CLIMATE CHANGE AND DEVELOPMENT

CONSULTATION ON KEY RESEARCHABLE ISSUES

SECTION 4: SOUTH ASIA REGION
SECTION 4.2. INDIA SCOPING STUDY
TERI

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Introduction

This report presents the findings of a consultation exercise on climate change and development in India. This exercise was conducted by TERI, with support from IIED (International Institute for Environment and Development), UK, and commissioned by DFID (Department for International Development), UK. The specific objectives of the consultation, which this report attempts to address, are:

- To establish what Indian stakeholders regard as the most urgent research needs in relation to climate change and its implications for poverty reduction and sustainable development.
- To identify what research other funders have supported, or are supporting in India, as well as where there are gaps or opportunities for co-financing and DFID value-added involvement.
- To provide a clear definition of the researchable problems for future DFID research programmes.

Approach

This study used a combination of methods described below.

Literature review

A detailed review was conducted of completed and ongoing studies on vulnerability and adaptation to climate change in India. This included the Indian National Communication, IPCC reports, books, journals, unpublished project reports, and websites. In addition, key literature from development sectors, such as agriculture, water resources, disaster management, health, energy, etc was also assessed from the perspective of climate change. This included various governmental plans and programmes, which have significant potential to either exacerbate or reduce vulnerability to climate change.

Consultations with sectoral experts

Given the lack of published literature that explicitly examines climate-development linkages for India, group discussions and one-to-one interviews were held with key experts to benefit from their insights and perspectives. Policymakers, researchers, and practitioners in various sectors (agriculture, water, disatsre management, forestry, health, etc) were consulted to understand what they view as the most pressing research needs with regard to climate change in the context of sustainable development. In some cases the Delphi technique was used, i.e., discussing the implications of a possible country-level scenario on expected changes in the climate.

In-country workshop

At the end of the scoping exercise, a workshop was held with key government officials and experts from the climate change and development streams to share the outcomes of the literature review and consultations. The feedback of the participants helped identify priorities for conducting, communicating, and using research.

Climate change and development in India: an overview

This chapter provides an overview of vulnerability to climate change in India, and developmental challenges facing the country. It explores the linkages between climate change impacts and development goals, as well as between climate change adaptation and development policies. It thus sets the stage for a detailed sectoral analysis of climate change and development issues and priorities in the subsequent chapters of this report.

Vulnerability to climate change in India

Climate projections[1] for India, reported in the country's first National Communication to the UNFCCC, indicate marked increase in seasonal surface air temperature in the 21st century, becoming conspicuous after the 2040s. Models predict little change in total monsoon rainfall for India as a whole, but project overall decrease in the number of rainfall days and increase in rainfall intensity over a major part of the country (GOI 2004).

India with its large and growing population, densely populated and low-lying coastline, and an economy that is closely tied to its natural resource base, is highly vulnerable to climate change. Two-thirds of the total sown area of the country is drought-prone, with monsoon rains showing high inter-annual, intra-seasonal, and spatial variability. As high as 66% of the cultivable land is still rainfed, and contributes to 45% of the grain production in the country (Honore 2002). With 67% of the population dependent on the agriculture sector, climate change could have far-reaching impacts on livelihoods, food security, inflation, and economic growth.

Also river flows and freshwater availability will be affected by monsoon variability and glacial melt imposed by warming. Increased glacial melt due to warming would initially increase the summer flows in some river systems followed by a reduction in flows later. Water stressed conditions would impact millions dependent on the resource.

40 million hectares of land is liable to floods, with 8 million hectares and 30 million people affected each year on average (NCDM and NDMD 1999). In the pre-monsoon and post-

[1] Using the second generation Hadley Centre Regional Model (Had RM2) and the IS92a future scenarios of increased greenhouse gas concentrations.

monsoon seasons, the coastline, particularly the eastern coast, is vulnerable to tropical cyclones. Sea level rise and extreme events may adversely affect coastal ecosystems and structures, leading to loss of settlements, property, recreation beaches, and tourism infrastructure.

The consequences of all these impacts are likely to disproportionately burden the poor, and thereby exacerbate inequities in health status and access to adequate food, clean water and other resources (IPCC 2001). The poor depend for their livelihoods on climate-sensitive sectors, often live on marginal lands that are vulnerable to extreme events, and lack the financial, technical, and institutional capacity needed to adapt to the impacts of climate change. For developing countries like India, climate change represents an additional stress on physical and social systems already pressured by population growth, urbanization, industrialization, and environmental degradation. Hence vulnerability and adaptation to climate change cannot be studied in isolation, but must be viewed in the larger context of sustainable development.

Development priorities in India

The process of development planning in India underwent a crucial shift in the 1990s from a focus purely on expansion of production of goods and services and consequent growth of per-capita income, to the enhancement of human well being. Despite ambitious targets, however, poverty reduction and sustainable development remain key challenges, as borne out by the following indicators (GoI 2002).

- Incidence of unemployment*1* is relatively high at more than 7 per cent.
- More than half the children 1-5 years old in rural areas are under-nourished, with girl children suffering even more severe malnutrition.
- The infant mortality rate has stagnated at 72 per 1000 for the last several years.
- As many as 60 per cent of rural households and about 20 per cent of urban households do not have a power connection.
- Only 60 per cent of urban households have taps within their homes, and far fewer have latrines inside the house.

The ongoing Tenth Five Year Plan (2002-07) gives emphasis to good governance as the key to success of developmental programmes. In order to ensure significant progress towards improvement in quality of life, it sets monitorable targets for the following key indicators.

1 On current daily status basis

Box 1. Monitorable targets for the Tenth Plan and beyond

- Reduction of poverty ratio by 5 percentage points by 2007 and by 15 percentage points by 2012
- Providing gainful and high quality employment at least to addition to the labour force over the Tenth plan period
- All children in school by 2003; all children to complete 5 years of schooling by 2007
- Reduction in gender gaps in literacy and wage rates by at least 50 percent by 2007
- Reduction in the decadal rate of population growth between 2001 and 2011 to 16.2 percent
- Increase in literacy rates to 75 percent within the plan period
- Reduction of Infant Mortality Rate (IMR) to 45 per 1000 live births by 2007 and to 28 by 2012
- Reduction of Maternal Mortality Ratio (MMR) to 2 per 1000 live births by 2007 and to 28 by 2012
- Increase in forest and tree cover to 25 percent by 2007 and 33 per cent by 2012
- All villages to have sustained access to potable drinking water within the plan period
- Cleaning up of major polluted rivers by 2007 and other notified stretches by 2012

Source: GoI (2002)

The Plan recognises the need to translate national targets into balanced development across states, and to enhance institutional capacity at the grassroots level. To this end, a three pronged strategy for attaining equity and social justice to target poverty has been proposed.

1. Agricultural development is viewed as a core element of the Plan since growth in this sector is likely to lead to the widest spread of benefits especially to the rural poor.
2. Growth strategy to focus on gainful employment opportunities. Sectors having large employment potentials would be targeted. This includes sectors like the agriculture sector, construction, tourism, transport, IT and communication enabling services etc.
3. Continuing need to supplement the impact of growth with special programmes targeted to groups that may not benefit sufficiently from the normal growth process.

For development to be viewed as a people's movement, and not just a state initiative, requires empowerment of self-help groups, pani (water) panchayats, village education committees, local health committees and joint forest management committees.

Box 2. India and the Millennium Development Goals (MDGs)

The MDGs place human development as centre stage in the path of social and economic progress. The goals have been accepted as a yardstick for measuring development progress across countries. MDG targets relevant for the key sectors reviewed in this report are:
Agriculture and food security: Halve by 2015 the proportion of people who suffer from hunger
Water resource management: Halve proportion of people without safe drinking water by 2015
Public health: Have halted by 2015 and begun to reverse incidence of malaria and other diseases
Provide access to affordable essential drugs in cooperation with pharmaceutical companies
Forests and energy: Integrate SD principles into policies and reverse losses of environmental resources
Livelihoods: Halve by 2015 proportion of people with income less than $ 1 a day

In India, the attainment of the MDGs remains problematic due to the existence of large regional variations. Poor states like Bihar, Orissa, Rajasthan, Uttar Pradesh, and Madhya Pradesh have to support large and rapidly growing populations. Significant progress in achieving the MDGs will require considerable efforts. For instance, while progress can be made on increasing net primary enrolment and primary completion, it will be challenging to attain the education related MDGs and address the gender gap in primary and secondary enrolment. Moreover, data availability is itself a critical limitation to gauge the path towards meeting the MDGs.

Source: World Bank Report No. 30266-IN

There is a need to review ongoing development programmes undertaken by the government, and various bilateral and multilateral agencies, to place them in the context of enhancing capacity to address long-term adaptation to climate change.

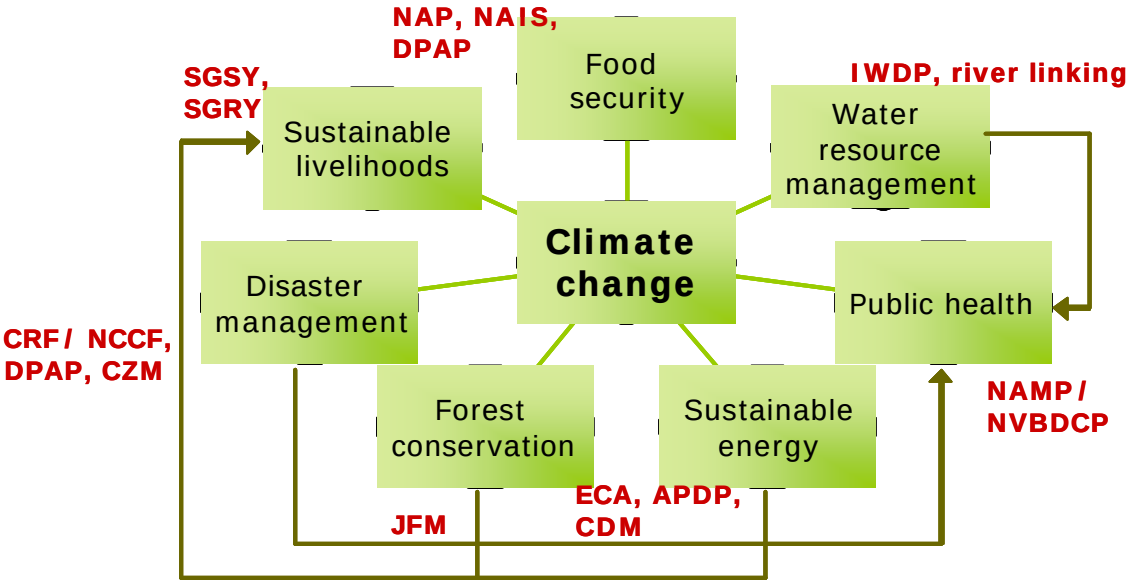
Climate change and development linkages

Climate change impacts and associated vulnerability are of particular concern to developing countries like India. Vast population depend on climate sensitive sectors like agriculture and forestry for livelihood. By adversely affecting freshwater availability and quality, biodiversity and desertification, climate

change tends to disproportionately impact the poorest in the society exacerbating inequities in access to food, water and health. The capacity to adapt is a function of access to wealth, scientific and technical knowledge, information, skills, infrastructure, institutions and equity and therefore varies among regions and socio-economic groups. Climate change therefore is intrinsically linked to other environmental issues and to the challenge of sustainable development.

