GLOBAL WARMING: ITS IMPACT ON INDIA

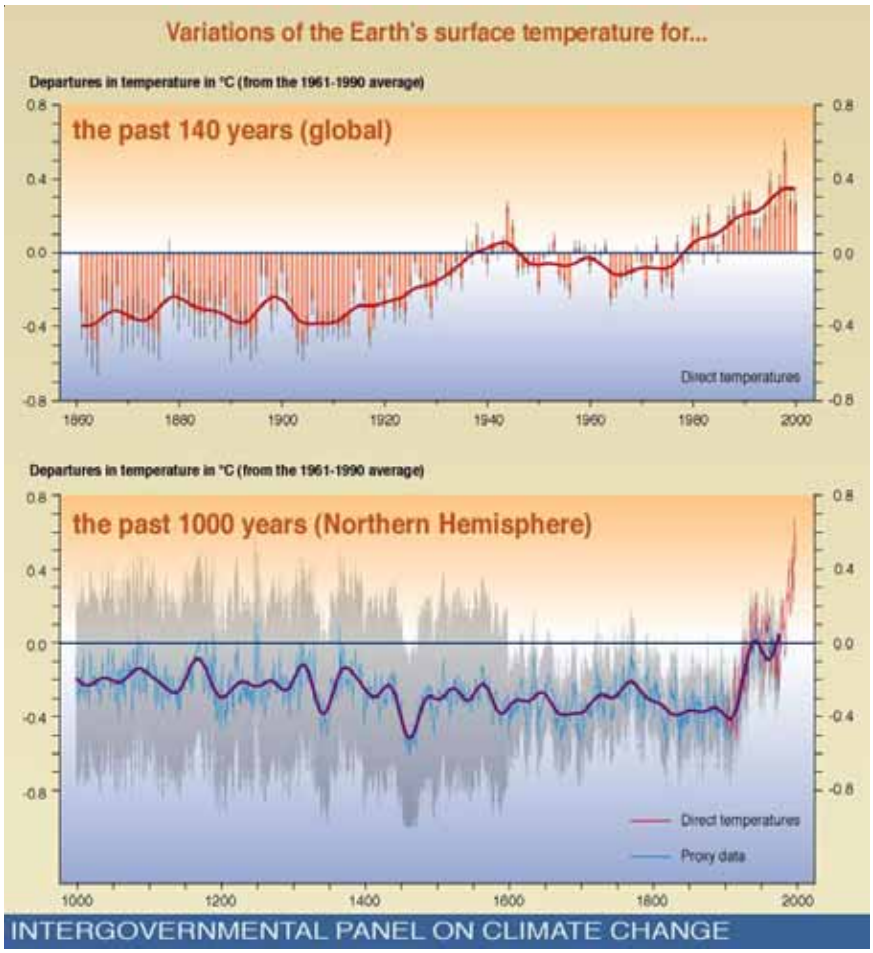
SUMMARY

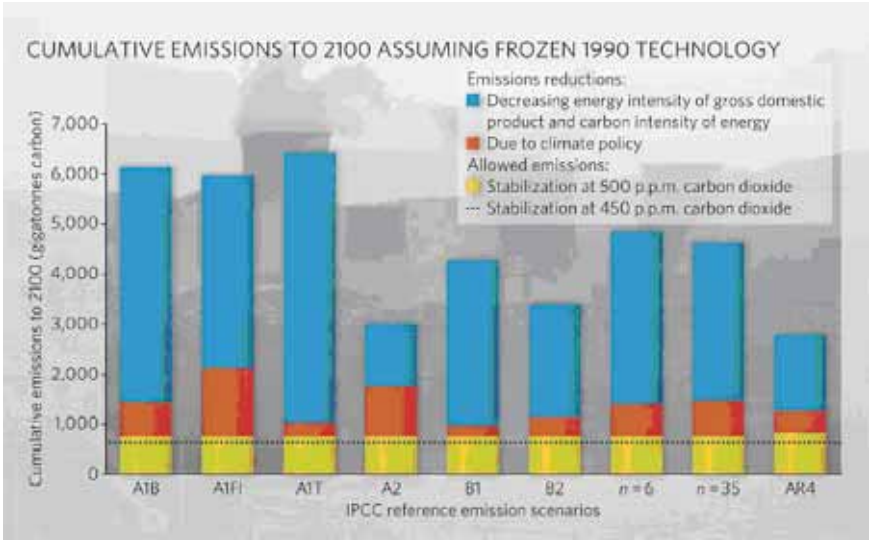
Rising levels of green house gases together with sulphur dioxide (SO_2) and suspended particulate matters such as dust, etc. in the environment of our living planet i.e. earth are expected to cause climate change. By absorbing infrared radiation, these gases control the flow of natural energy through the climate system. Among the Green House Gases, Carbon dioxide (CO_2) is currently responsible for over 60 per cent of the "enhanced "Green House Effect, which is responsible for climate change. This gas occurs naturally in the atmosphere, but anthropogenic sources and Human activities, i.e. Deforestation or Depletion of Land resources are adding much more of this gas into the atmosphere. Current emissions amount to over seven billion tones of carbon, or almost one per cent of the total mass of carbon dioxide in the atmosphere. CO_2 produced by human activities enters the natural carbon cycle. Many billions of tones of carbon are exchanged naturally each year between the atmosphere, the oceans and land vegetation. Global warming is caused by an increase in the temperature of the Earth's lower atmosphere. And global warming may lead to climate changes resulting from alterations to regional climatic events such as rainfall patterns, evaporation and preventive measures. Climate induced natural disasters (CINDs) like drought, flood and cyclone become serious problems to coastal areas. CINDs are of regular occurrence particularly in coastal areas of Orissa and have become the part of normal life. The changes in climate due to global warming, lead to induce the chances of different types of natural disasters such as Drought, Floods, Cyclones and Forest fire and man made disasters like Ozone depletion, Environmental acidification etc. IPCC of UN in its report has confirmed the global

warming trend and projected that the globally averaged temperature of the air above earth's surface would rise by 1.4 to 5.8^{0}C over the next 100 years. India is highly vulnerable to climate change as its economy is heavily reliant on climate-sensitive sectors like agriculture and forestry and its low-lying densely populated coastline is threatened by a potential rise in sea level. It appears that progress in climatology and in the development of numerical models not only enables scientists to relate extreme weather events such as floods and droughts, with climate variations, but they can give some insight to climate change scenarios due to global warming such as sea level rise and changes in frequency, strength and geographical distribution of extreme events. These results should be of great help in taking the right measures and in building up the adapted policies. The Eighth session of the Conference of Parties (COP-8) to the UN convention on Climate Change (October 23 to November 01, 2002), New Delhi, ended here with a Delhi Declaration has successfully resolved the technical parameters necessary for the Implementation of the Kyoto Protocol (1997) on Green House Gases reductions. The Delhi Declaration gave primacy for the implementation of the clean development mechanism in the climate change process. The Bali conference on climate change (December 2007) showed all the countries the way forward to the next phase of the campaign to control the planet's changing climate, the specific objective being to put a multilateral arrangement in place that will succeed the 1997. Kyoto Protocol of the UN convention on climate change, which will terminate at the end of 2012. The Bangkok meeting (March 2008) was the beginning of the new process, which is scheduled to end in December 2009 at Copenhagen (Denmark). India has prepared a `National Action Plan on climate change' (June 30, 2008) which is in line with the international commitments and contains eight missions on climate mitigation and adaptation. Now the relevant ministries will prepare and submit their respective plans to the Prime Minister's Climate Change Council by September 2008.

INTRODUCTION

On February 2, 2007, the United Nations Scientific panel Studying Climate Change declared that the evidence of a warming trend is "unequivocal", and that human activity has "very likely" been the driving force in that change over the last 50 years. This report of IPCC was more conclusive as compared to the report released in 2001 which only pointed to the likeliness of human activity being responsible for climate change. The addition of the word "very", in the report, reflects the mounting Scientific evidence that the release of Carbon dioxide and other heat trapping gases from smokestacks, tailpipes and burning forests has played a central role in raising average Surface temp nature of the earth by more than one degree Fahrenheit since I900.The term "very likely" was defined in the report as





meaning with a certainty of more than 90 per cent. The findings were documented in the fourth assessment report of IPCC. The report set at rest the speculation of a group of skeptics who had been disputing on whether or not global warming is real. It also reminded the world about the crisis which threatens to change the face of the earth as we know it now.

