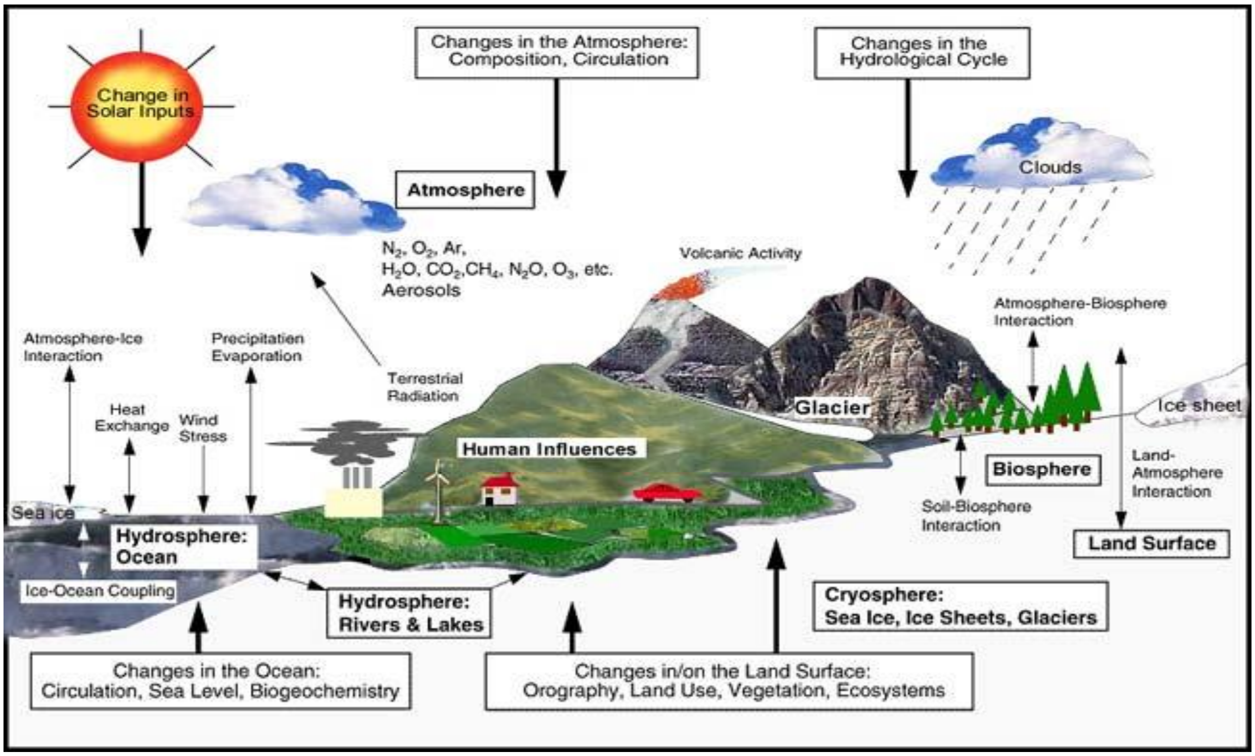
Climate Change

Introduction

About climate change

According to the Intergovernmental Panel on Climate Change[1], "climate change refers to a change in the state of the climate that can be identified by changes that persists for an extended period, usually decades or longer. It refers to any change in climate over time, whether due to natural variability or as a result of human activity." The UN Development Programme (UNDP) considers climate change to be the greatest global challenge of this century, as increased exposure to droughts, floods and storms is already limiting opportunities and reinforcing inequality. Climate change is a natural process, but it is the



Schematic view of elements of climate change

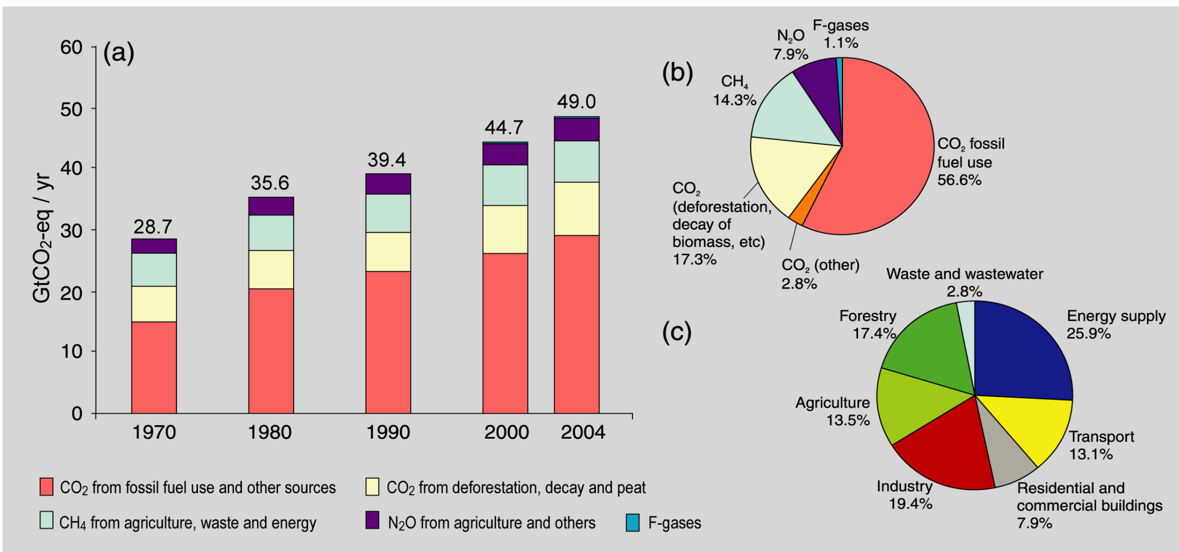
recent rapid changes induced by human activity that have made the issue important. So far, climate change has mainly been caused by emissions from the developed countries. At the same time, it is the developing countries that have felt the consequences of climate change

[1] The Intergovernmental Panel on Climate Change (IPCC) was formed in 1988 by the two united UN Environmental Programme (UNEP) and World Meteorological Organization (WMO) to provide objective information about climate change to the public and to policy-makers. IPCC is made up of scientists and experts from all over the world and promotes the UN goals of human development.

the hardest. A schematic view of the components of the global climate system[2] is given in the table above.

Causes of climate change

According to IPCC[3], global Green House Gas (GHG) emissions due to human activities have grown since pre-industrial times, with an increase of 70 % between 1970 and 2004. Carbon dioxide (CO_2) is the most important anthropogenic[4] GHG. Its annual emissions grew by about 80% between 1970 and 2004. Global atmospheric concentrations of CO_2, methane (CH_4) and nitrous oxide (N_2O) have increased markedly as a result of human activities since 1750 and now far exceed pre-industrial values determined from ice cores spanning many thousands of years. Atmospheric concentrations of CO_2 (379ppm) and CH_4 (1774ppb) in 2005 exceed by far the natural range over the last 650,000 years.