A two-fold link can be seen between climate change and development. One, the impacts of climate change can severely hamper development efforts in key sectors. e.g. increased threat of natural disasters and growing water stress will have to factored into plans for public health infrastructure. Second, development policies and programmes will themselves influence the ability to adapt to climate change. e.g. policies for forest conservation and sustainable energy will, if correctly targeted and implemented, enhance the resilience of communities and thereby reduce the vulnerability of their livelihoods to climate change. Figure 1 traces these linkages for key sectors that are discussed individually in the following chapters of this report.

Figure 1. Linkages between climate change and development for India

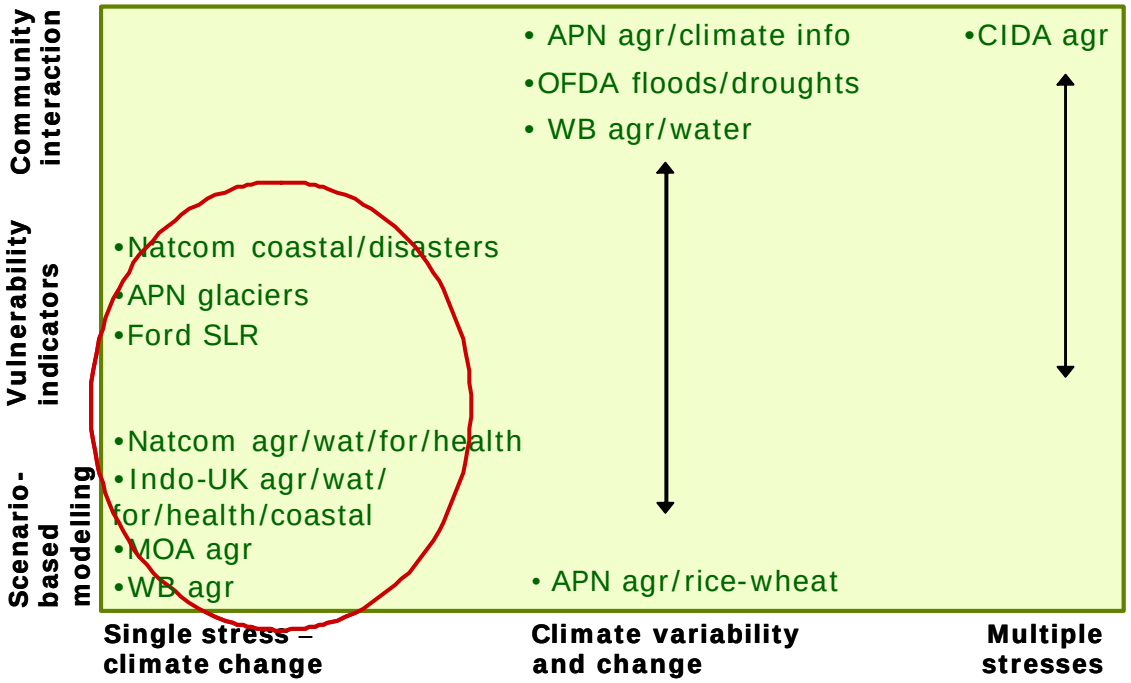


NAP - National Agriculture Policy, NAIS - National Agriculture Insurance Scheme, DPAP - Drought Prone Areas Programme
IWDP - Integrated Watershed Development Programme
NAMP - National Anti-Malaria Programme, NVBDCP - National Vector Borne Disease Control Programme
ECA - Electricity Conservation Act, APDP - Accelerated Power Development Programme, CDM - Clean Development Mechanism
JFM - Joint Forest Management
CRF - Calamity Relief Fund, NCCF - National Calamity Contingency Fund, CZM - Coastal Zone Management
SGSY - Sampoorna Grammen Swarozgar Yojana, SGRY - Swarnajayanti Grammeen Rozgar Yojana

Adaptation to climate change was highlighted as a key issue in the Delhi Declaration on climate change and sustainable development signed at the eighth session of the Conference of Parties to the UNFCCC (COP-8) in New Delhi in 2002. However, compared to the information available on mitigation aspects of climate change, there are relatively few studies focussing on vulnerability and adaptation. While early studies for India took a scenario-based impact assessment approach, recent studies have just begun to think of vulnerability and adaptation within the context of development.

Figure 2 maps out the focus and methodological approach of some recent climate change V&A studies. It shows that most studies have tended to study climate change as a single stress factor using scenario based modelling. However, a recently launched World Bank and DFID study complements scenario-based modelling with interaction with the vulnerable communities to explore vulnerability and adaptive to climate variability and change in agriculture and water resources in India. A CIDA-funded study completed by TERI in 2004 is the only one to look at a combination of two stresses viz. climate change and economic globalization, through an approach using both vulnerability mapping and community interaction.

Figure 2. Vulnerability of India to climate change: overview of approach taken by some recent studies



Annex I presents an inventory of studies and programmes on different aspects of vulnerability to global climate change in India. The results of various studies are discussed in the context

of specific sectors in the following chapters. Also, the conceptual and methodological gaps and limitations are drawn together in the final chapter to identify research priorities.

Box 3. Climate change: concern for policymakers. Dr Ajay Mathur, Senergy Global

Climate change is occurring, and though there is uncertainty about the exact magnitude, rate and regional patterns of its impacts, it will almost certainly bring about sea level rise and shifts in climatic zones due to increased temperatures and changes in precipitation patterns. Also, climate change is likely to increase the frequency and magnitude of extreme weather events such as droughts, floods, and storms.

Consequently, in some parts of India, climate change will further reduce access to drinking water; in other places, it will further strain limited infrastructure; and in yet other places, it will lead to decreasing crop yields. There will be regions where more than one of these additional stresses will occur simultaneously. In other words, the adverse impacts of climate change will exacerbate stresses from current climate variability, and will be superimposed on existing vulnerabilities.

This superimposition suggests that there is no such thing as an "adaptation project", and that the best way to address climate change impacts would be by integrating adaptation measures into sustainable development and poverty reduction strategies and projects. This would ensure that climate-change risks are integrated with all the other risks that are faced by the poor.

However, the uncertainty about the nature, timing, and location of climate-change impacts makes it difficult to assess the appropriate additional risks, or indeed judge whether adaptation is even necessary. It is impossible – in terms of money, time, or human capacity - to carry out a full-fledged impact risk assessment and adaptation analysis for every location and every sector (water, forestry, agriculture, infrastructure, etc.) in India to figure out whether adaptation is needed, and if so, how should it be designed.

At the policy level, therefore, the central question is to figure out the need to do things differently because of the expected adverse impacts which would basically require defining a planned framework of action to address most of these concerns.

Agriculture and food security and climate change

Agriculture and allied activities constitute the single largest component of India's gross domestic product, contributing nearly 25% of the total. The tremendous importance of this sector to the Indian economy can be gauged by the fact that it provides employment to two-thirds of the total workforce. The share of agricultural products in exports is also substantial, with agriculture accounting for 15% of export earnings. With a weight of 57% in the consumer price index, food prices are closely linked with inflation and any adverse shock on agriculture could have cumulative effects on the economy. Agricultural growth also has a direct impact on poverty eradication, and is an important factor in employment generation (Planning Commission 1997; 2002).

The National Commission for Integrated Water Resources Development has estimated that, to meet the requirements of food grains alone, the net sown area will have to be increased to 145 mha and the cropping intensity to 145% by 2050 (Planning Commission 1997). However, there is not much scope for increasing the area under food grains in the country, and the growth of food grain output can be achieved only through rapid increases in productivity. Finally, given that rain-dependent agricultural area constitutes more than 60% of the net sown area of 142 mha (TERI 2003) Indian agriculture continues to be fundamentally dependent on the monsoon.

Agriculture is the predominant means of livelihood for a large number of peasant cultivators and agricultural labourers, for whom it is not easy to shift to other occupations. Due to their low financial and technological adaptability, such groups are highly vulnerable to the impacts of climatic changes. For a country like India, sustainable agricultural development is essential not only to meet the food demands of present and future generations, but also for poverty reduction through economic growth, which creates employment opportunities in non-agricultural rural sectors (Fischer et al 2002).

Understanding the impacts of climate change

The results of various studies on the impacts of climate change on Indian agriculture are presented in Table 1. Details of the studies themselves are provided in Annex 4.

Table 1. Impacts of climate change on agriculture in India: results of various studies

GoI (2004)	Decline in yields are offset by increase in carbon dioxide concentrations with the magnitude varying from one crop to the other in different regions depending mostly on the scenario chosen. Wheat yields in central India may drop by 2% in a pessimistic climate change scenario.
TERI (2004)	Districts in western Rajasthan, southern Gujarat, Madhya Pradesh, Maharashtra, northern Karnataka, northern Andhra Pradesh, and southern Bihar are highly vulnerable to climate change in the context of economic globalization. Numerous physical (e.g. cropping patterns, crop diversification, and shifts to drought-/salt-resistant varieties) and socio-economic (e.g. ownership of assets, access to services, and infrastructural support) factors come into play in enhancing or constraining the current capacity of farmers to cope with adverse changes.
IPCC (2001)	Temperature rise of 1.5 degree centigrade and 2 mm increase in precipitation could result in a decline in rice yields by 3 to 15 %. Sorghum yields would be affected and yields are predicted to vary from +18 to -22 % depending on a rise of 2 to 4 degree centigrade in temperatures and increase by 20 to 40 % of precipitation.
Kumar and Parikh (1998)	Economic impacts would be significant even after accounting for farm-level adaptation. The loss in net revenue at the farm level is estimated to range between 9% and 25% for a temperature rise of 2 °C–3.5 °C.
Sanghi, Mendelsohn, and Dinar (1998)	A 2 °C rise in mean temperature and a 7% increase in mean precipitation would reduce net revenues by 12.3% for the country as a whole. Agriculture in coastal regions of Gujarat, Maharashtra, and Karnataka will be the most negatively affected. Possible losses are pointed out for the major foodgrain producing regions of Punjab, Haryana, and Western Uttar Pradesh.

