitor the implementation of various activities envisaged in the SAPCC and will act as repository of the information relating to Climate Change.

National Mission for Sustaining Himalayan eco-system (http://www.indiaenvironmentportal.org.in/files/national%20mission-4.pdf)

Criteria for allocation to states for SAPCCs

7.8 The Steering Committee recommendations should be the basis of consideration of the State Action Plans on Climate Change by the Planning Commission. Planning Commission should recommend budget provision for the SAPCC and allocate resources based on transparent criteria for adaptation and state-relevant actions. Finance Commission has already dealt with the issue of an appropriate criteria for rewarding the states for their environment related actions and has made detailed recommendation on the principles which should govern the allocation out of the divisible pool of resources for preservation and maintenance of forests and ecosystem based adaptation. Some additional criteria can be evolved in consultation with the state governments and the Ministries. The dominant criteria of course should be the relevance of the various activities proposed by States to the achievement of the NAPCC.

Section 8

Climate Change Finance

8.1 The cost of addressing climate change in India will depend on its adaptation needs, and the targeted level of GHG emissions intensity reduction within a certain time-frame. India's strategy for enhancing its adaptive capacity to climate variability is reflected in many of its social and economic development programmes. Government of India already spends around 2.8 per cent of GDP in programmes which has strong adaptation relevance.

8.2 In the past couple of years India has been witnessing an average GDP growth rate of around 8-9%. India will have to sustain this growth rate for the next 20 years to eradicate poverty and meet its other human development goals. Meeting the energy requirements for growth of this magnitude in a sustainable manner presents a major challenge. The need to accommodate India's environment pledges is expected to impact growth figures if no external financial support is extended. The investments so far have not been enough to bridge the gap in the need and availability of resources and the future is likely to be much harder requiring massive amount of resources, technology transfers and choices, research and development, incentives, etc reinforcing the fact that this ambitious pledge of 20-25% emission intensity reduction is not going to be costless.

8.3 Domestically, though no ready estimates of costs are available, and the Interim Report of the Planning Commission by Expert Group on Low Carbon Strategies for inclusive growth is yet to provide consolidated estimates, it is common understanding that funding requirements to address climate change would add upto several billions of dollars. If developing countries like India are to provide incremental economic or investment costs to address climate change, it is likely to have adverse impact on its growth/poverty eradication measures because of the competent demands on health, education, livelihood security and diversion of resources from core issues to climate change.

8.4 The integrated energy policy estimates that India's primary energy supply will need to be increased by 4-5 times and its electricity generation capacity by 6-7 times of its 2003 – 04 levels to be able to sustain 9% growth rate through 2031-32 with primary energy growth supply of around 5.8%. Now there is a strong correlation between emission, energy and GDP. On one hand we have to augment energy supply to enhance growth and GDP and on the other hand if a clean energy path is not opted it would increase emission and hence emission intensity of GDP. The table below presents a range of electricity generating technologies and their associated costs.

Capital Costs forVarious Electricity-Generating Technologies

Technology	Capital Costs per Installed kW
Gas/oil combined cycle	$445
Advanced gas/oil combined cycle	$576
Wind	$983
Coal	$1,092
Coal gasification cycle	$1,306
Waste and landfill gas combustion	$1,395
Geothermal	$1,708
Biomass	$1,732
Fuel cells	$2,041
Advanced nuclear	$2,188
Solar thermal	$2,946
Solar photovoltaic	$4,252

Source: Energy Information Administration, "Assumptions to the Annual Energy Outlook 2001" DOE/EIA0554 (2001), December 2000, Table 43, p. 69.

8.5 We can extract two extreme choices from the above table. First is that we can meet our energy and growth needs with less consideration for the environment using the cheapest technology which is gas/ oil combined cycle. The second choice is that we give weight to our voluntary pledge of reducing emission intensity and in doing so adopt the costly clean technologies. However in adopting the second choice even though we may be able to reduce emissions, we will have to invest as much as around 8-10 times more than the first choice, assuming both choices targets a sustained growth rate of 9%. The question is now that can we afford such a massive drain on climate change, letting loose other development priorities. The gravity of the situation is very evident from the resources required for mitigation in the energy sector, let alone the fulfillment of the pledge.