The fact that climate change is real, that it is happening and that its impact is devastating millions is no longer news. Research by renowned scientists worldwide has established the fact that the temperature of the earth has increased by about 0.7 degree Celsius. It is also a generally agreed fact that the increase in temperature is due to the concentration of Green House Gases in the atmosphere including Carbon Dioxide which today stands at 380 ppm. Due to this concentration of Carbon Dioxide in the atmosphere the earth has reached a climatic "tipping point" since a further increase in Carbon Dioxide levels will obviously increase the heating of the earth which would bring in its wake faster melting of ice caps, rising sea levels, more frequent heat waves, water shortages for up to 250 million people and the risk of extinction for up to 30 per cent of all species. These are serious consequences which in addition to causing widespread loss and destruction would also seriously hamper the fulfillment of the Millennium Development Goals. It is imperative that global warming is restricted to the extent by a possible collaborative action among nations.

Although the science of climate change has been accepted, its politics is still contested with developed nations refusing to take action on reduction of Green House Gases unless the developing ones do the same. The developing nations cite their right to develop as an excuse for inaction and

continue to argue that the developed nations, which are the biggest emitters, should curb their emissions first. While precious time is being lost in such arguments, Carbon Dioxide levels are increasing continuously and developing nations are continuously moving up on the list of emitters. Today America, China, Indonesia and India, in that order, are considered to be the four largest emitters. In this ongoing dispute between developing and developed nations a fact that has been largely forgotten is that the impacts of climate change have spared neither the developed nor the developing nations. The climate change events that have occurred in various parts of the world bear testimony to this fact. It would be interesting to note that most of these impacts have occurred in the last decade and have been increasing in frequency and intensity as predicted by scientists.

CHINA

China's sustained high growth rate and its pursuit of building a moderately well off society have been the primary drivers for the large increase in energy demand and GHG emissions. China needs larger GHG emission space, and at the same time China has an obligation to protect the global climate change. To achieve these dual goals, China has stated that it will adopt a low carbon economy approach in its National Assessment Report on Climate Change (2006).China is shifting towards a low carbon economy, not only through mitigating GHG emissions, but also by means of rising domestic exploitation of the nation's natural resources. By using cleaner use of fossil energy, China will be able to change its current energy intensive, high emitting and low-output model of economic growth, and ease the conflict between economic development, natural resources management and social costs.Lu Xuedu, Zhuan Guiyang and Pan Jiahua Development Outreach: World Bank Institute April 2008.

INDIAN SCENARIO

India has also not been spared the impact of climate change. The country which is home to 1028.7 million people has a high population density of 344 persons per sq. km. which makes most areas of the country extremely vulnerable to various kinds of disasters which are bound to escalate with climate change. The country also has a long (7500 km) and populous coastline with a higher population density of 455 persons per sq. km. This coastal population depends heavily on sea based livelihood sources and is highly vulnerable to various disasters originating in the sea. Such sea based disasters have only worsened in the last decade. Another major threat that climate change poses to the country is through its impact on agriculture. Since agriculture is a source of livelihood for 65 per cent of the population

and contributes to 27 per cent of the GDP, adverse impact on Agriculture would have serious effect on the economy of the country. In addition it will also have an impact on food security and health. It has been estimated that 0.5 degree rise in temperature would result in reduction of wheat yields by 10 per cent. However, the loss of crops and agricultural land due to disaster intensification and land degradation caused by climate change can not be estimated. The extreme weather events that have occurred in the country in the last decade show that various parts of the country are already reeling under the impacts of climate change.

- In the North Himalayan Glaciers are receding by about 16 m every year. The receding glaciers have major implications for water availability in the glacier fed rivers such as Ganga and Yamuna which serve as the main source of water supply to settlements along their banks. An estimated 750 million people live in the watershed areas of rivers originating from Himalayan glaciers.
- An Action Aid study has shown that water levels in almost all streams in Kashmir valley have fallen by 2/3rd and Ground water levels have dropped by more than 1/3rd. These problems are occurring mainly due to the receding glaciers.
- In May 2002 severe heat waves conditions were recorded in coastal districts of Andhra Pradesh. Earlier the heat waves were restricted to the interior areas of the state.
- In 2003, twenty two out of twenty three districts in Andhra Pradesh were in the grip of a heat wave. In the same year more than 80 per cent of the state faced a drought.
- In 1999 two cyclones hit the state of Orissa in quick succession. About 15 million people were affected.
- In the Sunderbans delta for islands, Bedford, Lochahara, Suparibhanga and Kabasgadi, have submerged due to sea level rise rendering 6000 families homeless.
- The desert region of Barmer, in Rajasthan was affected by floods in 2006. The floods claimed the lives of 140 people.

MITIGATION AND ADAPTATION: URGENT ACTION NEEDED

The above extreme events underscore the need to take action on climate change issues. It would not be sufficient to say that we are only the fourth largest emitters. Action would be required at two levels. The first would be for mitigation and adaptation in areas where these impacts are already being felt. The second would be to achieve a reduction in carbon emissions through technical and legislative measures. Nearly a quarter of population in the country is below the poverty line. Poverty makes people more vulnerable to climate change as they lack the resources to adapt to climate change. It is ironical that the poor contribute the least to carbon emissions but are most vulnerable to climate change.

The city of Mumbai was flooded due to heavy rains in 2005. 944 mm rainfall was recorded in a period of 24 hours. About 1000 people lost their lives due to floods.

The major impacts of climate change on various regions of India are as under:

East

The increased disaster frequency and intensity indicates that the state is under severe stress due to climate change impacts. In the past decade the state has experienced various disasters due to extreme weather conditions such as heat waves, floods and droughts. The disasters in the state are occurring more frequently and penetrating into areas which were relatively free of disasters earlier. The prominent incidents which point to the fact that climate change is occurring in the state are as under:

- In 2001 twenty five out of thirty districts in the state were affected by floods. Districts in Western Orissa with no previous flood history were also affected. Floods have now become an annual affair for Orissa.
- In 2007 the coastal district of Balasore was affected by four floods virtually wiping out crops in the state and severely affecting human beings and livestock.
- The state suffered one of its worst droughts in 2001 which affected 11 million people in two thirds of the state's districts. The drought affected earlier drought free states such as Sundergarh and Kendrapara.
- In 1998 a heat wave in Orissa killed about 1500 people, mostly in coastal Orissa, an area known for moderate temperatures. The Titilagarh and Koraput belt comprising most of Southern and Western Orissa has experienced exceptional rise in daily maximum and minimum temperatures.
- In 1999 two cyclones hit the state in quick succession. The second cyclone lasted three days and affected 14 coastal districts. About 15 million people

were affected and 50 per cent of the forest cover in Jagatsinghpur and Kendrapara was destroyed.

- Some districts in the state are affected by sea level rise. In Kendrapara district five villages out of a group of seven villages were submerged in the sea due to sea level rise. The two remaining villages, Kanhupur and Satbhaya, continue to face the danger of submergence as the sea continues to advance towards the villages.

The predictions of impacts of climate change in future for the state also seem to be quite grim. It is expected that the sea level would continue to rise would lead to increased levels of inundation and storm flooding, accelerated coastal erosion, seawater intrusion into fresh groundwater and encroachment of tidal waters into river systems. Coastal erosion will also endanger natural protective features like mangroves and barrier islands, exacerbating flood risks. Deltas and coastal areas will be affected by sea level rise. Increased rainfall will lead to more frequent flooding with flood prone areas suffering more. As a result of all these effects the coastal communities will suffer more. All these stresses on rural areas would trigger mass migrations to urban areas putting pressure on already overburdened infrastructure.

Agricultural land in the coastal region would be vulnerable to inundation and salinisation. This would affect the paddy crop adversely. Orissa normally produces about 5 million tons of rice each year. Effect on agriculture would also throw a number of people dependent on it out of work.

A possible increase in cyclone intensity of 10-20 per cent against a rise in sea surface temperature of 2 degree centigrade to 4 degree centigrade is expected. It has been found that climate change has already intensified Asian monsoons and river flows. Deforestation and climate change impacts would also lead to more severe and frequent flooding.

Earlier Western Orissa was a known calamity hotspot. However, now coastal Orissa is also experiencing heat waves with mean maximum temperature in the capital, Bhubneshwar being more than 40 degrees centigrade.

In addition to Orissa climate change impacts are also being noticed in the Sunderbans in the state of West Bengal. Although the area forms a small part of the state, it enjoys the status of being one of World Heritage sites due to its unique ecosystem. Sunderbans is one of the world's largest ecosystems spread over an area of 9,630 sq. km. It consists of 102 low lying islands, 48 of which are inhabited. It is also the habitat of the Royal Bengal tiger. The islands and its ecosystems including the community are severely stressed on availability of natural resources and highly vulnerable to changes in climate. Climate change is leading to increasing salinity and

higher tidal surges and leading to permanent submergence of land. This has affected the communities and the ecosystem. It has been estimated that 1 m rise in sea level will submerge 1000 sq. km of land in the Sunderbans. In the last 20 years four islands namely Bedford, Lochahara, Suparibhanga and Kabasgadi have submerged rendering 6,000 families homeless. Scientists have estimated that one of the largest islands namely Sagar Island will lose 15 per cent of its habitat area by 2020. Communities are already responding by adjusting the timing of cropping, changing crop types, increasing rainwater harvesting and increasing island mud barrages.