Narain (2003) in a study to assess the capacity to enhance abilities of individuals in responding to the adverse impacts of climate change suggests that households engaged in agriculture can employ a range of strategies. This includes,

- improving access to available water (e.g. makeshift storages, digging deeper tubewells, exchanging irrigation timeshares, buying groundwater, and engaging in water theft)
- reducing demand for water (e.g. switching to less water consumptive crops, adopting more efficient irrigation practices, and altering dates for agricultural operations)
- coping with the adverse impacts of periodic drought (e.g. credit, sale of valuables and livestock, use of stored seeds and foodgrains)
- diversifing sources of livelihood (e.g. alternative employment opportunities, migration)

The study mentions that while many of these response options are to be employed at household level, existing responses may not be adequate to cope with prolonged and worsening water stress due to climate change.

Kumar and Parikh (2001) builds a case for government policy interventions in light of the potentially severe implications of

climate change. Specific recommendations include the need for R&D on more heat-resistant crop varieties, development of a database of farmer-level adaptation strategies that can be widely disseminated, and further research on the socio-economic implications of climate-induced changes with emphasis on security of food supply.

Adaptation in the context of development

It is important to recognise that policy decisions related to agriculture or water resources will influence decisions from the farmer's level to the national level, and have the potential to enhance adaptive capacity to climate change. Alternately factors that reduce vulnerability to climate risks – spanning the entire gamut from irrigation, better infrastructure, electricity, credit, crop insurance, markets, transport, and price information - reduce a farmers' heavy dependence on climate, and help him to benefit from market opportunities, or switch to alternative crops or employment options. At the other end of the scale are better health facilities, education, and awareness, which are key developmental priorities but are often ineffectively implemented due to conflicts and policy gaps and the sheer magnitude of the problem. The incorporation of climate change risks in such policies can help farmers tackle current climatic variability as well as extreme events like droughts and floods, and have significant implications for longer-term vulnerability reduction and poverty alleviation.

There is a strong need to review existing policies and assess the context in which they can effectively enhance adaptive capacity. In some cases, these measures might relate to current development efforts being planned. In others, some policies might exist that if strengthened would help enhance capacities. This would include providing easy access to agricultural credits, providing insurance coverage, strengthening agricultural extension activity, expanding area under irrigation etc.

The role of science and technology has in the past also played a crucial role in increasing yields and production across the country. Biotechnology could be used to develop cultivars characteristic to certain weather conditions. This would include the development of drought resistant, salt tolerant and pest resistant cultivars of different crops. This would ensure a strong approach to dealing with food security besides addressing climate change (Brenner, 1996).

At the same time important insights can be drawn from local knowledge or traditional know-how, and the role of local institutions and indigenous arrangements (for example, micro-credit and land tenure) in enhancing the resilience of the poor.

Box 4. Development goals in India agriculture

The Tenth Five Year Plan envisaged a growth of 4% per annum of agricultural GDP (up from 3.2% in 1980-96, 2.6% in 1996-02, and 1.8% in 2002-04). However, agriculture in India is constrained by the availability of land and water. There is little possibility of expansion of cultivated area other than reclamation of wasteland and focus on raising the productivity of the land. Despite large investments in irrigation, only 40 % of the agricultural area is irrigated so far. Therefore, the plan aims to revive public investment in building irrigation capacity and water management along with attention to rainwater harvesting and watershed development. Relevant science and technology inputs to enhance diversification is planned along with appropriate supportive price policies.

The Government of India (GoI) has several plans and programmes to facilitate development of degraded lands to improve conditions in rainfed regions across the country (Box 4).

- The Drought Prone Area Programme (DPAP) of the GoI is aimed at soil and moisture conservation in drought prone areas. The primary objective is promotion of overall economic development mainstreaming marginalized and vulnerable sections.
- The Desert Development Programme (DDP) was later introduced to restore ecological balance, conservation of soil and water and to arrest the desertification through shelterbelt plantations.
- The Integrated Wasteland Development Programme (IWDP) was introduced with the aim to develop wastelands for overall economic development besides improving economic conditions of resource poor population.
- The National Watershed Development Programme in Rainfed Areas (NWDPRA) initiated in 1990-91 targeted improvement in agricultural production in rainfed areas restoring ecological balance.
- In order to channelise greater resources for rainfed areas, National Bank for Agriculture and Rural Development (NABARD) set up a Watershed Development Fund of Rs 2 billion in the year 2000-2001.
- Apart from these, the River Valley Project, Flood Prone River programme, the watershed development project for shifting cultivation Areas (WDPSCA) –were introduced to check siltation of reservoirs and enhance productivity of degraded lands.

Institutions both governmental and non-governmental play important roles in providing a thrust to these programmes. Panchayati Raj Institutions (PRIs) and Non Governmental

Organisations (NGOs) have an active role to play in the implementation component of most of these programmes.

Box 5. Addressing the MDGs for poverty and hunger

The MDGs call for halving the number of people suffering from hunger by 2015. For India this relates to bringing the calorie deficiency down from 62.2 % in 1990 to 31.1 % in 2015. In the 1990s a mere decline of 9 % has been observed. The government has launched a mid-day meal programme in 1995. The Programme has been reported to have a direct effect on the enrolment rates in villages helping in the promotion of unviersalisation of primary education.

The MDGs aim to reduce the percentage of underweight children by one-half between 1990 and 2015 which implies a reduction in the child under-weight rate from 55 % in 1990 to 27 % in 2015. A comparison of data in the 1990s shows a modest decline of about 11 % between 1992-1999. Also regional variation is quite marked – varying from 24-28 % in northeastern states and Kerala to 51-55 % in the states of Bihar, Rajasthan, Uttar Pradesh, Madhya Pradesh and Orissa. The government targets child nutrition through its Integrated Child Development Services (ICDS) programme promoted in anganwadi centres in each village. However, the programme has not been successful given the low enrolment rates of children in these centres.

Senior agriculture experts from research and academia consulted in the course of the present study opined that issues related to climate change have been well discussed in various fora and many recommendations have been made. The time has come for meaningful actions to be taken. Land degradation, land and water scarcity and population growth are already a major concern for sustaining agricultural productivity. Climate change will just add to the stress on agricultural resources in many developing countries. Considering the present scenarios, successful adaptation to climate change in India would be possible only through the holistic rural development. Research and policy goals should be decided keeping this in mind.

Water resource management and climate change

The vital importance of combating the threat to global water resources was emphasized at the World Summit on Sustainable Development in Johannesburg, where parties endorsed water as one of the WEHAB priorities. The Summit highlighted the building pressures on water resources due to population growth, unsustainable consumption patterns, and uncontrolled uses. In addition, climate change is expected to worsen water availability by altering the hydrological cycle. Temperature changes will affect evapotranspiration rates, soil moisture, storm intensity, etc in a major way while changes in precipitation will affect the timing and magnitude of droughts and floods, shift run-off regimes and alter ground water recharge characteristics (Gleick 1998). These temperature and precipitation changes will have significant effects on the demand, supply, and quality of water (Lal and Harasawa 2001). The Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) points out that the greatest vulnerability to climate change will be in unmanaged or unsustainably managed water systems that are currently water stressed. It also states with a high level of confidence that freshwater availability is expected to be highly vulnerable to anticipated climate change. In particular, surface run-off is expected to decrease drastically in arid and semi-arid India under the projected climate change scenarios. Climate change is likely to change the volume as well as temporal distribution of streamflows (IPCC 2001). In this scenario, there is need for targeted research on hydrologic and human responses in watersheds to global climate change, particularly in developing countries.

India receives an average annual precipitation of about 4000 billion cubic metres (BCM). The average flow in the river systems of the country is about 1880 BCM. Though there is abundant water, only a small proportion of it is actually available for use in the form of surface and underground running water. Surface water and ground water resources, which can be utilized, are estimated at about 690 BCM and 432 BCM respectively (CWC 1998). As a result of wide fluctuations in the availability of water, spatially and temporally, water shortage is virtually an annual feature in several parts of the country. More than 80% of water resources in India is being utilised for agricultural purposes (Pachauri and Batra 2001). Both surface and ground water resources are tapped for this purpose. Moreover, acceleration in the rate of consumption due to an increasing population and changing lifestyles is a cause for

concern for effective sustainable management and utilisation of this resource. According to United Nations projections, India is estimated to experience water stress by 2025, and is likely to cross the 'water scarce' benchmark by the year 2050 under the high growth scenario. Water stress and scarcity are defined as situations where per capita annual water availability is less than 1700 m3 and 1000 m3 respectively.

Understanding the impacts of climate change

The results of various studies on the impacts of climate change on water resources in India are presented in Table 2. Details of the studies themselves are provided in Annex 4.

Table 2. Impacts of climate change on water resources in India: results of various studies

GoI (2004)	Decline in total run-off for all river basins except Narmada and Tapi. A decline in run-off by more than two-thirds the amount in the control scenario has been predicted for the basins of Sabarmati and Luni with severe drought conditions prevalent in a futuristic climate scenario.
Indo-UK programme	Except for Godavari, where there are not any significant changes reported in the annual cycle of rainfall, the Ganges and the Krishna basins show major declining trends which is an interesting observation at a basin scale.
Narula and Bhadwal 2003	A decrease of 20% to 30% in total flows in the Lakhwar sub-basin in Uttaranchal on account of climate change alone was estimated.
Lal et al (2001)	Studied the impact of climate change on water resources using outputs from various GCMs
Tangri and Hasnain (2003)	Examined the impact on glaciers in the Himalayan region
Wilk et al (2002)	Studied impacts on mean annual run-off and assured water yields for a reservoir in southern India

Consultations with senior water scientists from academic as well as administrative fields revealed the view that the pattern of rainfall needs to be studied more scientifically and exhaustively to discern the impact of climate change. More reliable climate predictions are needed for better policy formulation. They felt it is not the total amount of annual rainfall but the pattern which dictates the fate of the agricultural production and so the state of the poor farmers. Given the predominantly rainfed nature of Indian agriculture, technological interventions are necessary to reduce this dependency and thus reducing the vulnerability of the poorest of poor farmers who always suffer the most under any climatic irregularities.