8.6 Keeping the costs aside for a while we now come to the policy intervention to support the pledge. Aggressive adaptation and mitigation measures will have to be pursued in crucial sectors like energy, water, forestry etc. In this regard the National Action Plan on Climate Change (NAPCC) announced in June 2008, outlines a number of steps to be taken in critical sectors, to simultaneously advance India's development and climate change related mitigation and adaptation objectives. The table at Annexure to Section 4 provides a brief review of the financial outlays under the eight missions.

8.7 There are two broad channels available for raising funds; international and domestic sources. Talking about international sources first, a major channel for mobilizing funds to the developing countries is the green climate fund. The GCF is being looked at as one of the biggest source of consistent fund flow for developing countries like India and the absence of which could hinder developing countries capacity to meet its environmental goals. However, GCF is still under construction and its operational modalities, scope of activities and financial resources are not known.

8.8 Carbon Markets

8.8.1 Mechanisms like carbon trading allow developed countries in meeting their carbon reduction targets besides benefiting developing countries in terms of financial resources that complement their sustainable development efforts. The market can be compliance based such as the one created under Kyoto protocol or it could be voluntary in nature. India is an active player in the CDM and Indian economy offers huge potential for GHG emission reduction. National CDM Authority (NCDMA) in MoEF has so far accorded Host Country Approval to over 2000 projects having a potential to facilitate an overall inflow of approximately US $ 7.07 billion in the country by the year 2012 if all the projects get registered.

8.8.2 However, negotiations on preserving and strengthening CDM in the 2nd commitment period of the Protocol from 2013 onwards are not making headway and it is likely that this source of funds may dry up or dwindle drastically. The scale of likely financing available either through new market mechanisms on multilateral or bilateral basis is uncertain. Moreover, majority of current Indian projects under CDM are smaller in size.

8.8.3 Efforts need to be undertaken to increase participation of banks in financing such voluntary projects, bundle small projects to reduce transaction costs and increase the average project size. Most of the projects in India are unilateral in nature wherein the project entity undertakes the registration of the project by themselves and aim to sell the carbon emission reduction (CER) units at the spot market rather than selling them in forward markets. There is also a need to ensure that CDM or carbon market does not get reduced to a sale of carbon reduction for the benefit of other countries but becomes a source of technology.

8.9 Therefore, India has to mostly utilize and rely on the domestic sources of climate finance, which are budgetary allocations and the very recent National Clean Energy Fund which is being fed by a cess on coal. The cess has become operational and its revenue (of the order of about $800 million every year) will go to a newly created National Clean Energy Fund (NECF) for supporting commercialization of clean-energy technologies. The Fund will finance innovative projects in clean energy technologies and harnessing renewable energy sources to reduce dependence on fossil fuels. From the Fund, already allocation of Rs 200 crores has been proposed for environmental remediation programmes and another Rs 200 crore for Green India Mission.

8.10. Apart from the figures indicated in the mission table above, additional budgetary allocations have been made from the 13th Finance Commission for 2010-15. The 13th FC keeping in view the urgent need for action for combating climate change, has recommended three types ofgrants to state governments of Rs 5000 crore each, viz. for forest cover, renewable and water sector.

8.11. The issue second to raising of funds is allocation of funds. In the light of resource scarcity, prioritization is required across the sectors. It should be ensured that allocation

follows the principle of Fiscal Responsibility and Budget Management. India needs to lay greater emphasis on adaptation than mitigation while allocating funds to different environment priorities and within competing adaptations and mitigation needs, social preferences backed by cost and efficiency should take over the allocation decisions. In the process an inherent algorithm function should be seen driving the investment decisions.

X' amount of funds to sector 'I', given total resources 'T, guided by:

- ***Xi= f(m, a, e, p, s, d, y, z)----(1)***

- ***where m=mitigation; a=adaptation; e=reduction of carbon emissions efficiency; p= cost per unit carbon saved; s=fiscal cost; d= distribution of benefits (household & community); y=empowerment; and z=other social externalities)***
- ***$\sum Xi = T$***

Conclusion

8.12. The budgetary commitments and proposed announcement of funds may not be sufficient when compared to the actual requirement of resources to deal with the problem of climate change at the national level. However, in the light of resource scarcity, competent demands, and India being a developing country, the provision of funds reflect India's strong will to address the challenge of climate change. In this backdrop and in India's limited capacity to generate resources domestically for climate change actions, the budget and plans of growth reflect India's will to be environment friendly. With international collaborations and finalization of the financial mechanism of resource flow from the developed world to the developing countries through the Green Climate Fund and technology transfer, India's resources will enhance India's capacity to address climate change actions.