West

Climate change impacts have also affected the urban and rural areas in Western India. The effects have been more pronounced on the Eastern coast as more climatological disturbance is seen over Bay of Bengal than over the Arabian Sea. However, the effects on Agriculture and on communities on the Western coast are visible.

- In the Western Indian state of Rajasthan Pearl Millet is the main crop. The production of pearl millet is reduced by 10-15 per cent due to a 2 degree rise in temperature. .
- Rajasthan was affected by severe droughts in 2002. The drought affected 32 districts with a rainfall deficit of 53.4 per cent.
- The effects of climate change are also visible in Jhalawar, Rajasthan. The area has been experiencing droughts since the last four years. Agricultural yields have also reduced substantially, particularly for the majority of farmers who lack irrigation facilities. The medium farmers are coping by sale of available stock. The only option available to landless laborers is migration from the area. Small and marginal farmers cope in a number of ways which include sale of cattle, shift to other crops, labor and migration.
- Maharashtra too has been facing the effects of drought. In 2001 20,000 villages in the state were affected by drought. The number of villages affected in 2002-03 and 2003-04 was 33 and 11 respectively.
- In 1994 the summer temperatures in Western India reached 50 degree centigrade providing favorable conditions for disease carrying vectors to breed. In the same year there was a plague outbreak in Surat, Gujarat. In the period following summers of the same year Surat experienced heavy rains and was hit by a malaria epidemic. Hot and humid climate is ideal for disease carrying vectors.
- Coastal states of Maharashtra, Goa and Gujarat face a grave risk due to sea level rise. It has been estimated that a 1m rise in sea level will affect

seven per cent of the population in Goa and also affect 13 lakh people in Maharashtra. Besides actual inundation a large number of people would be vulnerable to regular flooding also.

In future further negative impacts on agriculture are expected due to changes in soil, pests and weeds. In addition to above soil in the Western parts of India is prone to salinisation. This will further degrade the soil as the soil loses its moisture due to increase in temperature.

North

In the Northern part of India, impacts of climate change have been on water availability and agriculture. The average temperatures are also on the rise in these areas. The water scarcity is occurring due to receding glaciers in the Himalayas. The wheat yields and apple yields are also being affected due to rise in temperature. The rise in temperature raises issues for food security and livelihoods.

- In Kullu valley apple production in 1995 was one fourth of peak production year of 1988-89. In 1989-90 the production of apples reduced to 50 per cent of previous year's all- time- high production. The production has been declining since then. There have been seasonal shifts in the region due to climate change which have had an impact on the apple crop. The shift is as mentioned below:

TRADITIONAL CALENDAR OF THE KULLU VALLEY

Local term	Approximate period	Description (Ideal)	Description (Present)
Magh	Jan 15-Feb 15	Cold with snow fall	Some rain and snow
Falgun	Feb 15-Mar 15	Less cold with snow	Rain
Chaitra	Mar 15-Apr 15	Rain, snow rare	Some fain and snow
Baisaki	Apr 15-May 15	No rain, clear skies (paddy, dal and corn sown	Dry with some rain
Jeth	May 15-Jun 15	Hot (paddy, dal and corn sown)	Dry
Asadh	Jun 15-Jul 15	Hot (until June 30), pre-monsoon rain	Hot and dry
Sawan	July 15-Aug 15	Rain	Hot and rainy
Bhadra	Aug 15-Sep 15	Rain (until Aug 30, apple harvest), dry	Predominantly rainy season (stock of drying grass for fodder)
Ashwin	Sep 15-Oct 15	Clear (corn, dal harvest; wheat, barley sown)	First half rainy and second half dry
Kartik	Oct 15-Nov 15	Mostly clear (paddy harvest), shorter days	Same as ideal
Mangsir	Nov 15-Dec 15	Snowfall, drying fir leaves and wood for fuel	Same as ideal
Paush	Dec 15-Jan 15	Maximum cold with snow	Very little snow

Source: Field interview

- In Kashmir global warming is affecting agriculture and water security. It has been found that temperature in Kashmir region has risen by 1.45 degrees centigrade and in Jammu by 2.32 degrees centigrade. IMD's monitoring reveals increase in temperature in Jammu and Kashmir valley with increase in maximum temperature of 0.05 degrees centigrade per year.
- The water level in almost all streams and rivers in Kashmir has decreased by 2/3rd during the last 40 years. Ground water level has dropped by 1/3rd in the upper areas of the region.
- Snowfall has also undergone a change with December and January receiving scant rainfall and February and March witnessing heavy snowfall. While winter and spring water run off has clearly increased due to early meltdown of snow.
- It has been seen in the valley that there has been a reduction in snowfall and increase in the frequency of cloudbursts.
- Agriculture in the valley has been adversely affected due to climate change. Yields of Paddy and Maize have reduced due to increase in temperatures. The almond crop has also suffered damage. Due to reduced water in streams Maize and Cherry yields have been reduced by half.

Thus it is seen that climate change has major implications for water security, food security and livelihoods in Kashmir.

Climate change also has a major impact on the unique ecosystem and communities in Ladakh. On the one hand rising levels of some key wetlands have submerged the breeding grounds of some birds. On the other hand the floods of 2005-06 claimed several lives in addition to causing economic destruction. The local community was caught unawares due to their ignorance about the changing climate.

South

In Southern India Andhra Pradesh is an established climate change hotspot. The state has a long history of disasters. The coastal areas of the state are affected by cyclones and the areas in the interior are affected by droughts and heat waves.

Certain districts namely, Ananthpur, Chittoor, Cuddapah, Hyderabad, Karnool, Mehboobnagar, Nalgonda and Prakasam are chronically drought prone.

In addition to droughts heat waves have become a major problem for the state since 1994. From 1986 to 1993 the heat waves were of a moderate nature and continued for a maximum period of seven days. Since 1994 the heat waves have become more severe and frequent and continue for a longer period.

- In 2003, 22 out of 23 districts in the state were affected by heat waves. In the same year 80 per cent of the state faced a drought.
- In 2003 drought in various parts of Andhra Pradesh forced the government to set up gruel centers in the state to help the villagers survive since even tea or tubers were not available. Such gruel centers were also set up in the districts of Ananthpur and Mehboobnagar. A large number of villagers migrated from these districts to nearby cities
- In 1997 and 1998 the spell of moderate to severe heat waves continued for 19 days.
- In May 2002 severe heat wave conditions were recorded in Coastal districts of Andhra Pradesh. The heat waves occurred in two spells of six days and seven days. It has been seen that earlier heat waves occurred only in interior districts of Telangana. They have now shifted to the coastal areas.
- In 2003 the state experienced another heat wave with severe heat wave conditions lasting for a period of 27 days. The prominent coastal areas affected were Kavali in Nellore district and Ongole in Prakasam district.

It is seen from the above incidents that climate change is affecting areas which were free from such disasters and it is hitting these areas with unprecedented severity.

Chennai is one of the three major coastal cities in India affected which would be affected by sea level rise. The sea levels are expected to rise by up to 5 m by 2021 which would lead to submergence of large parts of Kolkata, Mumbai and Chennai triggering off mass migrations from these areas and creating major environmental problems for these cities.

Average annual surface air temperatures over the Indian sub-continent shows a slight warming trend by about $0.4^{O}C$ in the last 100 years. Major parts of the northwest especially Delhi and NE India exhibit cooling trends. Maximum temperatures show very little trend over most regions of the country except the northwest region where they show significant decrease i.e. ~$0.6^{0}C$/100 years). At present, the warming trend cannot yet be reliably detected above the noise of natural climate variability; the observed tendencies must be interpreted only as possibilities with lots of uncertainties.

Monsoon rainfall does not show significant trend over the century scale but decadal trends have been noticed. Decreasing trend in larger number of districts in the case of annual rainfall suggests that there may be overall decrease in pre-monsoon and post -monsoon rainfall. The results bring out a conspicuous observation that while no trend has been observed in some meteorological subdivisions, individual districts have shown a decreasing or increasing trend. It may be mentioned that the analysis has limitations due to several factors like deployment of rain gauge stations and their numbers

(Srivastava et al, 1998).