Continuous sensitization is the key for a better understanding about the risks and uncertainties involved with the climate change or natural disasters. Awareness is also necessary for a successful interventio n any new strategy or technology in the communities.

Adaptation in the context of development

In India, integrated watershed development has emerged as an effective approach in augmenting water supply through conservation of rainwater in rainfed farming systems, which account for nearly two-thirds of the country's cultivated land and encompass the arid and semi-arid regions and the drought prone areas. Interventions in dry land/ rain fed regions that are characteristic of poor climate - dry weather and low rainfall conditions and highly eroded soils were primarily targeted under the programme. The IWMP suggests the employment of an integrated and coordinated approach across various ministries to promote soil and water conservation by optimising land-use production systems and use of sustainable low-cost location specific technologies (MoEF, 2001). The watershed approach basically is a project based development plan for water harvesting, water conservation and other related social and economic activities that seek to enhance the production potential of an area on a sustainable basis.

There is growing awareness at the central government level that integrated watershed development can also prove a potent instrument of adaptation to climate change. There are special programmes such as Drought Prone Areas Programme (DPAP) for almost one-sixth of the land area in the arid and semi arid regions of the country, in addition to the special programme of watershed treatment in the catchment of river valley projects and flood prone rivers.

Expert consultations emphasised the importance of water demand management for the sustainable use of this precious natural resource. Stronger economic incentives for efficient water use in all sectors of economy will limit demand, ensuring higher levels of sustainability. At the same time, social issues need to be addressed and a feeling of ownership needs to be brought in the community. For instance, storage of water in a bigger way seems to be one of the most obvious solutions to water scarcity. But, the ecological and social implications of this action should be well taken care of. A multi stakeholder approach could be useful for handling such issues.

The renewing capacity of the environment and ecosystems sustaining the renewable water resources need to be preserved or enhanced to meet future demands of quantity and quality of fresh water. These needs have to be met at acceptable economic, environmental and social costs without degrading the quality of these resources, which diminish their ability to support the ecological, social and cultural systems necessary for the maintenance and improvement of human welfare, thereby jeopardizing sustainability.

Box 6. Adapting to Climate Change? Mr Chetan Pandit. Chairman Indian Water Resources Society, Ministry of Water Resources

There already exists a broad vision for the water management for the next five decades. This is based on the projections that the population will stabilise at 1600 millions by the year 2050. For this population the food requirement is estimated at 500 MT. To grow this quantity of food, and also other agro products like the oil seeds, sugarcane, fruits and vegetables, fibre etc. we need to improve the land productivity by about 50%; and increase the irrigation coverage to 160 Mha. The total water requirement for 2050 is estimated at 1450 bcm, of which about 85% will be for agricultural use and the rest for domestic, industrial and other uses.

As against this, the total utilizable quantity of water is estimated at 1122 bcm - 690 bcm from surface sources and 432 bcm from the ground water sources. Even this is possible only if we increase the total storage capacity from the present 177 bcm to about 384 bcm. That still leaves a deficit of 300+ bcm and the problem is how to bridge this gap. Trans-basin transfer of water is being considered as one of the answers which may increase the utilization by about 200 bcm. Conservation measures at community level will also help increase the utilizable quantity. The estimates for the impact of these measures vary between 50 bcm to 140 bcm.

That is the broad planning if there was no climate change. How does it alter in view of climate change? We do not yet know. To get somewhere near the answer it is necessary to undertake following investigations.

1. Since 85% of the water use is for agriculture, we first need to determine the changes in crop water requirement. This includes changes in the quantity of water required and also the new temporal distribution of the demand.
2. We need to estimate the modified runoff pattern due to changes in rainfall pattern. The way to do this is: the meteorologists should give us hydrologists one or more synthetic rainfall series for the changed scenario. Next, this synthetic rainfall series should be converted to synthetic river flow series using rainfall-runoff models.
3. Finally, we should simulate the basin behaviour using the synthetic rainfall and runoff series and the modified crop water requirement in the post climate change scenario. Once we reach this stage only then we can really understand how climate change will affect our water planning and then we can think of and try out different strategies to deal with it.

Disasters and climate change

Understanding the impacts of climate change

The Third Assessment Report of the IPCC (Intergovernmental Panel on Climate Change) predicts an increase in climate variability with more hot days, heat waves, and heavy precipitation events, leading to intensified droughts, floods, and tropical cyclones (IPCC 2001). The report draws attention to the possibility that the poor in developing countries, who lack financial and technical resources to effectively defend themselves against natural disasters, will be disproportionately impacted by climate change. A telling indicator of this is that India and China accounted for 25% of global economic losses and 31% of fatalities from natural disasters between 1994 and 2003, while insurance compensation arising from these events amounted to less than 1% of global insurance losses over the same period (Swiss Re 2004).

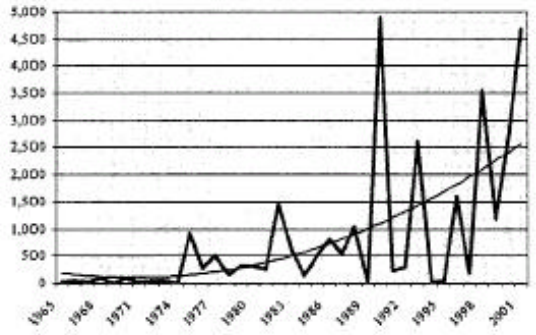
Table 3 reports India's record of losses from natural disasters, which is also seen to be steadily increasing in Figure 3.

Table 3. Disaster history by major hazard in India during 1996-2001

Hazard	Reported events	Reported deaths (thousands)	People affected (thousands)	Reported losses (USD millions)	Loss reports submitted	Percent reported
Windstorm	15	14.6	25213.7	5619	15	100
Flood	29	8.9	150980.3	2928	18	62
Earthquake	3	20.1	16387	4707	6	200
Drought	4		90000	588	3	
Other	24	5.9	356.9			13

Source: World Bank (2003)

Figure 3. Reported catastrophe losses in India during 1965 – 2001, in nominal USD million at then applying exchange rates



Source: World Bank (2003), based on data from OFDA-CRED (2003)

Traditionally the impacts of climate variability or extreme events have been tackled through government assistance or informal risk sharing at the community level (TERI 2005).

- Typically attention has been focussed on relief and reconstruction in the aftermath of a disaster rather than on prevention and preparedness. The affected state government manages relief work and reconstruction efforts with financial support from the central government through the Calamity Relief Fund (CRF), with additional assistance from the National Calamity Contingency Fund (NCCF) in case of severe calamities. However, financial discipline is an issue, with heavy demands from the state governments, late contributions from states to the CRF, and delays in transferring funds to the district level (NCDM 2002). Declaring districts drought-prone is also a politically sensitive issue because of the implications for financial assistance, and various waivers and concessions made available (including food-for-work schemes and rescheduling of short term agricultural loans).
- The Ministry of Agriculture has a National Agricultural Insurance Scheme, administered through the Agriculture Insurance Corporation, which covers all farmers irrespective of their size of landholding. This scheme was introduced in the year 1999-2000 and operates on the basis of an "area approach" i.e., defined areas for each notified crops for widespread calamities and on individual basis for localised calamities such as floods, hailstorms, landslides and cyclones. Although government crop insurance is subsidised, it has very low coverage. It fails to provide the right incentives to farmers as crops yields are insured irrespective of efforts. Conversely, farmers who have suffered losses as a result of lack of rainfall in a particular part of a district may not be eligible to benefit from crop insurance unless the entire district is declared drought-affected. Finally, there are high administrative costs and consequently long delays in making claim payments.
- Farmers respond to the lack of formal financial services by turning to moneylenders, selling assets, reducing inputs in farming, or diversifying their activities. Another strategy is to send family members to work elsewhere and remit payments. However, such traditional risk management strategies while reducing vulnerability in the short term can increase vulnerability over the longer term by promoting sub-optimal asset allocation. For instance, small farmers may opt for multiple cropping to reduce income variability rather than risk growing the most

profitable crops. Traditional risk sharing strategies also break down in case of disasters affecting an entire community or area (Hess et al 2002).

- In the last couple of years, weather indexed insurance products have been tried out on a pilot basis by private insurance companies in India. These include crop insurance for groundnut farmers in Andhra Pradesh, soya farmers in Madhya Pradesh, orange growers in Rajasthan, and rice farmers in Uttar Pradesh. Weather-indexed insurance can help farmers protect their overall income rather than the yield of a specific crop, improve their risk profile enhancing access to bank credit, and hence reduce overall vulnerability to climate variability and change. Unlike traditional crop insurance where claim settlement can take up to a year, quick payouts in private weather insurance contracts can improve recovery times and thus enhance coping capacity.

In the long-term, a strategy is needed for disaster preparedness measures like drought proofing and flood control. Strengthening natural resource management is an important element of reducing environmental vulnerability. Scientific inputs are needed for disaster preparedness, particularly in view of the potential adverse impacts of climate change. Integrating all such efforts with development policy is essential for building resilience and mitigating environmental vulnerability in the long run.

Adaptation in the context of development

Natural disasters have not been adequately factored into the planning process before. The experience of disasters in recent years has realised that episodic shocks have the potential to disrupt development process quite substantially unless contingency plans are already in place and fiscal and monetary policies can be adjusted with sufficient flexibility. Although Disaster Management has not been conventionally a subject for Five-Year Plans, but given the increasing severity and occurrence of disasters – earthquakes, cyclones, floods, droughts - and the significant set back and threat they pose to the development of a region or state, the Government of India in its Xth Plan document has addressed the issue on disaster preparedness and mitigation strategies to minimize the periodic shocks to the country's development efforts. Though the focus has been discussed, integration into the planning process might take some time.

The Plan highlights that disaster mitigation components need to be built into all Plan projects, so as to minimise both the likelihood of damage and the cost of post-disaster restoration and rehabilitation. This will mean some additional outlay for

projects coming up in disaster-prone areas, first for building a comprehensive data-base on risks and actions already taken, and secondly for undertaking a vulnerability analysis and risk assessment for the project in question. In addition, the construction of specific disaster-prevention projects (flood defences, cyclone shelters) would need to be considered in the context of the growing incidence of disasters.