8.13 While a National Clean Energy Fund has been set up by the Ministry of Finance with revenues from coal cess, it will be appropriate if a more broad-based National Strategic Fund for Climate Change RD&D is set up with the objective of supporting R& D in respect of climate change science, development and deployment of adaptation and mitigation/clean energy -related technologies and projects, development of new technologies, networks of scientific and RD&D institutions, and environmental conservation and management practices including investment (equity and/or debt) and venture capital financing of initial commercial scale deployment of the technologies. With a view to mobilise resources from all possible sources and involve all stakeholders in this exercise, the financial resources for the operation of the Strategic Fund could be sources from public, private, corporate and international sources. The Fund should be a vehicle for receiving international support for climate change through agreed bilateral and multilateral channels with a view to finance NAMAs, and actions aimed at adaptation, development/deployment of technologies and capacity building. The sources could differ according to the uses and purposes.

Section 9

Summary of recommendations

In view of the significant environmental, social, and economic impacts of an increasingly warming world, India needs to channelise and enhance its potential response for mitigation and adaptation in line with the country's overall developmental goals and aspirations.

The existing policies and programs under the 11th Plan have made some headway in terms of addressing climate change, e.g building adaptive capacity through ongoing development programmes, launch of a National Action Plan on Climate Change, and reducing the energy and emissions intensity of the economy and society. However, there is still a considerable potential to enhance the effectiveness of policies and programs to accelerate sustainable development and guide the country along a more proactive path in addressing climate change issues.

This section summarises the possible further policy initiatives and programmes in the core areas of mitigation and adaptation that can strengthen the existing policies and actions to accelerate the move towards sustainable development.

9.1 Integration of NAPCC into central sector plans

NAPCC is being implemented by various Ministries to enhance the capacity to cope effectively with the consequences of climate change. The objectives of the NAPCC should permeate the planning process at all levels. Specific sectors that are included in the NAPCC should be built into the respective sectoral plans. Sectors of particular interest, in this regard, are agriculture, water, health, coastal management, forests and other ecosystems, energy including renewable energy, and infrastructure and climate change assessment. This will however require large amount of resource mobilization. The assessment made by various Ministries for implementing their Missions is tabulated in the statement at Annexure to this Section . 12th Plan should take these requirements into account while finalizing sectoral outlays.

9.2 Specific sector recommendations

Agriculture:

9.2.1 A programme for science based *Agricultural Intelligence System* should be launched under the sectoral plan to facilitate understanding of impact of real-time weather and other inputs on production of important commodities. This should include setting up of Weather Watch groups should be set up for climate sensitive commodities for real-time monitoring of weather impacts and to enable appropriate policy response.

9.2.2 Community partnerships should be supported in developing food and forage banks to manage scarcity during projected increased periods of drought and floods.

9.2.3. A 'Green Research Fund' should be set up for strengthening research and deployment of adaptation technologies and conduct/manage impact assessments.

Water:

9.2.4 The existing framework of collection and analysis /use of data from river basins etc. should be strengthened with more advanced modeling tools e.g. MIKE Basin/RIBASIM for basin simulation and management, Soil and Water Assessment Tool (SWAT) for generating hydrological scenarios, MODFLOW for ground water, WEAP for water management etc. An amount of Rs.300 cr. May need to be provided in the respective sectoral plan.

Forestry:

9.2.5 The Green India Mission should be aggressively implemented to achieve the target of a) qualitative improvement of forest cover/ecosystem in moderately dense forests (1.5 m ha), open degraded forests (3 m ha) , degraded grassland (0.4 m ha) and wetlands 0.1 m ha; b) eco-restoration/afforestation of scrub, shifting cultivation areas, cold deserts, mangroves, ravines and abandoned mining areas (2 m ha); c) bringing urban/ peri-urban lands under forest and tree cover (0.20 m ha); and d) agro-forestry /social forestry (3 m ha). The implementation should aim at carbon sequestration of 55 $MtCO_2$ approx. in the year 2020.