Decreasing trend in the drought-affected areas in India located over northwest India; parts of central peninsula and southern parts of Indian peninsula have been reported. The number of cyclonic storms and severe cyclonic storms shows decadal oscillations with their number fluctuating from as low as 35 for decade 1981-1990 to as high as 62 in decades 1971-1980 and 1921-1930 (DE, 2001). The decadal variability of cyclone frequency also shows more or less similar pattern. The maximum number of 29 monsoon cyclones occurred during the decade 1890-1990. This number fell to 6 during the 1990s. There have been significant decreasing trends in both the frequencies, but the frequency of cyclonic disturbances has decreased at the rate of about six to seven disturbances per hundred years in monsoon season. The frequency of cyclonic storms of monsoon has decreased at the rate of one to two cyclones per hundred years (Singh, 2001).

Increased temperatures would have an adverse impact on health of individuals due to increased heat stresses. It has been estimated by scientists at IIT, Delhi that temperatures over India have increased over India by 0.4 degrees Centigrade over the last century. The increased temperatures have led to severe heat waves across various parts of India taking a heavy toll of lives. According to WHO global warming will also lead to increase in respiratory and cardio-vascular diseases. Water borne diseases such as cholera and dysentery could rise with a change in rainfall pattern and change in access to water and sanitation. Climate change would lead to a rise in infectious diseases as temperature and rainfall affect the distribution of disease vectors and disease organisms. Cold is a limiting factor for mosquito growth. Hence, mosquito population would tend to grow in warmer weather leading to a rise in diseases carried by them such as malaria, dengue fever, yellow fever and several kinds of encephalitis. It has also been found that dengue virus takes 12 days to incubate in the Aedes mosquito at 30 deg. C but only 7 days to incubate at 32 deg. C. This would translate into a threefold increase in transmission rate of the disease.

The monsoon rainfall is expected to increase by up to 30 per cent by the end of 21st century, as a result of climate change, which again would affect agriculture which is largely dependent on rains. According to World Bank a seven per cent increase in rainfall accompanied by 2 degree centigrade rise in temperature will reduce net agricultural revenues for the whole country by 12.3 per cent. The climate change models are expected to lead to a reduction in soil moisture leading to a reduction in growth of teak forests from 5.4 cubic meters per ha. to 5.07 cubic meters per ha. and productivity of deciduous forests from 1.8 cu. m per ha. to 1.5 cu. m per ha.

INDIA'S COMMITMENT ON CLIMATE CHANGE

All the G8+G5 summit (2007) at Germany India's Prime Minister, Dr. Man Mohan Singh put forward a very constructive proposal. He mentioned that in pursuing its development objectives, India would ensure that its per capita emissions would at no time, exceed the average per capita emissions of developed countries.India has suggested to establish innovative 'Global Climate Change Venture Fund' for transferring climate friendly technologies to the developing nations on concessional terms. India has also proposed that few developed and developing countries, may set up a network of R&D institutions 'CLEAN-NET' which would specialize in technological innovation in the field of climate change.While adopting a positive, constructive and forward looking approach in climate change negotiations, India has been careful to maintain solidarity among the developing countries. India's leadership role in these negotiations has been fully appreciated. In the coming weeks and months, Indian diplomacy will have to rise to the challenge of contributing to the resolution of an issue which is global in scope and compelling in its urgency, even while safeguarding our right to pursue our development objectives and achieve our goal of poverty eradication. What we seek is an equitable solution. We cannot accept the proposition that developed countries get to keep what they have, in terms of occupying the available carbon space, because they got here first, while the rest of us must be content with a lower level of development because we are late-comers. There cannot be a perpetual division between haves and have-nots in the name of climate change. As long as this is recognized and accepted, the people of India will not be found wanting in fulfilling their role as responsible global citizens'Shyam Saran (2008)

IMPACTS OF GLOBAL WARMING

In developing countries like India, climate change could represent an additional stress on ecological and socio-economic systems that are already facing tremendous pressures due to rapid urbanization, industrialization and economic development. With its huge and growing population, an 8,000 km long densely populated and low-lying coastline, and an economy that is closely tied to its natural resource base, India is considerably vulnerable to the different natural disasters induced by climate change. It is observed that there will be an increase in the frequency of heavy rainfall events in South and Southeast Asia due to the doubling in CO_2 concentrations in the atmosphere. Lal et al. (1995) present a climate change scenario for the Indian subcontinent, taking projected emissions of greenhouse gases and sulphate aerosols into account. It predicts an increase in annual mean maximum and minimum surface air temperatures of 0.7^0 C and 1.0^0 C over land in the 2040s with respect to the 1980s. Human society will face new risks and pressures. Some regions are likely to experience food shortages and hunger. Water resources will be affected as precipitation and evaporation patterns change around the world. Economic activities, human

settlements, and human health will experience many direct and indirect impacts of climate change.

Impact on Cities

The two most relevant to the subject are the progressive rise in sea level and the increased intensity and frequency of climatic episodes leading to natural disasters. Both represent a significant threat to urban areas in developing countries. According to several projections, the sea level is expected to increase anywhere from 8 to 88 centimeters during the 21st century, mostly due to thermal expansion and the loss of mass from glaciers and ice caps. The frequency and intensity of natural disasters are also growing rapidly worldwide. A recent analysis of great natural catastrophes since 1960 shows an increase in the 1990s by a factor of three and this seems to be directly correlated with global warming.

The rapid pace of urbanization compounded with an ever-increasing population burden has also significantly increased the overall vulnerability of urban areas to natural disasters. The location of many urban areas with large populations and critical economic assets in high-risk zones contributes to the increased attention given to impacts in urban areas of disasters induced or enhanced by climate change. In the case of cities in developing countries, the size and vulnerability of informal settlements, generally built in unstable areas such as coastal zones, flood-prone planes and ravines, and geologically unstable slopes, greatly increases their vulnerability. The impacts of a rising sea level and more frequent and intense natural disasters in rural areas will likely generate an additional influx of people to cities. Such "environmental refugees" often become permanent, thus increasing the vulnerability of cities yet again. Developing countries are considered to be particularly vulnerable to climate change as many are in tropical and sub-tropical zones with economies and societies highly dependent upon the climate and heavily impacted by its variations. Many of the largest cities in Africa, Asia and Latin America are port cities, historically linked to a colonial past, and directly subjected to the impacts of a rising sea-level. The high cost of land in a central city and around ports has often encouraged major commercial developments on land reclaimed from sea and river estuaries that are especially vulnerable to a rise in sea level.

Impact on Agriculture

The magnitude of projected changes in temperature, rainfall and carbon dioxide in future of different parts of the world, including India has been compiled by IPCC (Watson et. al., 1998). According to this report, by 2010 CO_2 level will increase to 397-416 ppm from the existing level of 368 ppm in

the year of 2000. This will further increase to 605-755 ppm by 2070. There is considerable uncertainty in the projected magnitude of change in rainfall and temperature for India (Table-1). The increase in temperature is less in Kharif than in Rabi crops. The Rabi rainfall will, however, have larger uncertainty. Kharif rainfall is likely to increase by as much as 10 per cent.

TABLE: THE EXPECTED MAGNITUDE OF CHANGE IN CLIMATIC FACTORS IN SOUTH ASIA BY 2010 AND 2070 AD DUE TO GLOBAL WARMING

Climatic factors	*Rabi*		*Kharif*	
	2010	*2070*	*2010*	*2070*
Temperature increase ^{o}C	0.3 to 0.7	1.1 to 4.5	0.1 to 0.3	0.4 to 2.0
CO_2	397 to 416	605 to 755	397 to 416	605 to 755
Rainfall change in southwest monsoon region per cent	0 -10 to 10	0	0 to +10	

SOURCE: Inter-Governmental Panel on Climate Change (IPCC) of United Nations Report (Watson et. al., 1998)

Such global climatic changes will affect agriculture through their direct and indirect effects on Kharif and Rabi crops, soils, livestock and pests. Increase in atmospheric carbon dioxide has a fertilization effect on crops resulted into their growth and productivity. Increase in temperature can reduce crop duration; increase crop respiration rates alter photosynthate, affect the survival and distributions of pest populations thus developing new equilibrium between crops and pests. This equilibrium decreases fertilizer use efficiencies and increase evapotranspiration. Indirectly, there may be considerable effects on land use due to snowmelt, irrigation, frequency and intensity of inter and intra seasonal droughts and floods, soil organic matter transformations, soil erosion decline in arable areas due to submergence of coastal lands, and availability of energy. All these can have tremendous impact on agricultural production and hence food security of any region. Equally important determinants of food supply are socio-economic environment including government policies, capital availability, prices and returns, infrastructure, land reforms, and inter and intra-national trade that might be affected by climate change.