Global GHG emission trends

Global increases in CO_2 concentrations are due primarily to fossil fuel use, with land-use change providing another significant but smaller contribution. The largest growth in GHG emissions between 1970 and 2004 has come from energy supply, transport and industry, while residential and commercial buildings, forestry (including deforestation) and agriculture sectors have been growing at a lower rate. It is very likely that the observed increase in CH_4 concentration is predominantly due to agriculture and fossil fuel use. CH_4 growth rates have declined since the early 1990s, consistent with total emissions (sum of anthropogenic and natural sources) being nearly constant during this period. The increase

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[2] As given by IPCC in 2001
[3] Intergovernmental Panel on Climate Change
[4] Anthropogenic effects, processes or materials are those that are derived from human activities, as opposed to those occurring in biophysical environments without human influence. The term is often used in the context of environmental externalities in the form of chemical or biological wastes that are produced as by-products of otherwise purposeful human activities.

in N_2O concentration is primarily due to agriculture. There is very high confidence that the net effect of human activities since 1750 has been one of warming.

Most of the observed increase in global average temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic GHG concentrations. It is likely that there has been significant anthropogenic warming over the past 50 years averaged over each continent except Antarctica.

Evidence of climate change

The IPCC's fourth report states that the warming of the climate system is unequivocal. This is evident from observations that show:

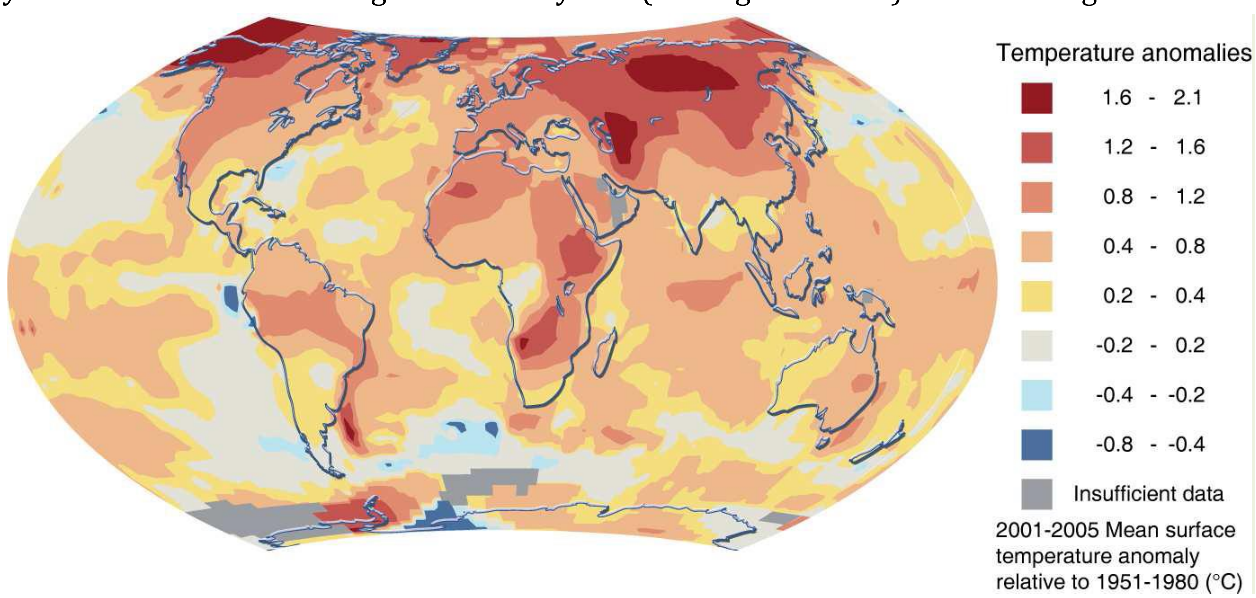
a) An increase in average air and ocean temperatures

b) An increase in the average global sea level and melting of ice and snow

c) Changes in weather, such as wind patterns, the amount and type of precipitation, and frequency of severe weather events

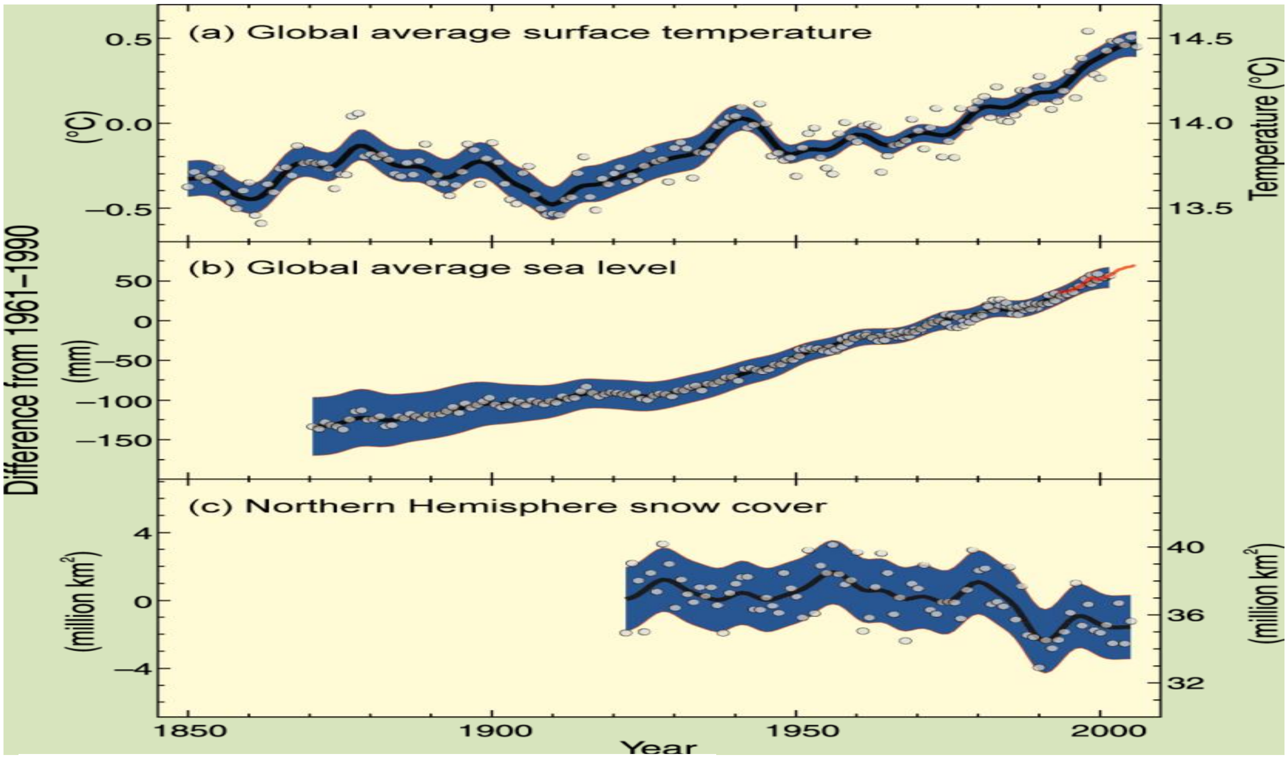
a) Temperature rise in air and oceans

During the period from 1906 to 2005, the global mean temperature increased by 0.74°C. Especially in recent years, the mean temperature has increased substantially since the reading of global temperatures started around 1850, and 20 of the 21 warmest registered years have occurred during the last 25 years (see Figure below). The rise in global mean



temperature during the last 50 years has been twice as great as during the last 100 years. The IPCC states that the temperature increase is widespread across the globe, but higher in the northern latitudes, as Figure below illustrates. It is expected that inland regions will generally warm faster than oceans and coastal zones. The main rise in ocean temperature is in surface water, but new scientific findings show that the average temperature of the global ocean has increased down to depths of at least 3,000 meters.