9.2.6 The Green India Missions should promote convergence of NAP with activities and objectives of NREGA in order to maximize efficiency and resource use. The central assistance for the afforestation per year is around Rs 350 crores. With convergence between NREGA and NAP, the financial resources for the Green India Mission can be augmented.

9.2.7 The monitoring mechanism and spatial and temporal performance of Green India activities should take place through high resolution IRS satellite image based. This could include initiatives aimed at maintenance of "**Long Term Ecological Sites",** use of modern methods of **"Terrestrial Laser Scanners" (TLS),** and attention to **Ecological hotspots.**

Coastal Zone Management

9.2.8 ICZM must be accorded enhanced priority in the context of climate change. Climate Change Impact Assessment should be integrated into the already existing practice of cumulative impact assessment of the environment.

Infrastructure:

9.2.9 Infrastructure related development projects should be climate resilient. Assistance to developmental activities or even environmental impact assessments may be made conditional on assessment of risks posed by climatic factors. These risks include direct threats to a project's investment (such as the effects of extreme events on infrastructure),

the underperformance of investments (failure of irrigation schemes), or investments that heighten vulnerability based on exposure to extreme conditions of climate (storm surges, landslides, floods etc).

Health:

9.2.10 Besides enhancing risk protection in four areas of risks arising from climate change, such as (a) Climate Change and Vector Borne diseases, (b) Aerosols and Respiratory Diseases, (c) UV-A and UV-B and Corneal Damage and Cataract and (d) Environment and Heart Diseases,, additional focus may be given on 'diarrheal and viral diseases', 'heat stress and certain types of cancer such as skin cancer'. Multi -disciplinary long term studies should be initiated in partnership with Indian Meteorological Department, Central Pollution Control Board and Indian Space Research Organization.

9.3 Climate Change Assessment

9.3.1 A GHG Inventory Management System (GHG – IMS) programme needs to be institutionalised, as India is required to publish its GHG inventory after every two years. The program is initially to be planned in the same manner as the Climate Change Assessment Centre, to be housed under INCCA and operationalized at the MoEF. The program would coordinate with network agencies for estimation and regular publication of GHG inventory. The nodal centre at MoEF would also act as a data repository and analysis centre for GHG inventory related issues and would support policy makers in feeding information pertaining to development of response strategies to the climate change challenge. The total budgetary support for initiating this activity as well ensuring its regular functioning would be INR 20 crore for the initial period of 5 years and thereafter, regular budgetary support would be required to ensure its continuity.

9.3.2 A **Black Carbon Research Initiative (National Carbonaceous Aerosols Programme) BCRI-NCAP** should be launched to enhance understanding of the impact of aerosols and greenhouse gases (such as carbon dioxide) on climate. This program is envisaged to comprise of 65 observatories and 101 institutions and the budgeted expenditure for this initiative would be INR 200 crores over a 5-year period.

9.3.3 A network of 10-12 **Long-Term Ecological Research Observatories** representing different biomes and geographical regions should be launched. The LTEOs will be used as locations for experimental research in ecology. This program is planned to comprise of 25 institutions and 10 observatories and would cost INR 100 crores over the 5-year period. Centre for Ecological Sciences is proposed to act as the coordinating agency for the scientific programme and the overall management at the National level.

9.3.4 For the North Eastern Region, a programme of **Co-ordinated Studies (CS) on Climate Change (NECC) (CS-NECC)** should be launched to understand the impacts of climate change on a sectoral and regional basis.

9.3.5 A specific programme aimed at **Climate Change Assessment Studies (CCAS)** and institutionalizing the obligatory and scientific work of the Ministry is urgently called for**.** The programme is required to build capacity in carrying out modelling studies of

climate change with the help of technological, economic and scientific observations/data and making assessment of climate change impacts, and vulnerability and adaptation to climate change on a regular basis. A dedicated Centre for Studies & Research in Climate Change should be set up within MoEF to provide scientific and analytical support for carrying out these functions. This programme may initially be conceptualised within the MoEF with a Director and at least 10 scientists and experts from different fields and associated support staff. The Centre should also plan, collate and coordinate the assessment work for National Communication which is a regular and mandatory international obligation performed by the Ministry. 12th Plan should support provision of at least INR 25 crore over 5 years to the Centre with an appropriate institutional arrangement.