Impact on Forest Ecosystems

The response of forests to climatic changes is complex and is uncertain and involves dynamic interactions between various plant species in an ecosystem. There are risks involved in scaling up the short-term transient responses of individual plant species or trees to long response of entire forest ecosystems.

The impact of climate change on biodiversity of tropical forests is quite speculative. Plants are stressed and become vulnerable to pest attacks under increased temperature and low soil water availability. This diversity of tropical forests however, provides some protection against widespread attack of pests and diseases. The intensity and frequency of forest fires in tropical forests is of serious concern under climate change situations. Dry weather would upset the water balance and lead to increased frequency of fires as reported in boreal forests by Acharya (1995). Thus increased temperature, lower humidity and reduced precipitation increase the risk of forest fires, which ultimately lead to lower plant diversity

Due to the impact of increased temperature and precipitation change on soil composition, the terrestrial ecosystems appear to be storing increasing amounts of carbon, largely attributed to increasing plant productivity due to elevated CO_2 concentration, increased temperature and soil moisture changes. The soil carbon pools change as a result of changes in carbon inputs and losses. There is also change in soil nitrogen content.

The productivity increases with increase in ambient temperature, given sufficient availability of moisture and nutrients. However, the process of photosynthesis responds differently to increased temperatures i.e. it initially increases and then slows down. While respiration is slow initially but then increases. This increase continues till an equilibrium is reached between photosynthesis and respiration and there is no net carbon assimilation. There is consensus that any positive influence of increased CO_2 concentration on productivity will be small and negligible.

Impact on Water Resources

The climatic changes likely affect water supply, quality and demand and may have ramifications for decision makers. Water demand generally increases with time as population and per capita consumption increases. Water availability on the other hand has been considered relatively constant. Climate change may either increase or decrease water availability through precipitation, temperature, cloud ness and humidity, increasing the level of uncertainty, which can result in increased recurrence of hydrologic hazards such as floods and droughts. A number of studies have evaluated the relationship between stream flows and the occurrence of El Nino and La Nina (Piechota & Dracup, 1996 and Chiew et. al., 1998).

In India, the major river systems of the Indian sub-continent namely Brahmaputra, Ganga and Indus which originate in the Himalayas are expected to be more vulnerable to climate change because of substantial contribution from snow and glaciers into these river systems (Singh and Naresh Kumar, 1997). Studies have shown that increase in the temperature

by 1.5°C will increase the risk of some floods in the Ganga and Brahmaputra plains (Siedel et. al., 2000). A warmer climate would cause a reduction in water availability excepting the flows in summer. It was also concluded that impact of warmer climate on water availability would be felt more in basins with seasonal than in basins covered with permanent snow and glaciers (Ramasastri, 2003). Mehrotra (2000), while using disaggregated General Circulation Model (GCM) and a conceptual rainfall runoff model for the Damanganga (Gujarat), Sher and Kolar sub basins in Narmada basin and Hemavati in Cavery basin, studied that monsoon and annual runoff is expected to decrease due to the projected climate changes in Damanganga and to increase in Sher and Kolar sub basins. Further it was noted that basins located in the sub-humid and semi arid and arid regions are more sensitive to climate changes than those in humid regions of the country as reported by Dooge (1989).

Impact on Vulnerability

As climate change is coupled with other global changes, vulnerability needs to be evaluated against a background of dynamic flux of both anthropogenic and biophysical factors. Vulnerability of mountain ecosystems assumes more importance when one realises that impacts of global change in mountains will have profound effects not only on hill people but also those in the adjoining plains (Maikhuri, *et.al.*). Natural disasters or hazards are an important cause for the loss of land in the coastal region of our country. The deltaic regions of West Bengal, Orissa and Andhra Pradesh are especially vulnerable to cyclones and the storm surges associated with them. Global warming is expected to result in the global sea level rise affecting various marine habitats in the low-lying areas.

In coastal areas, the mangrove forest ecosystems are more vulnerable to the climatic changes, as directly influenced by tides. Due to sea level rise the undertidal and supralittoral zones are likely to be extended farther inland causing destruction of existing mangroves and associated biota. Climate changes coupled with anthropogenic pressures and poor management practices may reduce productivity and loss of mangrove dependent biodiversity, adversely impacting ecological and socio-economic benefits. The mangroves being more vulnerable are constantly under threat from increasing anthropogenic pressures such as indiscriminate cutting, reclamation mainly for agriculture and urbanization, fuel and construction and overgrazing by domestic cattle as well as from sea level rise due to global warming (Ellison and Stoddart, 1991). In the country, ~ 30 per cent of the mangrove area has been reclaimed for different anthropogenic activities during the period of 1975-90 (Jagtap *et al.*, 1993). Recently, Rao

et. al., 1999 studied that the maximum damage to mangrove forests is caused by habitat loss, human interference and trade. By using time series data on a set of forestry parameters, the vulnerability of mangrove forests to the changing climate can be assessed. Unfortunately, such data for the mangroves of India do not exist. Considering the projection of climate change resulting in sea level rise, and vulnerability and adaptability of mangrove forests to these changes of climate, it is necessary to develop a national level programme to collect required data for Indian mangroves.

There is a direct impact of climate change reported on the vulnerability of rice crop yield in North West India. It is because, the changed climate along with doubling of CO_2 seems to have enhanced the yield potential of rice, while the irrigated rice yield seems to have decreased as compared to present climate, leading to more yield gap between achievable rice yield and potential rice crop yield in 2050's climate as compared to gap under existing climate. Reduction in irrigated rice crop yield ranges from about 12 per cent at Saharanpur (Uttar Pradesh) to 25 per cent at Hissar of Haryana (Gosain & Tripathi, 2002). The variability in the irrigated rice crop yield increases by the factors of 1.3 to 1.6 in 2050's anomaly climate as compared to present climate at various locations in India. This enhancement in year-to-year variability in rice crop yield raises concern about food security in India.

CLIMATE INDUCED NATURAL DISASTERS

Climate induced natural disasters (CINDs) like drought, flood and cyclone become serious problems to coastal areas. CINDs are of regular occurrence particularly in coastal areas of Orissa and have become the part of normal life. The 1999 tropical cyclone that hit Orissa resulted in a death toll of about 10,000, and demonstrates the extreme significance of coastal vulnerability related to climate variability. A study of Jawaharlal Nehru University (JNU), 1993 reveals that in the absence of protection, a one-meter sea level rise on the Indian coastline is likely to affect a total area of 5763 km^2, and put 7.1 million people at risk as well as indicates that the dominant cost is land loss, which accounts for 83% of all damages. The extent of vulnerability, however, depends not only on physical exposure, but also on the level of economic activity in the coastal region.

State/Union Territory	*Costal area (million hectares)*			*Population (million hectares)*		
	Total	*Inundated*	*Percent-age*	*Total*	*Affected*	*Percent-age*
Andhra Pradesh	27.504	0.055	0.19	66.36	0.617	0.93
Goa	0.37	0.016	4.34	1.17	0.085	7.25
Gujarat	19.602	0.181	0.92	41.17	0.441	1.07
Karnataka	19.179	0.029	0.15	44.81	0.25	0.56
Kerala	3.886	0.012	0.3	29.08	0.454	1.56
Maharashtra	30.771	0.041	0.13	78.75	1.376	1.75
Orissa	15.571	0.048	0.31	31..51	0.555	1.76
Tamil Nadu	13.006	0.067	0.52	55.64	1.621	2.91
West Bengal	8.875	0.122	1.38	67.98	1.6	2.35
Union Territory						
Andaman and Nicobar Islands	0.825	0.006	0.72		0	0
India	**139.594**	**0.571**	**0.41**	**416.74**	**7.1**	**1.68**

Note: Costal area and population are based on the 1981 and 1991 census
Source: JNU, 1993

CLIMATE CHANGE INDUCED DISASTERS

Climate change is likely to have a significant impact on the global environment. In general, the faster the climate changes, the greater will be the risk of damage. The mean sea level is expected to cause flooding of low lying areas and other damage. Climatic zones including agricultural zones could shift towards the poles. Forests, deserts, rangelands, and other unmanaged ecosystems would face new climatic stresses. As a result, many will decline or fragment and individual species will become extinct.