Climate models predict a global warming of about 1.4 to 5.8°C between 1990 and 2100 without any climate change policies being implemented to achieve emission reductions. These projections are based on a wide range of assumptions about the main forces driving future emissions, such as population growth and technological change. Even a 1.4°C rise



Changes in temperature, sea level and snow cover

would be greater than in any century time-scale trend for the past 10,000 years. When it comes to regional and seasonal warming, predictions become much more uncertain. Most areas are expected to warm, but some will warm much more than others. The cold northern regions are expected to experience the greatest warming during winter. The reason is that snow and ice reflect sunlight. Less snow means more heat is absorbed from the sun, which increases warming. This results in a strong positive feedback effect. By the year 2100, winter temperatures in northern Canada, Greenland and northern Asia are predicted to rise by 40% more than the global average.

b) Sea level rise and glacier melting

As the upper layers of the oceans warm, water expands and the sea level rises. The increased temperatures also cause glaciers to melt and thereby result in a rise in the sea level. The IPCC reports that the mean sea level has risen by nearly 20 centimeters during the 20th century. Models suggest that warming of 0.6°C would result in the sea level rise to date. The average sea level is predicted to rise by between nine and 88 centimeters by 2100. This would mainly be caused by the thermal expansion of the upper layers of the ocean as they warm, with some contribution from melting glaciers. The uncertainty range is large, and changing ocean currents, local land movement and other factors will cause local variation compared with the global average. In its Fourth Assessment Report, the IPCC states that the contraction of the Greenland ice sheet is predicted to continue to contribute to sea level rise after 2100. If this contraction is sustained for centuries, it may lead to the virtually complete disappearance of the Greenland ice sheet and a resulting contribution of about seven meters to sea level rise. Snow cover has declined by some 10 % since the late 1960s at mid and high latitudes in the Northern Hemisphere. It is also very likely that the annual duration of lake and river ice cover has shortened by about two weeks during the course of the 20th century. Almost all recorded mountain glaciers in non-polar regions have retreated during this period as well. In recent decades, the extent of Arctic sea ice in the spring and summer has decreased and the Arctic sea ice has thinned.

c) Changes in weather

Many regions of the world are experiencing increasing amounts of precipitation. However, there are large regional differences. For example, an increase of 0.5 – 1 percent per decade has been measured in most mid and high-latitude areas in the Northern Hemisphere, accompanied by a two per cent increase in cloud cover. Precipitation over tropical land areas seems to have increased by 0.2 to 0.3 % per decade, while a decline in precipitation of about 0.3 per cent per decade has been observed in sub-tropical land areas (10 to 30°N) in the Northern Hemisphere during the 20th century. On the other hand, the frequency and intensity of droughts in parts of Africa and Asia seem to have worsened. Global precipitation is predicted to increase, but, at the local level, trends are much less certain. By the second half of the 21st century, it is likely that winter precipitation will rise at northern mid to high latitudes and in Antarctica. For the tropics, models suggest that some land areas will see more precipitation, and others less. Australia, Central America and Southern Africa show consistent decreases in winter rainfall. Climate models also consistently show extreme precipitation events becoming more frequent over many areas.

The frequency and intensity of extreme weather events such as storms and hurricanes is likely to continue to increase. There is now higher confidence in the projected increases in droughts, heat waves and floods, as well as their adverse impacts[5].

Impacts of climate change

More specific information is now available across a wide range of systems and sectors concerning the nature of future impacts, which are discussed below.

a) Impact on sectors and systems

- **Ecosystems:** The resilience of many ecosystems is likely to be exceeded this century by an unprecedented combination of climate change, associated disturbances (e.g. flooding, drought, wildfire, insects, ocean acidification) and other global change drivers (e.g. landuse change, pollution, fragmentation of natural systems, overexploitation of resources). Over the course of this century, net carbon uptake by terrestrial ecosystems is likely to peak before mid-century and then weaken or even reverse, thus amplifying climate change. Approximately 20 to 30% of plant and animal species assessed so far are likely to be at increased risk of extinction if increases in global

[5] IPCC (2007). 'Summary for Policymakers'.

average temperature exceed 1.5 to 2.5°C. For increases in global average temperature exceeding 1.5 to 2.5°C and in concomitant atmospheric CO_2 concentrations, there are projected to be major changes in ecosystem structure and function, species' ecological interactions and shifts in species' geographical ranges, with predominantly negative consequences for biodiversity and ecosystem goods and services, e.g. water and food supply.

- **Food:** Crop productivity is projected to increase slightly at mid to high latitudes for local mean temperature increases of up to 1 to 3°C depending on the crop, and then decrease beyond that in some regions. At lower latitudes, especially in seasonally dry and tropical regions, crop productivity is projected to decrease for even small local temperature increases (1 to 2°C), which would increase the risk of hunger. Globally, the potential for food production is projected to increase with increases in local average temperature over a range of 1 to 3°C, but above this it is projected to decrease.
- **Coasts:** Coasts are projected to be exposed to increasing risks, including coastal erosion, due to climate change and sea level rise. The effect will be exacerbated by increasing human-induced pressures on coastal areas. By the 2080s, millions more people than today are projected to experience floods every year due to sea level rise. The numbers affected will be largest in the densely populated and low-lying megadeltas of Asia and Africa while small islands are especially vulnerable.
- **Industry, settlements and society:** The most vulnerable industries, settlements and societies are generally those in coastal and river flood plains, those whose economies are closely linked with climate-sensitive resources and those in areas prone to extreme weather events, especially where rapid urbanisation is occurring. Poor communities can be especially vulnerable, in particular those concentrated in high-risk areas.
- **Health:** The health status of millions of people is projected to be affected through, for example, increases in malnutrition; increased deaths, diseases and injury due to extreme weather events; increased burden of diarrhoeal diseases; increased frequency of cardio-respiratory diseases due to higher concentrations of ground-level ozone in urban areas related to climate change; and the altered spatial distribution of some infectious diseases. Climate change is projected to bring some benefits in temperate areas, such as fewer deaths from cold exposure, and some mixed effects such as changes in range and transmission potential of malaria in Africa. Overall it is expected that benefits will be outweighed by the negative health effects of rising temperatures, especially in developing countries. Critically important will be factors that directly shape the health of populations such as education, health care, public health initiatives, and infrastructure and economic development.
- **Water:** Climate change is expected to exacerbate current stresses on water resources from population growth and economic and land-use change, including urbanisation. On a regional scale, mountain snow pack, glaciers and small ice caps play a crucial role in freshwater availability. Widespread mass losses from glaciers and reductions in snow cover over recent decades are projected to accelerate throughout the 21st century, reducing water availability, hydropower potential, and changing seasonality of flows in regions supplied by meltwater from major mountain ranges (e.g. Hindu-Kush, Himalaya, Andes), where more than one-sixth of the world population currently lives. Changes in precipitation and temperature lead to changes in runoff and water