Disaster managers from government and non-government organisations commented on the known link between disasters and development. Disaster related losses create compel in compromising the overall development of the country. The poor and the disadvantaged people are the most seriously affected during any kind of natural disaster. Experts feel that there is correlation between long-term disaster mitigation and poverty reduction. Strategic action is necessary now! Capacity building and sensitisation is necessary for both "major" and "minor" disasters. A tri-partite partnership involving private sector, government and NGOs could enhance the effectiveness any intervention. Central government should play a catalytic role. Decentralization and emphasis on the role of state/local governments could be very important. Adaptation cost estimates need to be carried out very critically and the issue related to its payment.

Other key research issues that emerged from the in-country consultations are highlighted below.

- Learning from traditional knowledge and community responses, which can be used to design large social insurance systems.
- Making research useful to decision makers by communicating practical information (e.g. the implications of climate change for the frequency and intensity of natural disasters) in simple language. Research must equip decision makers with the best available tools and reasonably firm numbers for planning.
- Mainstreaming climate change concerns in disaster management requires sensitization of grassroots practitioners, which can be addressed by establishing a network of researchers and practitioners.
- Simple yet responsive schemes need to be designed to strengthen the coping capacity and reduce response and recovery time of vulnerable communities.

Public health and climate change

This section draws on GOI (2004), which contains the most comprehensive assessment of the potential impacts of climate change on health in India.

Understanding the impacts of climate change

Changes in climate may alter the distribution of important vector species (for example, mosquitoes) and may increase the spread of disease to new areas that lack a strong public health infrastructure. High altitude populations that fall outside areas of stable endemic malaria transmission may be particularly vulnerable to increases in malaria, due to climate warming. The seasonal transmission and distribution of many other diseases transmitted by mosquitoes (dengue, yellow fever) and by ticks (Lyme disease, tick-borne encephalitis), may also be affected by climate change (Table 4).

Table 4. Known effects of weather / climate and potential health vulnerabilities due to climate change

Health concerns	Vulnerabilities due to climate change
Temperature-related morbidity	Heat- and cold-related illnesses Cardiovascular illnesses
Vector-borne diseases	Changed pattern of diseases Malaria, filaria, kala-azar, Japanese encephalitis, and dengue caused by bacteria, viruses and other vector-borne pathogens
Health effects of extreme weather	Diarrhoea, cholera, and poisoning caused by biological and chemical contaminants in the water (even today about 70% of the epidemic emergencies in India are water-borne) Damaged public health infrastructure due to cyclones / floods Injuries and illnesses Social and mental health stress due to disasters and displacement
Health effects due to food insecurity	Malnutrition and hunger, especially in children

Source: GoI (2004)

Malaria is endemic in all parts of India, except at elevations above 1,800 metres and in some coastal areas. The principal malaria-prone areas are Orissa, Madhya Pradesh, Chhattisgarh, and the north-eastern parts of the country. According to the World Bank, in 1998 about 577,000 Disability- Adjusted Life Years (DALYs) were lost due to malaria.

Presently, the transmission window (based on minimum required conditions for ensuing malaria transmission) is open for 12 months in eight states (Andhra Pradesh, Chhattisgarh, Karnataka, Kerala, Maharashtra, Orissa, Tamil Nadu and West Bengal), nine to 11 months in the north-eastern states (Gujarat, Haryana, Madhya Pradesh, Punjab, Rajasthan, Uttar Pradesh and Uttaranchal). The states of Himachal Pradesh and Jammu

and Kashmir have transmission windows open for five to seven months, respectively.

Considering a 3.8°C increase in temperature and a seven per cent increase in relative humidity by the 2050s (with reference to the present), nine states of India may have transmission windows open for all 12 months. The transmission windows in the states of Jammu and Kashmir and Rajasthan may increase by three to five months as compared to the base year. States like Orissa and some southern states, where the mean temperature is more than 32°C in four to five months, a further increase in temperature is likely to cut the transmission window by two to three months.

Adaptation in the context of development

In India, the overall susceptibility of the population to environmental health concerns has dropped dramatically during the past few years with the improvement in availability of the health infrastructure. However, the extent of access to and utilization of health care has varied substantially between states, districts and different segments of society. Communicable diseases have become more difficult to combat because of the emergence of insecticide-resistant strains of vectors and antibiotic-resistant strains of bacteria. Undernutrition, micro-nutrient deficiencies and associated health problems coexist with obesity and noncommunicable diseases in the country. The existing system suffers from inequitable distribution of institutions and access to nutrition and health care.

Box 7. Addressing the MDGs for health

The MDGs call for reducing child and infant mortality rates by two-thirds of the current rates between 1990 and 2015. This implies a reduction of the IMR to 27 and under-five mortality rate to 32 by 2015. Over the decades, infant mortality rates have been declining in India. From about 130-140 deaths/ 1000 live births in 70s, the numbers have fallen to 68 in 2000. However, absolute levels continue to be high. More than a million children die each year below the age of one. India also rates poorly on the pace of IMR reduction to several countries in South Asia, including Bangladesh. Apart from this, there are large-scale intra state and inter-state variations also which needs to be addressed.

The Government of India in its Xth Five Year Plan aims to reduce the morbidity and mortality due to malaria by 25 per cent till the year 2007 and 50 % by 2010.The disease potential, i.e., the risk of contracting malaria by a population is the result of a combination of parameters such as climate change, public

and private health capabilities, and man-made conditions conducive to malaria, such as unhygienic surroundings with accumulated water pools. Development associated with improved access to health systems, housing conditions, better infrastructure for waste disposal, better sanitary systems and new technological interventions vis-avis medication for malaria will play a key role in checking the spread of malaria in the future.

An integrated approach is required to evaluate the impacts of climate change on malaria in India, which will include not only the future climate and land-use pattern parameters but also would integrate the projected socio-economics which need to include access to medical intervention in the region/state/district. Serious attention towards making health services work is required by improving governance and service delivery.

Box 8. Further research needs in the health sector, Dr R C Dhiman, Malarial Research Centre

In addition to malaria, climate change is likely to affect other vector borne diseases like dengue, kala-azar and Japanese encephalitis. Therefore, the impact of climate change must also be studied in respect of these diseases.

The impact analysis of malaria and meteorological parameters done under NATCOM projects is based on generalized conditions. Since malaria is a local and focal disease, research on the following aspects is needed to reach to logical conclusions.

1. determine the malaria transmission indices based on T and RH in different ecological zones of the country viz. arid, semi-arid, deciduous dry, deciduous wet and tropical monsoon
2. study the impact of rainfall on creation of breeding habitats of malaria vectors/or flushing off the breeding habitats, in different malaria paradigms
3. conduct district wise long term prospective epidemiological studies in different eco-epidemiological types of epidemic prone areas to evaluate the role of temperature, rainfall and RH on mosquito vectors and malaria so as to develop early warning system for proactive adaptation measures

Livelihoods and climate change

It is argued that there exists a two-way link between natural resource management and livelihoods of the poor and the impoverished. Firstly, there are disproportionate stresses entailed for the poor from degradation or depletion of natural resources, due to their excessive reliance on local resources for subsistence or cash incomes. Subsistence farming communities and others who can ill-afford chemical fertilizers tend to rely on natural soil fertility; subsistence fisher-folk depend on sustenance of fish stocks in estuaries, rivers, lakes and coastal wetlands. Depletion of these resources imposes a direct cost on them. They, however, usually exert only minimal control over how the ecosystems are used. Secondly, poverty contributes to pressures on natural resource degradation, largely stemming from unabated overexploitation of the natural resource base. Roughly half of the global poorest are known to thrive on marginal lands — arid areas, steep slopes etc – that are prone to land degradation. Even as the land productivity declines and fish stocks deplete, the poor have little room to manoeuvre in coping with environmental or resource stress (TERI 2002).

Climate change, which could exacerbate problems of declining agricultural productivity, shrinking water supply and reduced yield of timber as well as non-timber forest products, could most directly impact the poor. The need for a holistic approach to natural resource management is borne out by the fact that many of the traditional coping strategies employed by farmers in response to climate variability help reduce vulnerability in the short term at the expense of increased vulnerability over the longer term by promoting sub-optimal asset allocation. For instance, small farmers may opt for multiple cropping to reduce income variability rather than risk growing the most profitable crops. Traditional risk sharing strategies also break down in case of disasters affecting an entire community or area (Hess et al 2002).

Bantilan and Anupama (2002) hints at the nexus between climate change impacts and poverty by addressing the lagged impact of drought on the productive capacity of farmers.

- Production-reducing impact of a farmer converting into a tenant, sharecropper or an attached labourer.
- Loss of draft power during the drought year, resulting in a fall in production due to non-cultivation of cultivable area, delayed sowing, and adoption of less intensive methods of cultivation in the following year/years with adequate rains.

- Loss of productive livestock and non-conception due to under-feeding during a drought is a permanent loss of productive capacity

Some key elements of a holistic approach which addresses issues of natural resource management, sustainable livelihoods, and climate change adaptation are mentioned below (TERI 2002).

- Develop stronger knowledge base at various levels (local, national and global) for enhanced understanding of ecosystem functions and capacity.
- Recognise and evaluate ecosystem services to enable internalization of values in production and consumption choices by governments, industry and communities.
- Engage in a public dialogue on goals, policies and trade-offs on ecosystems use, benefit distribution, and degradation thresholds.
- Involve stakeholders in ecosystems management to bring a larger repository of indigenous knowledge and expertise to bear on the problem at hand, and yield more equitable sharing of costs and benefits.

Box 9. Addressing MDGs in education

The MDGs aim that by 2015 all children are in school and that all children enrolled in grade 1 are retained until grade 5. India has made rapid strides in education in the last 4-5 decades. Though it may be possible to reach the gross primary enrolment rate to 100%, raising the net primary enrolment or attendance rate will be significantly more challenging as a result of large dropouts in between. The MDGs also call for eliminating gender disparities in schooling, such that the ratio of girls to boys enrolled at all schooling levels particularly primary and secondary levels, is 100 %. Data indicates impressive gains in reducing this ratio in the gross primary enrolment rate in the last fifty years. Yet there are large regional variations and the fall-out in the ratios increase subsequently over the years with the gap widening uptil primary and secondary school.