According to the IPCC report, the main threats to the urban populations and physical assets of developing cities, affected with more or less intensity based on the actual climate changes, which induced natural disasters, are the following:

- ***A rise in sea level***: This is the most fundamental challenge that urban settlements face from global warming. The threat will likely increase due to the ongoing influx of people and economic assets into coastal zones. At risk are entire sections of coastal cities and their infrastructure, beaches subject to erosion, river floors in estuarine zones subject to sedimentation, and wetlands and tidal flats subject to flooding. Furthermore, groundwater risks increased salinization, and coastal aquifers risk diminishing, affecting fresh water supplies and peri-urban agriculture.
- ***Tropical cyclones***: Increasingly frequent and intense tropical and extra-tropical cyclones will likely cause severe wind damage and storm surges

which, compounded with a rise in sea level, are expected to become a severe problem for low-lying coastal regions and cities. Ports and other coastal infrastructure are especially at risk.

- ***Flooding and landslides***: Expected increases in the scale, intensity and frequency of rainfall in most developing countries will severely strain or overwhelm the storm drainage systems of many urban centers. This could lead to periodic flooding of low-lying areas as well as landslides and mud-slips on geologically unstable slopes, often subject to informal settlements. Cities built next to rivers and on reclaimed lands in riverbed planes will be prone to additional inundations.
- ***Water quality and shortage***: Urban flooding damages water treatment works and flood wells, pit latrines and septic tanks. Sewage treatment systems and solid waste disposal areas can also be affected, contaminating water supplies. Where overall rainfall decreases, droughts will likely compromise the replenishment of the water tables, the normal sources of water supply. Doubling of CO_2 would lead to a global warming 1.5 to 4.5^0 C causing droughts and forest fire. Water resources will be affected as precipitation and evaporation patterns change round the world.
- ***Heat and cold waves***: Intense episodes of thermal variability could severely strain urban systems by adding an environmental health risk for more vulnerable segments of the population, imposing extraordinary consumption of energy for heating and air conditioning where available, and disrupting ordinary urban activities.

Climate models predict that the global temperature will rise by about 13.5^0 C by the year 2100. This phenomenon is known as global warming which may lead to climate change. This projected change is larger than any climate change experienced over the last 10,000 years. It is based on current emissions trends and assumes that no efforts are being made to limit green house gas emissions.

Natural hazards are an important cause for the loss of land in the coastal region of India. The deltaic regions of West Bengal, Orissa and Andhra Pradesh are especially vulnerable to cyclones and the storm surges associated with them. The recent super cyclone of Orissa provides an example of the type of damage that can happen. In particular, the interaction between a cyclone induced changes and the river discharges over the Hoogly estuary needs further research (Das, 2003).

Climate Change Induced Natural Disasters

The natural disasters particularly Floods and Droughts, even if local phenomena, can be related to large scale or global climate mechanisms. Through the study of atmospheric teleconnection mechanisms between

remote areas of the planet, scientists are now increasingly able to link extreme weather events such as droughts and storms with climate variations and climate change. The common perception of remote areas including rural households of the coastal areas is that climate has changed for the worse with increased frequency as well as intensity of CIND events in recent years. Although the warning system was also developed and found to be timely and largely accurate, the rainfall forecasting in drought years were misleading. Further, the cyclone warning was ignored by the rural households, which resulted in higher causality than expected (Roy *et al.*, 2002).

INCREASING FLOOD FREQUENCIES

There is evidence from climate models and hydrological impact studies that flood frequencies are likely to increase with global warming, which may produce changes in the frequency of intense rainfall (IPCC, 1995). In temperate regions, more floods are caused by changes in the magnitudes of snowmelt and rain on snow. Impacts of climate change are expected to be greater on Tundra lands and alpine regions. Deglaciation on temperate mountains would increase sediment loads in alpine rivers and accelerated sedimentation in lakes and artificial reservoirs. Lakes dammed by landslides, moraines and glaciers may drain suddenly and produce floods or debris flows of an order of magnitude larger than normal stream flow. Loukas (2003) examined the effect of the increased storm intensity due to climate change on the frequency and magnitude of floods in the region of coastal British Columbia. The results showed that annual maximum daily rainfall and its variation would increase for the three climate change scenarios affecting the frequency and magnitude of floods.

The records of recent flooding and paleoflooding indicate the high sensitivity of flood occurrence to changing climate for river basins in the USA and Europe. Analyses also indicate that there is no simple proportionality between the scale and frequency of floods and climate variations. However, in general, increases in precipitation lead to proportionally larger increases in runoff. The recent floods cannot also be taken as a proof of climate change as the associated rainfall events still fit in the natural variability of our climate, and floods of comparable magnitude have been observed earlier this century. Some research studies like government research (England) observed that global warming does not necessarily cause all devastating floods.

Less snow and glacier ice will influence the seasonality of river flow by reducing melt water production in the warm season. The expected smoothing of the annual runoff amplitude could be both beneficial e.g. energy production in winter, reduction of summer flood peaks and adverse e.g.

reduced water supply for summer irrigation in dry areas, more frequent winter floods. The general tendency in high mountains will be an increased vulnerability of people, transport routes, and economic infrastructures.

As climatic warming occurs, there will be notable changes in the hydrology of Arctic areas. River ice regime might be altered and substantial effects on the hydrology can be expected that will affect flow, water levels and storage. For cold continental rivers, many hydrologic extremes, such as low flows and floods, are frequently more a function of ice effects than landscape runoff. Projected climates will delay the timing of freeze up and so prolong the autumn low flow period. At break up, the rapid hydraulic storage and release of water by river ice jams often forms the most significant hydrologic event of the year. Of all river ice processes ice jams are the major source of economic damages. Changes in damages from such events depend on how climate change affects the frequency and severity of river ice freeze up and break up events.

Drought has generally received little attention, but it is reasonable to think that an increase in the occurrence and severity of droughts in order to compensate the first extreme and to re-establish the natural energy and water balance.

A deadly cocktail of floods, cyclones and droughts has made Orissa the capital of disasters in India. On the last 100 years, the state has been disaster affected for 90 years; floods have occurred for 49 years, droughts for 30 and cyclones have hit the state for 11 years. Since 1965, calamities are not only becoming more frequent but striking areas that never had a vulnerability record (Down to Earth, 2001). The sources for high volatility in agriculture growth in Orissa are three fold. Low irrigation coverage, an erratic climate and a very high degree of dependence on rice, which occupies 93.5 per cent of the food grains area. Climatic variability in Orissa during the last three decades has shown deviations in rainfall of 20 per cent or more every third year.

It appears that progress in climatology and in the development of numerical models not only enables scientists to relate extreme weather events such as floods and droughts, with climate variations, but they can give some insight to climate change scenarios due to global warming such as sea level rise and changes in frequency, strength and geographical distribution of extreme events. These results should be of great help in taking the right measures and in building up the adapted policies.

MITIGATION POLICIES ON CLIMATE CHANGE AT GLOBAL LEVEL

Keeping in view the impact of climate change, natural disaster

prevention and mitigation have an even greater importance. It is now possible to build up policies based on climate studies results, in order to get ready for the expected impacts of climate change. Until now, States and societies have learned from the past and may be more or less prepared to face certain events, which are recurrent. But up to date measures and policies will no longer be sufficient if the intensity of extreme events increases and if their geographical distribution changes. The uncertainty brought on by climate change will have to be taken into account in risk management.

There are many uncertainties about the scale and impacts of climate change, particularly at the regional level. Because of the delaying effect of the oceans, surface temperatures do not respond immediately to greenhouse gas emissions, so climate change will continue for many decades after atmospheric concentrations have stabilised. Meanwhile, the balance of the evidence suggests a discernible human influence on the global climate. Climate change is likely to have a significant impact on the global environment.

However, in 1988, the United Nations Environment Programme (UNEP) and the World Meteorological Organisation (WMO) established the Inter governmental Panel on Climate change (IPCC), consisting of more than 300 of the world's leading experts, to investigate climate change. The IPCC concluded, both 1990 and in 1992, that a doubling of greenhouse gases in the atmosphere will lead to "serious consequences for the world's social, economic and natural systems". Among other things, the IPCC concluded that emissions of greenhouse gases from human activities contribute to the natural greenhouse effect and will lead to an additional warming of the atmosphere. The IPCC estimated that a doubling of CO_2 would lead to a global warming of 1.5 to 4.5 ^{0}C.

It has been discovered that the protective ozone layer is getting progressively eroded due to the impact of increasing human activities (UNEP, 1987). The major cause for the depletion of the ozone layer is the world wide emission of man-made compounds called Chlorofloro carbons (CFCs) used in refrigeration, aerosol spray and in many other items of daily use. CFCs are by and large chemically inert, having no direct effect on humans or other living organisms. CFCs escaped into the atmosphere ultimately find their way into the stratosphere where they break down ozone molecules involving complex chemical reactions. Stratospheric ozone is important for the biosphere because it absorbs much of the UV radiation, which is harmful to animals and plants. As increased amounts of UV radiation reach the earth's surface, human population may be directly affected by increase in skin cancer, eye disorder and suppression of immune system in humans and other living organisms. One per cent decline in ozone results in an

estimated three per cent increases in the potential incidence of skin cancer. In addition, yield of some crops may decline, and irreversible changes may occur in marine and other ecosystems, which are exceedingly difficult to predict today.