availability. Runoff is projected with high confidence to increase by 10 to 40% by mid-century at higher latitudes and in some wet tropical areas, including populous areas in East and South-East Asia, and decrease by 10 to 30% over some dry regions at mid-latitudes and dry tropics, due to decreases in rainfall and higher rates of evapotranspiration. There is also high confidence that many semi-arid areas (e.g. the Mediterranean Basin, western United States, southern Africa and north-eastern Brazil) will suffer a decrease in water resources due to climate change. Drought-affected areas are projected to increase in extent, with the potential for adverse impacts on multiple sectors, e.g. agriculture, water supply, energy production and health. Regionally, large increases in irrigation water demand as a result of climate changes are projected. The negative impacts of climate change on freshwater systems outweigh its benefits (high confidence). Areas in which runoff is projected to decline face a reduction in the value of the services provided by water resources (very high confidence). The beneficial impacts of increased annual runoff in some areas are likely to be tempered by negative effects of increased precipitation variability and seasonal runoff shifts on water supply, water quality and flood risk. Available research suggests a significant future increase in heavy rainfall events in many regions, including some in which the mean rainfall is projected to decrease. The resulting increased flood risk poses challenges to society, physical infrastructure and water quality. It is likely that up to 20% of the world population will live in areas where river flood potential could increase by the 2080s. Increases in the frequency and severity of floods and droughts are projected to adversely affect sustainable development. Increased temperatures will further affect the physical, chemical and biological properties of freshwater lakes and rivers, with predominantly adverse impacts on many individual freshwater species, community composition and water quality. In coastal areas, sea level rise will exacerbate water resource constraints due to increased salinisation of groundwater supplies.

b) Impacts on regions

- **Africa:** By 2020, between 75 and 250 million of people are projected to be exposed to increased water stress due to climate change. By 2020, in some countries, yields from rain-fed agriculture could be reduced by up to 50%. Agricultural production, including access to food, in many African countries is projected to be severely compromised. This would further adversely affect food security and exacerbate malnutrition. Towards the end of the 21st century, projected sea level rise will affect low-lying coastal areas with large populations. The cost of adaptation could amount to at least 5 to 10% of GDP. By 2080, an increase of 5 to 8% of arid and semi-arid land in Africa is projected under a range of climate scenarios.
- **Asia:** By the 2050s, freshwater availability in Central, South, East and South-East Asia, particularly in large river basins, is projected to decrease. Coastal areas, especially heavily populated megadelta regions in South, East and South-East Asia, will be at greatest risk due to increased flooding from the sea and, in some megadeltas, flooding from the rivers. Climate change is projected to compound the pressures on natural resources and the environment associated with rapid urbanisation, industrialisation and economic development. Endemic morbidity and mortality due to diarrhoeal

disease primarily associated with floods and droughts are expected to rise in East, South and South-East Asia due to projected changes in the hydrological cycle.

- **Australia and New Zealand:** By 2020, significant loss of biodiversity is projected to occur in some ecologically rich sites, including the Great Barrier Reef and Queensland Wet Tropics. By 2030, water security problems are projected to intensify in southern and eastern Australia and, in New Zealand, in Northland and some eastern regions. By 2030, production from agriculture and forestry is projected to decline over much of southern and eastern Australia, and over parts of eastern New Zealand, due to increased drought and fire. However, in New Zealand, initial benefits are projected in some other regions. By 2050, ongoing coastal development and population growth in some areas of Australia and New Zealand are projected to exacerbate risks from sea level rise and increases in the severity and frequency of storms and coastal flooding.
- **Europe:** Climate change is expected to magnify regional differences in Europe's natural resources and assets. Negative impacts will include increased risk of inland flash floods and more frequent coastal flooding and increased erosion (due to storminess and sea level rise). Mountainous areas will face glacier retreat, reduced snow cover and winter tourism, and extensive species losses (in some areas up to 60% under high emissions scenarios by 2080). In southern Europe, climate change is projected to worsen conditions (high temperatures and drought) in a region already vulnerable to climate variability, and to reduce water availability, hydropower potential, summer tourism and, in general, crop productivity. Climate change is also projected to increase the health risks due to heat waves and the frequency of wildfires.

- **Latin America:** By mid-century, increases in temperature and associated decreases in soil water are projected to lead to gradual replacement of tropical forest by savanna in eastern Amazonia. Semiarid vegetation will tend to be replaced by arid-land vegetation. There is a risk of significant biodiversity loss through species extinction in many areas of tropical Latin America. Productivity of some important crops is projected to decrease and livestock productivity to decline, with adverse consequences for food security. In temperate zones, soybean yields are projected to increase. Overall, the number of people at risk of hunger is projected to increase. Changes in precipitation patterns and the disappearance of glaciers are projected to significantly affect water availability for human consumption, agriculture and energy generation.

- **North America:** Warming in western mountains is projected to cause decreased snowpack, more winter flooding and reduced summer flows, exacerbating competition for over-allocated water resources. In the early decades of the century, moderate climate change is projected to increase aggregate yields of rain-fed agriculture by 5 to 20%, but with important variability among regions. Major challenges are projected for crops that are near the warm end of their suitable range or which depend on highly utilised water resources. Cities that currently experience heat waves are expected to be further challenged by an increased number, intensity and duration of heat waves during the course of the century, with potential for adverse health impacts. Coastal communities and habitats will be increasingly stressed by climate change impacts interacting with development and pollution.

- P**olar Regions:** The main projected biophysical effects are reductions in thickness and extent of glaciers, ice sheets and sea ice, and changes in natural ecosystems with detrimental effects on many organisms including migratory birds, mammals and higher predators. For human communities in the Arctic, impacts, particularly those resulting from changing snow and ice conditions, are projected to be mixed. Detrimental impacts would include those on infrastructure and traditional indigenous ways of life. In both polar regions, specific ecosystems and habitats are projected to be vulnerable, as climatic barriers to species invasions are lowered.