The Government of India launched the National Policy on Education in 1986 with which it started a number of missions. To fill gaps in elementary education, the Government launched the Sarva Siksha Abhiyan in 2000/01. Operation Blackboard Scheme started in 1987-88, aims at improving the classroom environment by providing infrastructural facilities, additional teachers and education material. The District Primary Education Programme is assisted by funding from both multilateral and bilateral sources aiming at operationalising the strategies for achieving universal primary education and universal elementary education through district specific

planning. Mahila Samakhiya Programme aims to promote women's education and empowerment of women in rural areas, particularly those in economically marginalized groups. Of late, two new women- centric schemes have been launched viz. the Kasturba Gandhi Swantantra Vidyalaya (KGSV) and the National programme for Education of Girls at the elenmentary Level (NPEGEL).

Forestry and climate change

The National Communication study (GoI 2004) has made an attempt to study the impact of climate change on forests using BIOME 3 model for about 1500 grids (50 km X 50 km scale). The study predicts the equilibrium composition of different vegetation types under the control and the greenhouse scenario run. The underlying hypothesis of the model being that a combination of vegetation types to achieve the maximum Net Primary Productivity (NPP) represents the equilibrium vegetation.

The results show shifts in forest boundary, changes in species-assemblage or forest types, changes in net primary productivity, possible forest die-back in the transient phase, and potential loss or change in biodiversity. An increase in area under xeric shrublands and xeric woodlands replacing dry savanna is indicated in central India. Enhanced levels of CO2 are projected to result in an increase in the NPP of forest ecosystems over more than 75 per cent of the forest area. Even in a relatively short span of about 50 years, most of the forest biomes in India seem to be highly vulnerable to the projected change in climate. About 70 per cent of the vegetation in India is likely to find itself less than optimally adapted to its existing location, making it more vulnerable to the adverse climatic conditions as well as to the increased biotic stresses. Biodiversity is also likely to be adversely impacted.

These impacts on forests will have adverse socio-economic implications for forest-dependent communities and the national economy. The impacts of climate change on forest ecosystems are likely to be long-term and irreversible. Thus, there is a need for developing and implementing adaptation strategies to minimize possible adverse impacts. Further, there is a need to study and identify the forest policies, programmes and silvicultural practices that contribute to vulnerability of forest ecosystems to climate change.

A smaller study focussing on the Doon Valley (Negi 2000) shows that a sudden rise in both maximum and minimum temperatures has been recorded during 1951-60, owing to increased deforestation around Doon valley during the decade.

The percentage contribution of evergreen species was 69% in 1958, which has reduced to 24% by 1998. While on the other hand the contribution of deciduous species increased from 31% in 1958 to 76% by the year 1998. This is again attributed to increase temperatures followed by reduction in total rainfall,

which causes moisture limitations in the region, a situation favourable for deciduous species. The study reflects a 19% reduction in forest corridor in the region from 1960 onwards. The changing environment of Doon valley has ultimately altered the microclimate of sal forest from moist to dry in the Dehradun Forest division range, this has led to mass scale mortality in moist sal. The gaps created are being colonized with Mallotus phillipensis, Miliusa velutina and Ehertia laevis, which is expected to provide favourable conditions in due course of time for cycling succession of Shorea robusta, if protected.

According to the sector experts consulted, issues which need more attention have been mentioned elsewhere (e.g. NATCOM country report, various national and international consultations organised by UNDP, UNEP, MoEF and many other government and non government organisations), including the following.

- The loss of biodiversity is long term and irreversible
- Not only policy formulation but proper implementation is needed for enhancing the coping capacity of the communties whose livelihoods are dependent on forestry.
- Alternative employment generation is not easy but needs to be encouraged slowly but steadily.
- The severity of climate change needs to be studies in the perspective of forest loss as well as adverse impacts on livelihoods.
- Cost benefit analysis of landuse change studies could be valuable inputs to the decision making process.
- Forestry sector needs more attention as water and agriculture. This sector is equally important in maintaining the sustainability of ecology and livelihoods of a large section of people in India.
- Role of women in the forestry sector must be studied more emphatically.

Coastal regions and climate change

The National Communication study assesses the extent of vulnerability of coastal districts based on physical exposure to sea-level rise, social aspects related to population affected and extent of economic activities in coastal areas and the capacity to cope in these regions.

Using global models, sea level rise of 10-25 cm per 100 years has been predicted under a greenhouse scenario. To separate the influences of global climatic changes the available mean sea level historical data has been evaluated for 10 locations for a period ranging from 1920 to 1999. The rise in sea levels is reported maximum in the Gulf of Kutch and the coast of West Bengal. While West Bengal ranks first in terms of frequency of occurrence of cyclones, Chennai ranks first if normalised with respect to area and Karaikal in Pondicherry ranks first with respect to coastline length.

Box 10. Unique features of coastal regions

The coast is one of the most interesting ecosystems that you come across because it is an absolutely fascinating and unique interface between the social and the environmental.

1. It is close to the sea and therefore it has historical access to global influence, including a lot of in and out migration.
2. The interface between the land, and oceans makes it dynamic, unique, productive, absolutely volatile, and very rich.
3. A variety of property systems exists on the coast, all of which have different incentives and different implications for the policies introduced.
4. The multi-functionality of lot of coastal resources – coastal wetlands, coastal agricultural lands, beaches - allows for diversity of livelihoods, which needs to be preserved.
5. Multiple uses implies many different stakeholder who have to be engaged, leading to potential for conflict.

Source: Ms Ligia Noronha, ex-IDRC

Considering climate change adaptation in the context of development, the following research issues emerged as important in expert consultations and the in-country workshop.

- Detailed case studies are required to identify vulnerable coastal regions to assess vulnerability at local scales and for identification of suitable adaptive strategies.

- Apart from physical changes, pressures from coastal tourism, agricultural activities, impact on different communities – farming (salt water intrusion both surface and ground water), fishing (decline in catch due to warming trends in sea surface temperatures), impacts on specific coastal ecosystems - the sunderbans and coral reefs need to be studied in greater detail.
- Cyclone related risks in coastal regions needs to be assessed and preparedness and relief measures to cope with such hazards are required to be promoted.
- It is necessary to understand migration, which is an absolutely important aspect to livelihood strategy, and can either increase or reduce adaptive capacity.
- There is a need to understand the role of development and economic drivers, such as endowments, livelihoods, diversification strategies, social and information networks, and levels of empowerment.
- We need to study how the choices made by the community, industry, and governments can increase the risks to human lives and livelihoods and reduce rooms to manoeuvre by government and community, which has important implications for designing adaptation policy.

Energy and infrastructure and climate change

In recent years, particularly since COP-8, international negotiations on climate change have been marked by calls to broaden the ambit of the Kyoto Protocol by including developing country greenhouse gas (GHG) mitigation commitments. These demands are countered by developing countries by references to their low cumulative and current per capita GHG emissions, low per capita incomes, low GHG intensity of GDP at purchasing power parity, and high vulnerability and poor coping capacity to climate change impacts.

Clearly, the energy sector is one of the major contributors to GHG emissions, and sustainable use of energy including enhanced energy efficiency, greater reliance on renewable energy, and accelerated development and deployment of clean and advanced energy technologies is challenging and important in this context.

Nair et al (2003) analysed the long-term energy and emission trajectories for India under various scenarios using an integrated modeling framework. The key considerations into the modelling results for development policy include,

- Concerted policy initiatives need to be taken in order to encourage the development and penetration of renewables
- Emerging technologies in the transport sector
- Regional cooperation in energy markets

Climate change considerations in the energy sector must dovetail with broader developmental challenges, including the following

- improving access to energy services, especially in rural areas
- enhancing efficiency of energy production and use
- increasing the security of energy supply
- maintaining environmental sustainability in generation and use

Vulnerability of infrastructure and energy systems to climate change in India was studied under India's national communications study. With increase in temperature, an increase in power generation capacity of 1.5% would be required for enhanced space cooling requirements[1] (GoI 2004). Kapshe et. al., under this study made an attempt to analyse the impacts of climate change on infrastructural development. These relate

[1] Partly offset by energy conservation measures.

to the impacts to be felt on the Konkan railway line which is a in a coastal zone, interlinking of rivers and energy infrastructure.

In the study on Konkan railways, the analysis shows that low dependence and high forcing factors such as rainfall are the major climatic drivers having an impact on the system. Influence of other factors such as temperature, sea level rise and extreme events are also felt but requires improves understanding of these linkages. On the contrary, factors such as landslides have a high forcing effect but are also highly influenced by other elements within and outside the system such as precipitation patterns, geological characteristics of soil, stabilization and prevention mechanisms in the region.

It is felt that there is a need to undertake a detailed assessment of the impacts on infrastructures; this will require preparation of catalogue of historic extreme events, assessing the damages and providing the loss estimates in coastal and inland areas showing the spatial distribution of losses. Detailed GIS covers with topographic, vegetation and geological details showing the major infrastructure systems and components would act as inventory for any strategies to be planned to reduce risks. In this context, the sensitivity assessment of infrastructure systems to various climate-forcing parameters needs to assessed.

There is also an urgent need to develop adaptation strategies and prudent policy framework to protect the infrastructural assets of the country. Incorporation of future climate extremes in project design parameters is required. Lastly there is a need for the development of insurance markets that can help absorb sudden shocks due to extreme weather conditions by providing new products, reflecting changing risks in existing products, and enhancing access of the poor to insurance products.

In the short-term, the CDM (clean development mechanism) introduced under the Kyoto Protocol provides an avenue for providing finance and technology for sustainable energy in developing countries, while enabling Annex I countries to meet their reduction commitments in a flexible and cost-effective manner. At the same time, it forms a basis for developing country participation in global GHG mitigation efforts.

In the long-term, however, stabilization of GHG concentrations requires convergence of countries' emissions in an equitable manner. Developed countries would have to redirect their lifestyles towards a more sustainable path, whereas developing countries could adopt 'leapfrogging' as a development strategy (TERI 2001).

Conclusions: prioritization of issues, gaps, and the need for further research

The Delhi Ministerial Declaration on Climate Change and Sustainable Development, adopted at COP-8, supported effective and result-based measures for the development of approaches at all levels on vulnerability and adaptation, as well as capacity-building for the integration of adaptation concerns into sustainable development strategies. In the decade from 1994's Asian Development Bank-funded study of "Climate Change in Asia" to 2004's National Communication, climate change research activities in India have grown considerably in scope, technical expertise, regional coverage, and numbers of researchers involved. However, to a large extent, climate change continues to be studied in isolation of the broader development context. This consultative exercise has revealed a variety of research gaps – both conceptual and methodological – and also identified priorities for conducting, communicating, and using research. The overarching issues are discussed below, while sector-specific priorities are listed in Table 5.