9.4 Lower Carbon Growth Strategy

12th Plan should launch a process for development of a well coordinated policy of lower carbon inclusive growth. Strategy for mitigation should be implemented through a comprehensive programs of Nationally Appropriate Mitigation Actions so as to ensure the ultimate goal of sustainable development. The strategy should be formulated by an Empowered Inter-Ministerial Group. The Group should identify sectors and possible mitigation actions. The process under the 12th Plan should take into account the Report of the Group and hold widest possible consultation with the concerned Ministries and stakeholders before recommending a set of actions.

9.5 National Agency for Implementing Mitigation Actions

A national authority for preparing and implementing NAMAs should, be set up with clear responsibility of implementing NAMAs and finding the required resources from the national and international sources. The Agency should also have the responsibility of monitoring the outcomes relative to the national goals under international agreements. The national authority for NAMAs can function on the lines of the designated authority for CDM project. The Authority should have the powers to administer nationally developed MRV protocols and an institutional and financial structure to fulfill the domestic and international obligation for implementation of the mitigation actions.

9.6 State Action Plan on climate change

States should be supported to prepare and implement state level action plans on climate change. 12th Plan should launch a programme for supporting such actions at the state level and make specific provisions for this purpose in the relevant sectoral budget. Planning Commission should recommend budget provision for the SAPCC and allocate resources based on transparent criteria followed by the 13th Finance Commission, as suitably amplified. The dominant criteria of course should be the relevance of the various activities proposed by States to the achievement of the NAPCC.

9.7 National Strategic Fund for Climate

A National Strategic Fund for Climate Change RD&D may be set up with the objective of supporting development and deployment of adaptation and mitigation/clean energy - related technologies, R& D in respect of climate change science, development of new technologies, networks of scientific and RD&D institutions including investment (equity

and/or debt) and venture capital financing of initial commercial scale deployment of the technologies. The Fund should act as an independent entity in order to scale up its operations and fulfil both domestic and international mandate. The financial resources for the operation of the Strategic Fund could include funding by the Central and State Governments, private sectors, PSUs, multilateral and bilateral agencies, or endowment contributions. The National Clean Energy Fund (NECF) created with revenues from coal cess could be merged with the Fund.

Capacity building for Market Partnerships/Mechanisms

9.8 Efforts need to be undertaken to increase participation of financial institutions in financing voluntary projects for emissions reduction, bundle small projects to reduce transaction costs and increase the average project size. Although project based CDM is operational it should be enhanced in its scope through a programmatic mode of operation wherein projects could be implemented at a larger scale to generate credits. A capacity building initiative in this field should be launched with adequate budgetary provisions in public-private partnership mode.

Annex I

M-13033/1/11-E&F
Planning Commission
E&F Division

Yojana Bhawan, Parliament Street, New Delhi 110 001.
Dated 04.07.2011

OFFICE MEMORANDUM

Subject: Constitution of a Sub-group on Climate Change under the Working Group on Environment and Climate Change for the 12th Five Year Plan 2012-2017

The Steering Committee on Environment, Forests & Wildlife and Animal Welfare for the Twelfth Five Year Plan held its first meeting on 19th May, 2011 under the chairmanship of Dr. K. Kasturirangan, Member, Planning Commission. The Chairman has approved constitution of 4 Working Groups including 2 sub-groups under the Working Group on Environment and Climate Change. The composition and Terms of Reference of the Sub-Group on Climate Change is as under:-

1.	Shri J.M. Mauskar, Special Secretary, MoEF, New Delhi	Chairman
2	Shri Ranjan Chatterjee, Consultant, Planning Commission, New Delhi	Member
3.	Dr. Jagdish Kishwan, Addl. DG (WL), MoEF, New Delhi	Member
4.	Dr. Subodh Sharma, Adviser, MoEF, New Delhi	Member
5.	Dr. R. Krishnan, Scientist 'G' , IITM, Pune	Member
6.	Shri K.J. Ramesh, Adviser, Ministry of Earth Sciences, New Delhi.	Member
7.	Dr. C.B.S. Dutt, Group Director, NRSC, Hyderabad	Member
8.	Dr. V.M. Katoch, Secretary (Department of Health Research) & Director General, Indian Council of Medical Research, New Delhi	Member
9.	Prof. R. Sukumar, Chairman, Centre for Ecological Sciences, Indian Institute of Science, Bangalore	Member
10.	Shri N.H. Ravindranath, Asst. Professor, Indian Institute of Science, Bangalore	Member
11.	Prof. Amit Garg, IIM, Ahmedabad	Member
12.	Shri Akhilesh Gupta, Adviser, DST, New Delhi	Member
13.	Prof. A.K. Gosain, Civil Engineering Dept., IIT, Delhi	Member
14.	Dr. B. Sengupta, Member Secretary (Retd.), CPCB, New Delhi	Member
15.	Dr. Ajay Mathur, DG, BEE, New Delhi	Member
16.	Dr. Indrani Chandrasekharan, Adviser, PC	Member
17.	Dr. Biswajit Banerjee, Director (Forestry), PC	Member
18.	Shri R. Rashmi, Joint Secretary, MoEF	Convener