- **Small Islands:** Sea level rise is expected to exacerbate inundation, storm surge, erosion and other coastal hazards, thus threatening vital infrastructure, settlements and facilities that support the livelihood of island communities. Deterioration in coastal conditions, for example through erosion of beaches and coral bleaching, is expected to affect local resources. By mid-century, climate change is expected to reduce water resources in many small islands, e.g. in the Caribbean and Pacific, to the point where they become insufficient to meet demand during low-rainfall periods. With higher temperatures, increased invasion by non-native species is expected to occur, particularly on mid- and high-latitude islands.

c) Especially affected systems, sectors and regions

Some systems, sectors and regions are likely to be especially affected by climate change.

i) Systems and sectors in particular ecosystems include:

- Terrestrial: tundra, boreal forest and mountain regions because of sensitivity to warming; Mediterranean-type ecosystems because of reduction in rainfall; and tropical rainforests where precipitation declines.
- Coastal: mangroves and salt marshes, due to multiple stresses.
- Marine: coral reefs due to multiple stresses.
- Sea-ice biome because of sensitivity to warming.
- Water resources in some dry regions at mid-latitudes and in the dry tropics, due to changes in rainfall and evapotranspiration, and in areas dependent on snow and ice melt .
- Agriculture in low latitudes, due to reduced water availability.
- Low-lying coastal systems, due to threat of sea level rise and increased risk from extreme weather events.
- Human health in populations with low adaptive capacity.

ii) Regions:

- the Arctic, because of the impacts of high rates of projected warming on natural systems and human communities.
- Africa, because of low adaptive capacity and projected climate change impacts.

- small islands, where there is high exposure of population and infrastructure to projected climate change impacts.
- Asian and African megadeltas, due to large populations and high exposure to sea level rise, storm surges and river flooding.
- Within other areas, even those with high incomes, some people (such as the poor, young children and the elderly) can be particularly at risk, and also some areas and some activities.

d) Ocean acidification

The uptake of anthropogenic carbon since 1750 has led to the ocean becoming more acidic with an average decrease in pH of 0.1 units. Increasing atmospheric CO_2 concentrations lead to further acidification. Projections based on SRES scenarios give a reduction in average global surface ocean pH of between 0.14 and 0.35 units over the 21st century. While the effects of observed ocean acidification on the marine biosphere are as yet undocumented, the progressive acidification of oceans is expected to have negative impacts on marine shell-forming organisms (e.g. corals) and their dependent species.

e) Extreme events

Altered frequencies and intensities of extreme weather, together with sea level rise, are expected to have mostly adverse effects on natural and human systems as shown in the Table below:

Phenomenon and direction of trend	***Likelihood of future trends based on projections for 21st century***	***Examples of major projected impacts by sector***			
		Agriculture, forestry and ecosystems	***Water resources***	***Human health***	***Industry, settlement and society***
Over most land areas, warmer and fewer cold days and nights, warmer and more frequent hot days and nights	*Virtually certain*	Increased yields in colder environments; decreased yields in warmer environments; increased insect outbreaks	Effects on water resources relying on snowmelt; effects on some water supplies	Reduced human mortality from decreased cold exposure	Reduced energy demand for heating; increased demand for cooling; declining air quality in cities; reduced disruption to transport due to snow, ice; effects on winter tourism
Warm spells/heat waves. Frequency increased over most land areas	*Very likely*	Reduced yields in warmer regions due to heat stress; increased danger of wildfire	Increased water demand; water quality problems, e.g. algal blooms	Increased risk of heat-related mortality, especially for the elderly, chronically sick, very young and socially isolated	Reduction in quality of life for people in warm areas without appropriate housing; impacts on the elderly, very young and poor

Heavy precipitation events. Frequency increases over most areas	*Very likely*	Damage to crops; soil erosion, inability to cultivate land due to waterlogging of soils	Adverse effects on quality of surface and groundwater; contamination of water supply; water scarcity may be relieved	Increased risk of deaths, injuries and infectious, respiratory and skin diseases	Disruption of settlements, commerce, transport and societies due to flooding: pressures on urban and rural infrastructures; loss of property
Area affected by drought increases	*Likely*	Land degradation; lower yields/crop damage and failure; increased livestock deaths; increased risk of wildfire	More widespread water stress	Increased risk of food and water shortage; increased risk of malnutrition; increased risk of water-and food-borne diseases	Water shortage for settlements, industry and societies; reduced hydropower generation potentials; potential for population migration
Intense tropical cyclone activity increases	*Likely*	Damage to crops; uprooting of trees; damage to coral reefs	Power outages causing disruption of public water supply	Increased risk of deaths, injuries, water- and food-borne diseases; post-traumatic stress disorders	Disruption by flood and high winds; potential for population migrations, loss of property
Increased incidence of extreme high sea level (excludes tsunamis)	*Likely*	Salinisation of irrigation water, estuaries and freshwater systems	Decreased freshwater availability due to saltwater intrusion	Increased risk of deaths and injuries by drowning in floods; migration-related health effects	Costs of coastal protection versus costs of land-use relocation; potential for movement of populations and infrastructure

f) Risk of abrupt or irreversible changes

Anthropogenic warming could lead to some impacts that are abrupt or irreversible, depending upon the rate and magnitude of the climate change. Abrupt climate change on decadal time scales is normally thought of as involving ocean circulation changes. In addition on longer time scales, ice sheet and ecosystem changes may also play a role. If a large-scale abrupt climate change were to occur, its impact could be quite high. Partial loss of ice sheets on polar land and/or the thermal expansion of seawater over very long time scales could imply metres of sea level rise, major changes in coastlines and inundation of low-lying areas, with greatest effects in river deltas and low-lying islands. Current models project that such changes would occur over very long time scales (millennial) if a global temperature increase of 1.9 to 4.6°C (relative to pre-industrial) were to be sustained. Rapid sea level rise on century time scales cannot be excluded. Climate change is likely to lead to some irreversible impacts. There is medium confidence that approximately 20 to 30 per cent of species assessed so far are likely to be at increased risk of extinction if increases in global average warming exceed 1.5 to 2.5°C (relative to 1980-1999). As global average temperature increase exceeds about 3.5°C, model projections suggest significant extinctions (40 to 70 % of species assessed) around the globe.