Understanding regional and local dimensions of vulnerability

For climate change research to feed into policymaking, an understanding of the regional and micro-level aspects of poverty and climate change vulnerability is required. The Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) called for “greater emphasis on the development of methods for assessing vulnerability...especially at national and subnational scales where impacts of climate change are felt and responses are implemented.” However, very few studies have looked at regional and watershed level impacts of climate change, the scale at which most of the government programmes and plans are normally planned. Further, we need to understand how the notion of differential vulnerability plays and the synergy between present natural disasters such as tsunami and long-term climate change. A useful area for policy research is the issue of drivers and inertia in systems.

Improved climate change impact models

Almost all climate change studies in India have extensively utilized the climate change scenario run generated by the Hadley Centre regional model, not exploring other models. However, there is a strong need to develop the next generation of decision models which provide improved regional-scale projections and higher order data on extremes rather than just averages.

Complementing physical impact modelling with socioeconomic assessment

Most studies tend to focus on physical aspects of changes, ignoring the socio-economic aspects altogether. Top-down modelling studies, though useful must have a follow-up phase of research linking the results to people's lives. At a more macro level, estimating the costs and benefits of adaptation options would guide the choices of policymakers. Natural resource valuation and study of market responses are also critical for the formulation of appropriate fiscal incentives.

Action-oriented research

It is time to move from conceptual understanding of vulnerability to more action-based research. Undertaking pilot implementation projects for themes like natural resource management in rural areas, role of information technology in agriculture, and response measures to disasters, will provide valuable scope for learning by doing.

Incorporating stakeholder perspectives and responses

Involvement of stakeholders from all possible streams is essential to effectively address issues linking climate, development, and poverty. Despite the potential for conflict in engaging diverse stakeholders, there is a need to involve them in prioritising research areas, developing simple yet responsive adaptation mechanisms, and formulating policy. Further, there is a need to work closely with and learn from affected communities. For instance, the historical memory of traditional societies in coping with climate variability and natural disasters could guide the development of large social insurance systems. Moreover, self help groups and panchayati raj institutions can be a powerful tool to build community resilience, especially focussing on women.

Focus on less studied sectors

There is a need for detailed research in less studied sectors, to which the poor are most closely linked. These include energy, health and biodiversity. In particular, research could focus on diseases other than malaria, and specifically at the impacts on women. Ground water resources, natural disasters, natural ecosystems including mangroves, wetlands, marine ecosystems, coral reefs, glacial melt and grasslands are some areas that have not been studied in detail.

Cross-sectoral impacts

Studying cross-sectoral impacts and linkages is critical to developing appropriate adaptation interventions, which can be integrated with development plans. This also calls for the formulation of multidisciplinary teams to carry out research.

Flows of goods, services, information, and people

While the role of migration in coping with climate variability and change is known, it is still not fully understood in terms of timing, triggers, and thresholds. The role of information flows is also critical in adding to coping capacity and deserves urgent attention.

Box 11. Research priorities. Mr Kalipada Chatterjee, Winrock International India

Top down research must have a second phase of research where the lessons you have learnt should be translated into action and reaching people's life and enriching our environment...

When we talk of climate change as a threat, I think there should be an in-depth study on how climate change can affect water resources, energy security, agriculture system, human health, and bio diversity of our country and each of these can help us in deciding our development policies.

We should also see the positive aspect of climate change. The opportunity to my mind is that research can be linked to various technological aspects like energy efficiency or CDM. And so can we make our development process more efficient by taking this route. However, simple technological transfer will not help a country like India. We must have human resource development to have a technological base to receive technology and use it for our benefit.

Recently I had undertaken a study on adaptation in desert prone area in Rajasthan. Initially I thought that people are talking so much of traditional practices but then after the study I realized that those traditional practices are not very helpful, because climate change itself is not traditional, and its impacts will not be linear.

Institutional change

Mainstreaming climate variability and change in development planning will not happen without institutional change. Changing institutions and mindsets requires sensitizing those charged with rural implementation, providing them the required tools, and establishing a network of researchers, policymakers, and implementers. There is also need for non-formal arrangements that address the most vulnerable groups (landless, women, children, tribals, etc).

Communicating research to policymakers

The importance of communicating research to policymakers in simple and effective language, with explicit assumptions, cannot

be overstated. Researchers need to equip decision makers with the best available tools and reasonably firm numbers in terms of secular changes so that this information can be used to promote sectoral interventions that enhance adaptive capacity and reduce vulnerability.

Strengthening research capacity

The momentum for integrating climate change and development must come from developing country researchers themselves. The need is to encourage in-country and south-south collaborative research that is interdisciplinary in nature. This can be made possible through significant and sustained funding.

Box 12. Integrating climate change research in decision making. Dr Anand Patwardhan, TIFAC

We really need to look at ways of characterizing and measuring how information or knowledge regarding climate change and impacts on vulnerability gets factored into decision making in different levels. In order to do that we need what I would consider next generation impact models. Impact models today basically try to project what will happen in a particular scenario, while the next generation models need to be decision models.

The critical requirement is much better regional climate modeling capability i.e. the ability to generate regional climate information which can capture not only regional projections but also variables that pertain to climate extremes. For instance, higher orders statistics of how much more likely are heat waves going to be, or what is likely to happen with regard to tropical cyclones.

We need a program of research where we will actually be able to carry out pilot interventions, and carry out pilot adaptation project. We need to move into more action based research rather than research that derives primarily from theory.

In order to do research, we need to ensure that we have in place mechanisms for long term institutional strengthening and also collaborative research programs that are inter-disciplinary and South-South. We will need to strengthen the interface not only within the research community but also between the research community and policy community and the actual managers in the field. It will not happen automatically and it will really have to be done as conscious effort to design a long-term research program that we support and take forward.

In addition to these cross-cutting issues, sector-specific research priorities have been identified on the basis of the

review of climate change vulnerability and adaptation studies and programmes in India, and consultations with experts (Table 5).

Table 5. Research issues and gaps in climate change V&A studies in India

Sector	Issues
Agriculture	Except for a few studies, most of the studies broadly discuss the physical extent of impacts and exclude entirely associated socio-economic linkages. Cross-sectoral linkages have been addressed but there is still scope for refinement in the methodologies that have been used. Changes in water availability under a climate scenario and socio-economic response to these changes would affect water requirements in future and its consequent impact on agriculture Specific case studies are required to capture the regional dimensions of change Quantification of vulnerability Focus on 'no regrets' options like agroforestry systems, biofuels and resource conservation strategies, which have synergy with sustainable development priorities
Water resources	Very few studies have been carried out to assess the impacts of climate change on water resources and there is scope for detailed assessments at a watershed scale at which all government programmes and plans are normally planned. Almost all climate change studies extensively utilize the climate change scenario run generated by the Hadley Centre regional model. There is scope for carrying out experiments with different scenario runs to observe the range of expected changes and study consequent impacts. Only one model (SWAT) has been used for impact assessment. Assessment with other models like CropWat or ModFlow should be done and results compared Impacts of these changes on ground water resources have not been studied at greater lengths. This would be important in the light that ground water resources constitute a major component of the total available water resources. Also utilisation of ground water resources is predicted to increase tremendously in the coming years to meet agricultural demands. Studies have focussed more on the physical aspects of changes ignoring the socio-economic aspects altogether. Human interventions related to dams and diversions under present-day conditions have not been considered. Also land use scenarios for the future have not been considered. Studies have not integrated availability with water requirements for domestic, irrigation or industrial needs across different spatial scales. Specific studies can be carried out in various watersheds to identify water-stressed regions Use of IT and other high-tech technologies to go into an adaptive management mode in partnership with stakeholders. Incorporate climate change related safety concerns in development projects and infrastructures such as dams and bridges.
Coastal areas	Vulnerability assessment for all coastal districts has been done taking into account most of the physical and social impacts. There is need to integrate this however with the economic activities in coastal areas more strongly. Apart from physical changes, pressures from coastal tourism, agricultural activities, impact on different communities – farming (salt water intrusion both surface and ground water), fishing (decline in catch due to warming trends in sea surface temperatures), impacts on specific coastal ecosystems - the sunderbans and coral reefs need to be studied in greater detail. Cyclone related risks in coastal regions needs to be assessed and preparedness and relief measures to cope with such hazards should be promoted Survey different ecosystem areas to prepare an inventory of natural resources
Forestry	Case study approach including people's perception on changes in observations to supplement modelling based studies Vulnerability mapping of the resource will help in delineation of resource-constrained regions Associated cross-sectoral linkages – impact on water linked to agriculture Climate change impact on natural ecosystems including mangroves, wetlands, marine ecosystems, coral reefs, and grasslands has not been assessed but examples from the literature have been cited. Need to make climate data more accessible for model predictions. Need for intensive research in developing models with improved resolutions and more dimensions for realistic projections.