According to UN report, the hole in the ozone layer over Antarctica may close within 50 years as the level of destructive ozone-depleting CFCs in the atmosphere is declining from a peak of 2.15 parts per million (ppm) in 2000 to 1.15 ppm in 2001. Under the 1987 Montreal Protocol, the developing countries committed themselves to halving consumption and production of CFCs by 2005 and to achieving an 85 per cent cut by 2007. The four yearly UN report reviewing the ozone layer since the Montreal Protocol, said the reduction in CFCs proved the protocol was working. A hole of 10 million Sq. mile in size was reported over Antarctica. The present studies indicate that there is no increase in the size of the hole as it is stopped with the global efforts.

Acid rain has emerged as a great scourge of the industrial countries. The term "Acid Rain' is used to describe all forms of precipitation, rain, snow, sleet, dew which is more acidic than normal. In the last few decades the rainwater has become acidic over large areas in Europe and America. Environmental acidification is a man-made disaster. Emission of sulphur dioxide and oxides of nitrogen are prime contributors to the environmental acidification as they readily dissolve in the atmospheric moisture, forming sulphuric and nitric acids, which make the rain acidic. A vast expansion of thermal power generation and other industrial activities contribute to environmental acidification. However, there is no case of Acid Rain reported in any part of India so far.

INDIAN MITIGATION POLICY ON CLIMATE CHANGE

Climate Change is having an impact on India as well. These changes may include decrease in crop productivity, water availability, increase in vector borne diseases, extreme weather events like floods, cyclones and droughts and changes in perception patterns. In order to advance the preparedness of the country to deal with climate change, at present, the following activities are being undertaken:

- Capacity building at appropriate levels for taking Climate Change considerations in Social, Economic and Developmental Planning
- Impact assessment including impacts on Food and Water Resources, Eco-system and Bio-diversity, Human Settlements and Human Health
- Promotion of Scientific and Technological Research and Systematic Observation with a view to furthering understanding of Climate Change

- Education, Training and Public Awareness
- Enhancement of International Cooperation in pursuance of the objectives of the United Nations Framework Convention on Climate Change (UNFCCC)

India figures among the top ten contributors to greenhouse gas emissions. However, current per capita gross emissions in India are only one-sixth of the world's average. India is highly vulnerable to climate change as its economy is heavily reliant on climate-sensitive sectors like agriculture and forestry and its low-lying densely populated coastline is threatened by a potential rise in sea level. The Clean Development Mechanism (CDM), which was created in 1977 under Kyoto Protocol to the UNFCCC, is important for India as it allows developed countries to use Certified Emissions Reduction (CER) credits from project activities in developing countries, and also assists developing countries in achieving their Sustainable Development objectives.

The Eighth Conference of the Parties (COP-8) of the UNFCCC organized in New Delhi (23rd October- 1st November, 2002) will tremendously help in raising the awareness level in the country regarding Climate Change and would demonstrate to the world the impressive strides made in India in various sectors in conformity with Sustainable Development. The conference would also provide an opportunity to project what India can offer to the world, particularly the Developing Countries by way of its Environmental Management Technology (EMT) in various sectors like Industry, Transport, Power, Renewable energy, Agriculture and Forestry. This conference would become quite important, as the chances of the ratification of Kyoto Protocol have brightened as a consequence of agreements arrived at Bonn and Marrakesh and expected to take a number of major decisions relating to implementation of the Kyoto protocol.

India ratified the Kyoto Protocol in 2002. Being a developing country it was not required to cut emissions, but it has developed certain mechanisms to reduce emissions. The primary legislation in India is as follows:

- National Hydro policy, 1998 – Outlined strategies for hydro power potential.
- Energy Conservation Act, 2001 – Established Bureau of Energy Efficiency

A National Bio diesel Policy is also being considered to encourage use of Bio diesel.

There are other voluntary provisions which tend to reduce carbon emissions through reduction of energy use in buildings. Some of these are:

- TERI- GRIHA- Green Rating for Integrated Habitat Assessment is a rating system for rating of green buildings.
- LEEDS system-Leadership in Energy and Environmental Design encourages

and accelerates adoption of sustainable green building standards.

Clean Development Technologies

An attempt is being made all over the world to adopt technologies which would help to reduce energy needs and are non- polluting. The focus, at present, is on the following technologies:

- Wind energy.
- Solar power.
- Bio diesel
- Hydro power

India also established CDM-India board in 2003 and a large number of CDM projects have been set up in India.

STABILIZING MEASURES OF GLOBAL CLIMATE CHANGE BY MANAGING NATURAL RESOURCES/ ECOSYSTEMS

Generally, global climate change is due to over-use of fossil fuels and wrong exploitation of natural resources. The process, however, containable if vigorous action is taken right away. Environmental Scientists proposed the following ten steps to control the global climate change:

- Increasing natural photosynthesis
- Starting engineered photosynthesis
- Augmenting $CaCO_3$ sedimentation
- Managing wetlands
- Sequestering water
- Reclaiming deserts
- Limiting animal husbandry
- Burning hydrogenated fuels
- Developing renewable energies and
- Creating an evolutionary population plan
- Checking deforestation in the short term, enhancing agro forestry and plantations in the medium term and use of advanced technology for efficient forest management in the long term for arresting GHG emissions.
- Enhancing the incremental changes in the community participation for arresting climate changes by effective management of land.
- Use of GIS technology for mapping agro-ecological zones, vulnerable zones, rain fed irrigated/ zones, soil- degradation zones, etc. at district levels.

- Specific case studies on Impacts of climate change on ecosystems and water resources in the country should be conducted at micro-level where human dimensions can be incorporated.

Tropical countries can avoid the excessive CO_2 emissions and may adopt the remedial measures, which are needed anyhow to improve the biosphere, that is, those favourable to its long-term stability and vigour. India is a Party to the United Nations Framework Convention on Climate Change (UNFCCC). The objective of the Convention is to achieve stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. In 1997, Parties to the Convention adopted the Kyoto Protocol in recognition of necessity for strengthening developed country commitments under the Convention in furtherance to the objectives of the Convention. The Kyoto Protocol commits the developed countries, including economics in transition to reduce emissions of greenhouse gases by an average of 5.2 per cent below 1990 levels during 2008-2012.

Some immediate steps to take i.e. all CFCs must be phased out and all substitutes should be given rigorous scientific scrutiny for possible contribution to the greenhouse drift as well as to ozone destruction. Coal and petroleum can be replaced by natural gas, and hydrogen can be added to natural gas. India being a Party to the Montreal Protocol has taken actions to freeze the production and consumption of CFCs on July 1, 1999 and Halon on January 1, 2002. In this context, there is a big success in reducing the production & use of CFCs as an alternate of CFCs is available in the country and thus, Fridges and ACs is being manufactured as CFC free.

Subsidizing the petroleum and nuclear energy enterprises should stop; instead eolian, hydrogen and solar energies should be developed. These energies have been disadvantaged so far through lack of research and developing funding. Forest destruction must be halted and reforestation started. Mangroves, reef corals and deep-sea corals should be surveyed for extent, productivity, and state of health and possibilities for improvement.

The Earth is overpopulated in the sense that renewable resource cannot underwrite present human numbers and life-styles. We have overshot with technological development so that the resources of other peoples and future generations can only maintain the industrialized part of the world. Therefore, we need to research technological solutions for possible use to avert a massive population crash within the next century. The biosphere is sick and requires geotherapeutic measures in order to survive.

ROLE OF DIFFERENT SECTORS IN MITIGATORY MEASURES OF CLIMATE CHANGE

Awareness of the potential benefits of climate mitigation is still limited to specialized circles and has not yet been seriously communicated to all sectors of society, in the particular policy makers and the general public at global level. This is due to a lack of attention for the issue, insufficient commitment and resources for promotional activities at all levels. Simultaneously, education and training programmes and facilities for people professionally involved and the public at large have not been sufficiently developed with a focus on ways and means to reduce the climate change.

High Powered Committee (HPC) adopted a strong process oriented and participatory approach involving different sectors of the society like NGOs, Media, Police & Security Forces, Communications and Governments including Administrative Training Institutes (ATIs) at all levels, etc. as against an academic and technical approach (HPC Report, 2001).