1.5 International response to Climate change

In 1988, an IPCC was created by the World Meteorological Organization and the United Nations Environment Programme (UNEP) to study the evidence that concentrations of carbon dioxide in the atmosphere were increasing. This group issued a first assessment report in 1990 which reflected the views of 400 scientists. The report stated that global warming was real and urged that something be done about it. The Panel's findings spurred governments to create the **United Nations Framework Convention on Climate Change** (UNFCC) in 1992 to begin considering what could be done to reduce global warming and to cope with whatever temperature increases are inevitable. More recently, a number of nations approved an addition to the treaty: the **Kyoto Protocol**, which has more powerful (and legally binding) measures. This was adopted in 1997 and is aimed at establishing a first step towards achieving the main objective of the Convention: to stabilize GHG emissions from human activities. The Protocol establishes emission targets for the Annex I Parties[6]. The rules for the fulfillment of the Protocol for the first commitment period (2008-2012) were agreed upon in the Marrakesh Accords. Progress under the UNFCCC is summarized in the Table below:

Year	Outcome
1992	**UN Conference on Environment and Development** (Rio de Janeiro, Brazil): United Nations Framework Convention on Climate Change.
1997	Kyoto Protocol: outlines legally-binding commitments to cut emissions.
2001	**Marrakesh Accords**: spell out more detailed rules for the Protocol (e.g. concerning technology transfer and the flexible mechanisms) and prescriptions for implementing the Convention (concluded a cycle of negotiations, including the Buenos Aires Plan of Action and the Bonn Agreements).
2005	The **Kyoto Protocol** enters into force.
2006	Nairobi Work Programme on Adaptation.
2007	**Bali Road Map**; consists of a number of decisions that represent the various tracks that are essential to reaching a secure climate future. The Bali Road Map includes the Bali Action Plan, which charts the course for a new negotiating process designed to tackle climate change, with the aim of completing this by 2009.
2008	Start of the five-year commitment period under the Kyoto Protocol.
2009	The **Copenhagen Climate Change Conference** raised climate change policy to the highest political level. Close to 115 world leaders attended the high-level segment, making it one of the largest gatherings of world leaders ever outside UN headquarters in New York. More than 40,000 people, representing governments, nongovernmental organizations, intergovernmental organizations, faith-based organizations, media and UN agencies applied for accreditation. Some of its conclusions were: • It significantly advanced the negotiations on the infrastructure needed for effective global climate change cooperation, including improvements to the Clean Development Mechanism of the Kyoto Protocol. • It produced the Copenhagen Accord, which expressed clear a political intent to constrain carbon and respond to climate change, in both the short and long

[6] Industrialized countries like Australia, Canada, Denmark, France, Germany etc.

	term. • There was strong convergence of the views of governments to the long-term goal of limiting the maximum global average temperature increase to no more than 2 degrees Celsius above pre-industrial levels, subject to a review in 2015. There was, however, no agreement on how to do this in practical terms. • Developed countries' promises to fund actions to reduce greenhouse gas emissions and to adapt to the inevitable effects of climate change in developing countries. Developed countries promised to provide US$30 billion for the period 2010-2012, and to mobilize long-term finance of a further US$100 billion a year by 2020 from a variety of sources. • Agreement on the measurement, reporting and verification of developing country actions, including a reference to "international consultation and analysis", which had yet to be defined. • The establishment of four new bodies: a mechanism on REDD-plus, a High-Level Panel under the COP to study implementation of financial provisions, the Copenhagen Green Climate Fund, and a Technology Mechanism.
2010	The **Cancun Climate Change Conference** drew almost 12,000 participants, including 5,200 government officials, 5,400 representatives of UN bodies and agencies, intergovernmental organizations and nongovernmental organizations, and 1,270 accredited members of the media. The meeting produced the basis for the most comprehensive and far-reaching international response to climate change the world had ever seen to reduce carbon emissions and build a system which made all countries accountable to each other for those reductions. The countries agreed to the following: • to commit to **a maximum temperature rise of 2 degrees Celsius** above pre-industrial levels, and to consider lowering that maximum to 1.5 degrees in the near future. • to make fully operational by 2012 a **technology mechanism** to boost the innovation, development and spread of new climate-friendly technologies; • to establish a **Green Climate Fund** to provide financing to projects, programmes, policies and other activities in developing countries via thematic funding windows; • on the **Cancun Adaptation Framework**, which included setting up an Adaptation Committee to promote the implementation of stronger, cohesive action on adaptation. On the **mitigation** front, developed countries submitted economy-wide emission reduction targets and agreed on strengthened reporting frequency and standards and to develop low-carbon national plans and strategies. Developing countries submitted nationally appropriate mitigation actions (NAMAs), to be implemented subject to financial and technical support. Work continued on shaping the form and functions of a registry for NAMAs to enable the matching of such actions with finance and technology. Developing countries were also encouraged to develop low-carbon national plans and strategies. Work also progressed on **reducing emissions from deforestation and forest degradation (REDD)**, boosting **capacity-building** in developing countries, and how to deal with any consequences of response measures to action on climate change. Governments also agreed to include carbon capture and storage (CCS) in the projects under the **Clean Development Mechanism (CDM)**, subject to technical and safety standards.
2011	The **United Nations Climate Change Conference, Durban 2011,** delivered a

	breakthrough on the international community's response to climate change. In the second largest meeting of its kind, the negotiations advanced, in a balanced fashion, the implementation of the Convention and the Kyoto Protocol, the Bali Action Plan, and the Cancun Agreements. The outcomes included a decision by Parties to adopt a universal legal agreement on climate change as soon as possible, and no later than 2015. Other outcomes included: On mitigation: • The establishment of the Durban Platform for Enhanced Action • The agreement to see the Kyoto Protocol move into a second commitment period in 2013; in the interim, all developed country governments and 48 developing countries affirmed their emission reduction pledges up to 2020 Building on the Cancun Institutions • Developing countries will receive institutional, capacity and technological support to act on climate change • Better coordination and planning of the urgent need to adapt to climate change, especially in developing countries • Climate finance becomes more concrete in terms of infrastructure and coordination • The Green Climate Fund was officially launched
2012	**The UN Climate Change Conference** (18th session of the Conference of the Parties to the UNFCCC and the 8th session of the Conference of the Parties serving as the Meeting of the Parties to the Kyoto Protocol) took place in November 2012 in Doha, Qatar. The conference reached an agreement to extend the life of the Kyoto Protocol, which had been due to expire at the end of 2012, until 2020, and to reify the 2011 Durban Platform, meaning that a successor to the Protocol is set to be developed by 2015 and implemented by 2020. The conference incorporated for the first time the concept of "loss and damage", an agreement in principle that richer nations could be financially responsible to other nations for their failure to reduce carbon emissions. The Conference produced a package of documents collectively titled The Doha Climate Gateway over objections from Russia and other countries at the session. The documents collectively contained: • An eight year extension of the Kyoto Protocol until 2020 limited in scope to only 15% of the global carbon dioxide emissions due to the lack of participation of Canada, Japan, Russia, Belarus, Ukraine, New Zealand and the United States and due to the fact that developing countries like China (the world's largest emitter), India and Brazil are not subject to any emissions reductions under the Kyoto Protocol.[9] • Language on loss and damage, formalized for the first time in the conference documents. • The conference made little progress towards the funding of the Green Climate Fund.