2. Terms of Reference for the sub-group:-
   (i) To make recommendations on climate change for the 12th Five Year Plan based on review of the existing programmes, policies and initiatives taken for adaptation

and mitigation, including regulatory mechanism, research and development, infrastructure and institutional mechanism.

(ii) Analyze and recommend preparedness for economic impacts of Climate Change including Disaster Management and streamlining of mechanism for implementation of national and international commitments.

(iii) Analyze the trade and development impacts of climate change.

(iv) Review and recommend ways of strengthening modeling and prediction capabilities.

(v) Recommend programmes and policies in the area of water, agriculture and health management affected by Climate Change.

3. General Terms of Reference

(i) The Chairman may co-opt other Experts/Member and constitute Resource Groups for specific tasks if required.
(ii) The expenditure on TA/DA of official members of the sub-Group will be borne by their respective Ministry/Department as per the rules of entitlement applicable to them. TA/DA for non-official members will be borne by the Planning Commission as per SR 190 (a).
(iii) The sub-group will submit its report to the Planning Commission by the 15th August, 2011.
(iv) Shri R. R. Rashmi, Joint Secretary, MoEF is the Convenor and Dr. Biswajit Banerjee, Director (Forestry) will be the nodal officer in the Planning Commission for this Sub-Group and any further correspondence in this regard may be made with him.

(Indrani Chandrasekharan)
Adviser (E&F) / Telefax 2309 6785

To

Chairman, Convenor and all Members of the Sub-Group.

Copy to:-

1. PS to DCH/MOS (PC)/Members/Member Secretary, Planning Commission.
2. All Principal Advisers/Senior Consulstants/Consultants/Advisers/JS (SP&Adm.), Planning Commission.
3. Director (PC), Planning Commission.
4. Secretary, Ministry of Environment & Forests, New Delhi.
5. Secretary, Ministry of Water Resources, New Delhi.
6. Secretary, Ministry of Earth Sciences, New Delhi.

7. Secretary, Ministry of Agriculture, New Delhi.

8. Secretary, Ministry of Science & Technology, New Delhi.
9. Secretary, Ministry of Power, New Delhi.
10. Secretary, Ministry of Health, New Delhi.
11. Pay & Accounts Officer, Planning Commission.
12. Information Officer, Planning Commission.
13. Drawing and Disbursing Officer, Planning Commission.
14. Accounts I/Administration I/General I & II Sections, Planning Commission.
15. IF Cell, Planning Commission.
16. Library, Planning Commission.
17. For General Information in Yojana Bhavan through email.

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Special invitees

S.No	Name & address, Ph, E-mail	
	Dr. A.K. Singh, Deputy Director General (Natural Resource Management)	**Special invitee**

	Division of Natural Resource Management, Krishi Anusandhan Bhawan-II, New Delhi - 110 012. Phone25848364; Fax 25848366 E-mail: aksingh@icar.org.in, aks_wtc@yahoo.com, aksingh.icar@gmail.com	
	Dr. A. Unikrishnan, National Institute of Oceanography (NIO), Dona Paula, Goa - 403 004, India. EPABX:0832-2450450; Fax:0832-2450602, 2450603; e-mail: unni@nio.org :-ocean@nio.org	**Special invitee**
	Ms. Rajasree Ray, Assistant Economic Adviser, Ministry of Finance, Department of Economic Affairs, North Block, New Delhi-110001 Ph. 23092059 e-mail: rajasree.r@nic.in	**Special invitee**
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