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Undoubtedly, **NGOs** along with Governmental Organizations may play a major role in reaching out to the masses for mitigatory measures of climate change by organizing the awareness & educational programmes at community level. Similarly, the Central Government especially National Institute of Disaster Management (NIDM), Ministry of Home Affairs & all ATIs of State Governments through their Natural Disaster Management (NDM) faculties may start the training programmes on climate change by incorporating the contribution of different research centres working in the country and abroad. They may also conduct the training programmes on environmental Laws for the officers of Central Pollution Control Board

(CPCB), State Pollution Control Board (SPCB) and Public Prosecutors of States and UTs as they may be helpful in exploring the knowledge of various Acts of Environmental Protection, Water and Air Pollutions, Wild Life, Fisheries & Forests, etc. among the people and force them to follow these Acts strictly.

The role of the **Electronic Media** has during recent times emerged as a major component in the field of global climate change. Infact this sector needs to be integrated with the community's awareness generation towards climate change. At the same time, the role of the **Print Media** cannot be taken on a lower level of importance because it continues to be the medium of mass media in many parts of the Indian society still un-reached by the electronic media. Simultaneously, the other sectors including Police and Security Forces, etc. which are directly related to the community, may play a major role in the mitigatory efforts of climate change.

The **Educational Bodies** apart from School to University level have been implementing educational and awareness programmes on environment including climate change. At University level, various research laboratories are carrying out researches on different aspects of climate change and networking with the reputed research organizations located in the country & abroad. Many Universities have included the environmental law as a separate paper under the subject of Environmental Science for their PG students. In fact such activities are being proved very useful in creating the awareness not only among the students but also at community level.

> Adaptation is needed to reduce the effects of climate change, particularly for poor communities who are going to be the hardest hit. Communities need to be made aware of the risks they are facing due to climate change in order to help them to adapt. However, the best implemented measures will not be able to restore income levels, living conditions, healthcare and water availability to what they would have been without climate change. Sustainable agriculture, water management, disaster risk reduction and renewable energy are some of the areas which need concrete action and mainstreaming at community level.

Climate Change Adaptation

Various NGOs are working to help communities adapt to the modified climatic conditions. One admirable effort in this direction is by a NGO, DSCRC, which has introduced an innovative rainwater harvesting system in Purulia district of West Bengal. This system has helped farmers in the area cultivate an additional winter crop. Another effort to address a different aspect of the problem has been made by SEEDS India which constructed 300 houses for the villagers after the Floods in Barmer, Rajasthan. The traditional design of the houses was retained with the difference that the new houses were made out of mud stabilized with five per cent cement and

had proper foundations and structural members. Services of local masons were utilized to train them in the new construction techniques.

In addition to above, NGOs have also been working with communities on other aspects such as use of renewable energy to reduce energy and crop diversification but the important issue is that climate change adaptation calls for a change in traditional lifestyles of individuals or communities. The reality of climate change is before us. The choice is between adaptation and annihilation.

UN CLIMATE CHANGE PANEL CHAIR PACHAURI: "WE SWIM OR SINK TOGETHER"

ENVIRONMENT - **27-03-2008 - 10:31**

PACHAURI: "NO PART OF THE GLOBE CAN BE IMMUNE"

"We sink or swim together" - that was the message the UN's chief scientist on climate change brought to MEPs on Wednesday 25 March. India's Rajendra K. Pachauri is Chair of the Intergovernmental Panel on Climate Change (IPCC) convened by the United Nations to forge a scientific consensus on global warming. We spoke to Dr. Pachauri before his visit to Parliament's temporary committee on climate change where he delivered a speech on climate change and global security.

Together with former US vice president Al Gore the panel was awarded the Nobel Peace Prize last December for their efforts to raise awareness of climate change.

Dr. Pachauri said that Climate change is likely to result in problems with the availability of water across the globe. This is a result of changes in precipitation patterns and in melting of the glaciers in different parts of the world, and the demand for water is increasing. You could have several regions in the world with a conflict over natural resources like water.

Another threat could result from extreme events like floods, droughts and heat waves which we have projected will increase in frequency and in intensity. Also a large movement of population could impact on agriculture. Those regions of the world that don't produce enough food to meet their own needs, may have no choice but to move to other locations, and when that happens in large numbers, that clearly has the seeds of conflict in it.

For a variety of reasons: in some parts of the world the stable supply of water into river systems comes from these glaciers, South Asia is one example, some parts of China another. So this could affect the very availability of water in these regions. The other problem with the melting of these ice bodies across the globe would be sea level rise.

It is already taking place to some extent as a result of thermal expansion of the oceans with higher temperatures. But if the huge bodies of ice of western Antarctica and Greenland ice sheets, sitting on land, were to collapse, that would really mean several meters increase in sea level. It's very difficult to say if and when this will happen but the possibility certainly exists.

Firstly we have to accept that there is certain inertia; even if we were to stabilize the concentration of greenhouse gases in the atmosphere at current levels, climate change would continue for several decades. Therefore in a sense we're not going to

be able to stop global change, but to arrest its growth in the future. This makes it absolutely critical that we start reducing the emission of greenhouse gases by which the atmosphere and the climate of the earth can be stabilized.

Technology can certainly provide solutions to reduce emissions, but it comes into play only if we have the right set of policies. We need policies to promote the development of new technologies or the employment of the existing ones. We (the IPCC) have clearly stated in our report that the technology needed are already available or on the verge of being commercialised. These technologies will only be used if we have the right set of policies.

Suppose if governments would impose a tax on petroleum products; this would give the incentive to automobile companies to produce more efficient cars, also people could make more use of public transport. Pricing is an extremely important instrument to create change.

India: Climate Action Plan

Indian Prime Minister, Dr. Man Mohan Singh has released national climate action plan on 30 June 2008, which was eight missions, the emphasis on solar energy is bound to generate the most excitement as this sector has been lagging behind other segments of renewable power sources. The eight missions are:

1. National Solar Mission
2. National Mission for Enhanced Energy Efficiency
3. National Mission on Sustainable Habitat
4. National Water Mission
5. National Mission for Sustaining the Himalayan Ecosystem
6. National Mission for Green India
7. National Mission for Sustainable Agriculture
8. National Mission on Strategic Knowledge for Climate Change

Significant feature of National Action Plan:

1. India will not budge from its position in the International commitment for climate change. The plan is only a domestic document.
2. The national plan is to promote development objectives while addressing climate change effectively.
3. Push to solar energy sector along with other sources of renewable sources of energy (1,000 MW solar power by 12th Plan).
4. Fiscal incentives to move industry, manufacturers and consumers towards a low carbon path (10,000 MW saving by 2021).
5. Tax benefits to industries using clean/energy efficient technologies.
6. To cut down CO2 emissions from thermal power plants, by the end of 12th Plan.

7. To implement Energy Conservation Act, 2001 by domestic trading energy credits (energy saving certificates).
8. Plan is silent on adaptation of agriculture to climate change, water management and inter-ministerial coordination.
9. Coal thermal power plants to be closed (5000 MW Coal thermal plants will shut by 11th Plan. Additional 10,000 MW by 12th Plan).

(Times of India 1 July 2008)

In the G-8 Summit (July 2008) in Japan, which is also attended by Indian Prime Minister, Dr. Man Mohan Singh, world leaders have agreed to set a global target of cutting carbons emissions by at least 50 per cent by 2050 in an effort to tackle global warming.

CONCLUSION

The global heating process is already engaged and we cannot stop it in the near future. Indeed, thermal inertia is protecting us now by retarding the effects of trace gas build-up, but this same inertia will insure continued perturbations for centuries, even after correction becomes efficient. What is most important now is synthesis, the overall appreciation of the problem of global climate change and possibilities for correction, bearing in mind regional constraints and desirable changes. This should be the concern of the nascent international community of person interested in the survival and well being of the biosphere. Undoubtedly, the CDM created under Kyoto Protocol (1977) to the UNFCCC, is important for India as it allows developed countries to not only use CER credits from project activities in developing countries but also assists developing countries in achieving their sustainable development objectives.

The Eighth session of the Conference of Parties (COP-8) to the UN convention on Climate Change (October 23 to November 01,2002), New Delhi, ended here with a Delhi Declaration which failed to break new ground to stabilize the world's climate but firmly projected the view of the developing countries. However, this meet successfully resolved the technical parameters necessary for the Implementation of the Kyoto Protocol (1997) on Green House Gases reductions. The Delhi Declaration gave primacy for the implementation of the clean development mechanism in the climate change process. Hence, developing countries refused to take on any commitments for reductions in GHG emissions.

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If not this planet ……...….Where?
If not now ……..…...When?
If not you ……...……...….Who?

Amitabh Bhachhan
(Film Actor)

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