Responses to climate change: Mitigation and adaptation

Climate mitigation is any action taken to permanently eliminate or reduce the long-term risk and hazards of climate change to human life, property. IPCC defines mitigation as "An anthropogenic intervention to reduce the sources or enhance the sinks of greenhouse gases." **Climate adaptation** refers to the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damage, to take advantage of opportunities, or to cope with the consequences. IPCC defines adaptation as the, “adjustment in natural or human systems to a new or changing environment. Adaptation to climate change refers to adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Various types of adaptation can be distinguished, including anticipatory and reactive adaptation, private and public adaptation, and autonomous and planned adaptation.”

The terms “adaptation” and “mitigation” are two important terms that are fundamental in the climate change debate. While mitigation tackles the causes of climate change, adaptation tackles the effects of the phenomenon. The potential to adjust in order to minimize negative impact and maximize any benefits from changes in climate is known as adaptive capacity. A successful adaptation can reduce vulnerability by building on and strengthening existing coping strategies.

In general the more mitigation there is, the less will be the impacts to which we will have to adjust, and the less the risks for which we will have to try and prepare. Conversely, the greater the degree of preparatory adaptation, the less may be the impacts associated with any given degree of climate change.
For people today, already feeling the impacts of past inaction in reducing greenhouse gas emissions, adaptation is not altogether passive, rather it is an active adjustment in response to new stimuli. However, our present age has proactive options (mitigation), and must also plan to live with the consequences (adaptation) of global warming.

The idea that less mitigation means greater climatic change and consequently requiring more adaptation is the basis for the urgency surrounding reductions in greenhouse gases. Climate mitigation and adaptation should not be seen as alternatives to each other, as they are not discrete activities but rather a combined set of actions in an overall strategy to reduce greenhouse gas emissions.

Role of the government: Strategies for mitigation and adaptation

Many impacts can be avoided, reduced or delayed by mitigation. A portfolio of adaptation and mitigation measures can diminish the risks associated with climate change.

1.7.1 Mitigation in the short and medium term

Studies indicate that there is substantial economic potential for the mitigation of global GHG emissions over the coming decades, that could offset the projected growth of global emissions or reduce emissions below current levels No one sector or technology can address the entire mitigation challenge. All assessed sectors contribute to the total. The key mitigation technologies and practices for the respective sectors are shown in the table below.

Sector	Key mitigation technologies and practices currently commercially available	Key mitigation technologies and practices projected to be commercialized before 2030
Energy	Improved supply and distribution efficiency;	CCS for gas, biomass and coal-fired

sector	fuel switching from coal to gas; nuclear power; renewable heat and power (hydropower, solar, wind, geothermal and bioenergy); combined heat and power; early applications of Carbon Capture and Storage (CCS).	electricity generating facilities; advanced nuclear power; advanced renewable energy, including tidal and waves energy, concentrating solar and solar PV.
Transport sector	More fuel efficient vehicles; hybrid vehicles; leaner diesel vehicles; biofuels; modal shifts from road transport to rail and public transport systems; non-motorised transport (cycling, walking); land-use and transport planning.	Second generation biofuels; higher efficiency aircraft; advanced electric and hybrid vehicles with more powerful and reliable batteries.
Buildings	Efficient lighting and daylighting; more efficient electrical appliances and heating and cooling devices; improved cook stoves, improved insulation ; passive and active solar design for heating and cooling; alternative refrigeration fluids, recovery and recycle of fluorinated gases.	Integrated design of commercial buildings including technologies, such as intelligent meters that provide feedback and control; solar PV integrated in buildings.
Industry	More efficient end-use electrical equipment; heat and power recovery; material recycling and substitution; control of non- CO2 gas emissions; and a wide array of process-specific technologies.	Advanced energy efficiency; CCS for cement, ammonia, and iron manufacture; inert electrodes for aluminium manufacture.
Agriculture	Improved crop and grazing land management to increase soil carbon storage; restoration of cultivated peaty soils and degraded lands; improved rice cultivation techniques and livestock and manure management to reduce CH_4 emissions; improved nitrogen fertilizer application techniques to reduce N_2O emissions; dedicated energy crops to replace fossil fuel use; improved energy efficiency.	Improvements of crops yields.
Forestry/ forests	Afforestation; reforestation; forest management; reduced deforestation; harvested wood product management; use of forestry products for bioenergy to replace fossil fuel use	Tree species improvement to increase biomass productivity and carbon sequestration. Improved remote sensing technologies for analysis of vegetation/ soil carbon sequestration potential and mapping land use change.
Waste management	Landfill methane recovery; waste incineration with energy recovery; composting of organic waste; controlled waste water treatment; recycling and waste minimization.	Biocovers and biofilters to optimize CH_4 oxidation.

1.7.2 Mitigation and adaptation strategies in the long term

(i) Changes in lifestyle and behaviour patterns can contribute to climate change mitigation across all sectors. Management practices can also have a positive role.

- Lifestyle changes can reduce GHG emissions. Changes in lifestyles and consumption patterns that emphasize resource conservation can contribute to developing a low-carbon economy that is both equitable and sustainable.
- Education and training programmes can help overcome barriers to the market acceptance of energy efficiency, particularly in combination with other measures.
- Changes in occupant behaviour, cultural patterns and consumer choice and use of technologies can result in considerable reduction in CO_2 emissions related to energy use in buildings.
- Transport Demand Management, which includes urban planning (that can reduce the demand for travel) and provision of information and educational techniques (that can reduce car usage and lead to an efficient driving style) can support GHG mitigation.
- In industry, management tools that include staff training, reward systems, regular feedback, documentation of existing practices can help overcome industrial organization barriers, reduce energy use, and GHG emissions.

(ii) New energy infrastructure investments in developing countries, upgrades of energy infrastructure in industrialized countries, and policies that promote energy security, can, in many cases, create opportunities to achieve GHG emission reductions compared to baseline scenarios.

- Future energy infrastructure investment decisions, expected to total over 20 trillion US$ between now and 2030, will have long term impacts on GHG emissions, because of the long life-times of energy plants and other infrastructure capital stock. The widespread diffusion of low-carbon technologies may take many decades, even if early investments in these technologies are made attractive. Initial estimates show that returning global energy-related CO_2 emissions to 2005 levels by 2030 would require a large shift in the pattern of investment, although the net additional investment required ranges from negligible to 5-10%.
- It is often more cost-effective to invest in end-use energy efficiency improvement than in increasing energy supply to satisfy demand for energy services. Efficiency improvement has a positive effect on energy security, local and regional air pollution abatement, and employment.
- Renewable energy generally has a positive effect on energy security, employment and on air quality. Given costs relative to other supply options, renewable electricity, which accounted for 18% of the electricity supply in 2005, can have a 30-35% share of the total electricity supply in 2030.
- The higher the market prices of fossil fuels, the more low-carbon alternatives will be competitive, although price volatility will be a disincentive for investors. Higher priced conventional oil resources, on the other hand, may be replaced by high carbon alternatives such as from oil sands, oil shales, heavy oils, and synthetic fuels from coal and gas, leading to increasing GHG emissions, unless production plants are equipped with CCS.
- Given costs relative to other supply options, nuclear power, which accounted for 16% of the electricity supply in 2005, can have an 18% share of the total electricity supply in 2030 but safety, weapons proliferation and waste remain as constraints.