	Forest management strategy should be streamlined in the context of climate change
Disasters	There is a huge gap between the available literature on climate change and the implications for natural disasters or extreme events. A study on past and likely future global disaster trends is needed to develop robust plans. Need to study not just physical health impacts of disasters but also affect on mental health of people Development of a gender-differentiated database on impacts so that appropriate interventions can be designed. All departments responsible for responding to disasters should be sensitized and involved in risk mitigation, for instance, the health and energy ministries. Traditional coping options, such as those observed in Andaman and Nicobar islands during the tsunami, should be studied for insights to develop adaptation strategies. Examine how choices made by people reduce the room to manoeuvre; need to allow for movement of species and systems through zoning, shelter belts, etc.
Energy	Link research with various technological aspects as represented by energy efficiency improvement, clean development mechanism, etc. Explore how human resource development and technology transfer can make the development process more efficient and sustainable. Examine constraints in penetration of environment friendly practices and appropriate technologies

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Annex 1: Summary of climate change and development studies in India

Title of the study	***Funding Agency***	***Brief description***
India's National Communications to the UNFCCC	GEF / Ministry of Environment and Forests, GoI	The study examined the vulnerability to climate change of Indian agriculture, water resources, coastal areas, forestry, health, and energy and infrastructure. Several organisations across the country were involved. www.natcomindia.org
The Initiative on Climate Change Impacts in India	UK-DEFRA (UK Department of Environment, Food and Rural Affairs)	Six institutions used common climate change and socioeconomic scenarios to model the impacts on agriculture, water resources, coastal areas, forestry, health, and energy and infrastructure in India. http://www.defra.gov.uk/environment/climatechange/research/report02/pdf/ga_research02_vol1.pdf
Scoping study on Vulnerability and Adaptation to Climate Change	World Bank	WII (Winrock International India), Delhi www.winrockindia.org/clc/sarrv.htm
Scoping study on Vulnerability and Adaptation to Climate Change	British High Commission	
	SDC	A study sponsored by SDC has recently been launched with the aim to discuss climate change and V & A issues with emphasis on the need for adaptation and implementation activities. The project shall aim to link sustainability with adaptation aspects. It plans to address ongoing developmental stress along with climate change induced stress thereby providing benefits in a holistic manner.
V&A projects with focus on Suderbans mangrove forests and Himalayan glacier melt	WWF (World Wide Fund for Nature and Natural Resources) International	WWF (World Wide Fund for Nature and Natural Resources) -India
Global Change Impact Assessment for Himalayan Mountain Region for Environmental Management and Sustainable Development	APN	-
Adaptive Capacity and Livelihood Resilience	Office of Foreign Disaster Assistance	Institute of Development Studies, Gorakhpur Environmental Action Group, Indian Ocean
Impacts, vulnerability and adaptation strategies of agriculture to Climate Change	MoA (Ministry of Agriculture)	16 State Agricultural Universities and ICAR Institutes A nationwide study comprising 14 premier agricultural research institutes in the country began on April 1, 2004 to study the impact of global environmental changes on different areas in agricultural production and prepare strategies for minimising the damage. Network on Climate Change and Indian Agriculture (NETCCIA) is a study aimed at quantifying the sensitivities of current food production systems to different scenarios of climatic change. The Tenth Plan

Title of the study	*Funding Agency*	*Brief description*
		project is led by Central Research Institute for Dryland Agriculture (CRIDA), a constituent of ICAR (Indian Council for Agricultural Research), nine ICAR institutes, including Indian Agricultural Research Institute (New Delhi), Central Plantations Crops Research Institute (Kerala) National Diary Research Institute (Haryana), and five agricultural Universities. The Rs 10-crore study will come out with an Indian National Agricultural Research System that would provide a detailed understanding of the impact of environmental changes and suggest ways to gear up for the situation. This study is expected to provide policy support to the Government and other stakeholders. (http://dryland.ap.nic.in/)
		Recognizing the importance of declining yields, the Department of Science and Technology, Government of India and UNDP have evolved a pilot project on 'Information Technology for Sustainable Agriculture in Punjab'. The project is being implemented by Technology Information, Forecasting and Assessment Council (TIFAC) on behalf of the Government of India. The objective of the study is to develop a multi-level decision support model for synergizing natural resource system with economic and social imperatives. The project also aims to develop indicators of sustainability for agricultural production system and suggest alternatives to conserve and improve the health of natural resource systems. (http://www.tifac.org.in/itsap/abt.htm)
Vulnerability of Indian agriculture to climate change and globalisation	CIDA (Canadian International Development Agency) and the Government of Norway	TERI carried out a study to assess the vulnerability of Indian agriculture to the dual impacts of climate change and economic globalization. A district-level vulnerability profile based on biophysical, socioeconomic, technological, and climate factors was developed, complemented by five village-level case studies. www.teriin.org/coping
	World Bank and DFID	The World Bank through part-support by DFID Trust Fund has launched a study to address vulnerability to climate variability and change. An assessment of adaptation issues and options in the agriculture and water resources sectors will be carried out. The study aims to assess the factors that determine the use/effectiveness of coping options to deal with climate variability and change.
	IDRC	Adaptive policy-making
	UNEP	developing a pilot GEF project on adaptation
Applying Climate Information to Enhance the Resilience of Farming Systems Exposed to Climatic Risk in South and Southeast Asia	APN (Asia Pacific Network for Global Change Research)	Tamil Nadu Agricultural University, IISc

Title of the study	*Funding Agency*	*Brief description*
Climate Variability and Rice-Wheat Productivity in the Indo-Gangetic Plains	APN	Rice Wheat Consortium for the Indo-Gangetic Plains CIMMYT – India office
Water Resources in South Asia: An Assessment of Climate Change-associated Vulnerabilities and Coping Mechanisms	APN	-
		TERI carried out a small GIS-based modelling study on the impact of climate change on precipitation patterns and water availability in Lakhwar sub-basin in the state of Uttaranchal. The case study methodology involved simulation and modelling of total runoff, as a function of the regional interaction of the climate, soil, hydro-geology, topography and land use conditions in the river basin. It was found that about 1500 km2 of the total 4000 km2 of the Lakhwar sub-basin receives an annual runoff of less than 1250 mm, and is hence highly sensitive to increased water stress due to climate change. A decrease of 20% to 30% in total flows on account of climate change alone was estimated, indicating that the amount of water available for usage in future would be reduced substantially. It is estimated that under the HadRM2 scenario, there is a net decrease in the volume of rainfall as well as the intensity of rainfall, leading to decrease in the total availability of water in the region including groundwater recharge. The region is also likely to experience monsoon rainfall which becomes less intense and more sporadic.
Inventory of Glaciers and Glacial Lakes and the Identification of Potential Glacial Lake Outburst Floods (GLOFs) Affected by Global Warming in the Mountains of the Himalayan Region	APN	Geo-information Science Division of CSKHP Agricultural University, Palampur
The Economic Impact of a One Metre Sea Level Rise on the Indian Coastline: Method and Case Studies	Ford Foundation	TERI
Ex-post study of UNDP Small Grants Programme projects	UNDP	An ex-post study of four UNDP Small Grants Programme projects was carried out in 2005 to evaluate their contributions in achieving global environmental benefits and local benefits.
Climate change and the Indian insurance industry	DEFRA	An ongoing study by TERI aims to examine the implications of climate change for the Indian insurance industry. It takes stock of the state of play in the Indian insurance sector, identifies emerging issues, and develops strategies for insurance companies, the regulatory authority, and the central government.
PACCIFY	UNEP	UNEP is presently supporting a capacity building programme for

Title of the study	*Funding Agency*	*Brief description*
(Programme for Awareness on Climate Change Issues Featuring the Youth)		school children. The programme targets 14 to 16 year-old students in schools to enhance awareness on climate change related issues.

Annex 2: GEF (Global Environment Facility) projects in India

Project Name	*Focal Area*	*Agency*	*GEF Grant (million dollars)*
Single Country Projects			
India Ecodevelopment	Biodiversity	IBRD	20.213
National Biodiversity Strategy and Action Plan	Biodiversity	UNDP	0.968
First National Report to the CBD	Biodiversity	UNDP	0.025
Conservation and Sustainable Use of the Gulf of Mannar Biosphere Reserve's Coastal Biodiversity	Biodiversity	UNDP	7.868
Conservation and Sustainable Management of Dryland Biodiversity, Phase 1	Biodiversity	UNDP	2.040
Capacity Building for Implementation of the Cartagena Protocol	Biodiversity	IBRD	1.000
Alternate Energy	Climate Change	IBRD	26.000
Development of High Rate BioMethanation Processes as Means of Reducing Greenhouse Gas Emissions	Climate Change	UNDP	5.500
Optimizing Development of Small Hydel Resources in Hilly Areas	Climate Change	UNDP	7.500
Selected Options for Stabilizing Greenhouse Gas Emissions for Sustainable Development	Climate Change	UNDP	1.500
Solar Thermal Power	Climate Change	IBRD	49.750
Coal Bed Methane Capture and Commercial Utilization	Climate Change	UNDP	9.190
Energy Efficiency	Climate Change	IBRD	5.000
Biomass Energy for Rural India	Climate Change	UNDP	4.213
Enabling Activity for the Preparation of India's Initial Communication to the UNFCCC	Climate Change	UNDP	2.000
Fuel Cell Bus Development in India (Phase II - Part 1)	Climate Change	UNDP	6.280
Removal of Barriers to Biomass Power Generation, Part I	Climate Change	UNDP	5.650
Removal of Barriers to Energy Efficiency Improvement in the Steel Rerolling Mill Sector	Climate Change	UNDP	7.030
Electric 3-Wheeler Market Launch Phase	Climate Change	UNDP	0.998
National Capacity Self-Assessment (NCSA) for Global Environment Management	Multi-focal Areas	UNDP	0.200
Regional and global projects			
Asia Least-Cost Greenhouse Gas Abatement Strategy (ALGAS)	Climate Change	UNDP	9.500
Fuel Cells Financing Initiative for Distributed Generation Applications	Climate Change	IBRD	9.850
Conservation and Sustainable Management of Below Ground Biodiversity, Phase I	Biodiversity	UNEP	5.296
Assessment of Soil Organic Carbon Stocks and Change at National Scales	Multi-focal Areas	UNEP	0.978
Promoting Industrial Energy Efficiency through a Cleaner Production/Environmental Management System Framework	Climate Change	UNEP	0.950
Photovoltaic Market Transformation Initiative (IFC)	Climate Change	IBRD	30.375
Development of a Strategic Market Intervention Approach for Grid-Connected Solar Energy Technologies (EMPower)	Climate Change	UNEP	1.000

SOURCE http://www/gefonline.org/projectlist.cfm accessed on 23 August, 2004.

Annex 3: List of people contacted and consulted

Name of the expert	**Sector**
Mr Chetan Pandit Chief Engineer Upper Yamuna River Board Ministry of Water Resources Government of India New Delhi	Water
Prof Subhash Chander Professor and Deputy Director IIT-Delhi New Delhi	Water
Dr A K Singh Project Director Water Technology Centre Indian Agricultural Research Institute Division of Environmental Sciences Pusa Campus New Delhi	Water
Dr Kalipada Chatterjee Winrock International India 1 Navjeevan Vihar New Delhi	Climate Change and V & A
Mr S K Joshi Joint Secretary, Ministry of Environment and Forests Paryavaran Bhawan CGO Complex New Delhi	Climate Change and V & A
Prof P K Aggarwal Indian Agricultural Research Institute Division of Environmental Sciences Pusa Campus New Delhi	Agriculture
Mr S K Pande Ex DG Forest Distinguished Fellow, TERI Habitat World Lodhi Road New Delhi	Forestry
Prof Santosh Kumar National Institute of Disaster Management Ministry of Home Affairs New Delhi	Disaster Management