- CCS in underground geological formations is a new technology with the potential to make an important contribution to mitigation by 2030. Technical, economic and regulatory developments will affect the actual contribution.

(iii) There are multiple mitigation options in the transport sector, but their effect may be counteracted by growth in the sector.

- Improved vehicle efficiency measures, leading to fuel savings, in many cases have net benefits (at least for light-duty vehicles), but the market potential is much lower than the economic potential due to the influence of other consumer considerations, such as performance and size. There is not enough information to assess the mitigation potential for heavy-duty vehicles. Market forces alone, including rising fuel costs, are therefore not expected to lead to significant emission reductions.
- Biofuels might play an important role in addressing GHG emissions in the transport sector, depending on their production pathway. Biofuels used as gasoline and diesel fuel additives/substitutes are projected to grow to 3% of total transport energy demand in the baseline in 2030. This could increase to about 5-10%, depending on future oil and carbon prices, improvements in vehicle efficiency and the success of technologies to utilise cellulose biomass.
- Modal shifts from road to rail and to inland and coastal shipping and from low-occupancy to high occupancy passenger transportation, as well as land use, urban planning and non-motorized transport offer opportunities for GHG mitigation, depending on local conditions and policies.
- Medium term mitigation potential for CO_2 emissions from the aviation sector can come from improved fuel efficiency, which can be achieved through a variety of means, including technology, operations and air traffic management. However, such improvements are expected to only partially offset the growth of aviation emissions. Total mitigation potential in the sector would also need to account for non-CO_2 climate impacts of aviation emissions.
- Realizing emissions reductions in the transport sector is often a co-benefit of addressing traffic congestion, air quality and energy security.

(iv) Energy efficiency options for new and existing buildings could considerably reduce CO_2 emissions with net economic benefit.

- By 2030, about 30% of the projected GHG emissions in the building sector can be avoided with net economic benefit. Energy efficient buildings, while limiting the growth of CO_2 emissions, can also improve indoor and outdoor air quality, improve social welfare and enhance energy security.
- Opportunities for realising GHG reductions in the building sector exist worldwide. However, multiple barriers make it difficult to realise this potential. These barriers include availability of technology, financing, poverty, higher costs of reliable information, limitations inherent in building designs and an appropriate portfolio of policies and program.
- The magnitude of the above barriers is higher in the developing countries and this makes it more difficult for them to achieve the GHG reduction potential of the building sector.

(v) The economic potential in the industrial sector is predominantly located in energy intensive industries. Full use of available mitigation options is not being made in either industrialized or developing nations.

- Many industrial facilities in developing countries are new and include the latest technology with the lowest specific emissions. However, many older, inefficient facilities remain in both industrialized and developing countries. Upgrading these facilities can deliver significant emission reductions.
- The slow rate of capital stock turnover, lack of financial and technical resources, and limitations in the ability of firms, particularly small and medium-sized enterprises, to access and absorb technological information are key barriers to full use of available mitigation options.

(vi) Agricultural practices collectively can make a significant contribution at low cost to increasing soil carbon sinks, to GHG emission reductions, and by contributing biomass feedstocks for energy use.

- A large proportion of the mitigation potential of agriculture (excluding bioenergy) arises from soil carbon sequestration, which has strong synergies with sustainable agriculture and generally reduces vulnerability to climate change.
- Stored soil carbon may be vulnerable to loss through both land management change and climate change.
- Considerable mitigation potential is also available from reductions in methane and nitrous oxide emissions in some agricultural systems.
- There is no universally applicable list of mitigation practices; practices need to be evaluated for individual agricultural systems and settings.
- Biomass from agricultural residues and dedicated energy crops can be an important bioenergy feedstock, but its contribution to mitigation depends on demand for bioenergy from transport and energy supply, on water availability, and on requirements of land for food and fibre production. Widespread use of agricultural land for biomass production for energy may compete with other land uses and can have positive and negative environmental impacts and implications for food security.

(vii) Forest-related mitigation activities can considerably reduce emissions from sources and increase CO_2 removals by sinks at low costs, and can be designed to create synergies with adaptation and sustainable development.

- About 65% of the total mitigation potential (up to 100 US$/t$CO_2$-eq) is located in the tropics and about 50% of the total could be achieved by reducing emissions from deforestation.
- Climate change can affect the mitigation potential of the forest sector (i.e., native and planted forests) and is expected to be different for different regions and subregions, both in magnitude and direction.
- Forest-related mitigation options can be designed and implemented to be compatible with adaptation, and can have substantial co-benefits in terms of employment, income generation, biodiversity and watershed conservation, renewable energy supply and poverty alleviation.

(viii) The waste sector can positively contribute to GHG mitigation at low cost and promote sustainable development.

- Existing waste management practices can provide effective mitigation of GHG emissions from this sector: a wide range of mature, environmentally effective technologies are commercially available to mitigate emissions and provide co-benefits for improved public health and safety, soil protection and pollution prevention, and local energy supply.
- Waste minimization and recycling provide important indirect mitigation benefits through the conservation of energy and materials.
- Lack of local capital is a key constraint for waste and wastewater management in developing countries and countries with economies in transition. Lack of expertise on sustainable technology is also an important barrier.

1.7.3 Policies, measures and instruments to mitigate climate change

A wide variety of national policies and instruments are available to governments to create the incentives for mitigation action. Their applicability depends on national circumstances and an understanding of their interactions, but experience from implementation in various countries and sectors shows there are advantages and disadvantages for any given instrument.

a) All instruments can be designed well or poorly, and be stringent or lax. In addition, monitoring to improve implementation is an important issue for all instruments.
General findings about the performance of policies are:

- Integrating climate policies in broader development policies makes implementation and overcoming barriers easier.
- Regulations and standards generally provide some certainty about emission levels. They may be preferable to other instruments when information or other barriers prevent producers and consumers from responding to price signals. However, they may not induce innovations and more advanced technologies.
- Taxes and charges can set a price for carbon, but cannot guarantee a particular level of emissions. Literature identifies taxes as an efficient way of internalizing costs of GHG emissions.
- Tradable permits will establish a carbon price. The volume of allowed emissions determines their environmental effectiveness, while the allocation of permits has distributional consequences. Fluctuation in the price of carbon makes it difficult to estimate the total cost of complying with emission permits.
- Financial incentives (subsidies and tax credits) are frequently used by governments to stimulate the development and diffusion of new technologies. While economic costs are generally higher than for the instruments listed above, they are often critical to overcome barriers.
- Voluntary agreements between industry and governments are politically attractive, raise awareness among stakeholders, and have played a role in the evolution of many national policies. The majority of agreements have not achieved significant emissions reductions beyond business as usual. However, some recent agreements, in a few

countries, have accelerated the application of best available technology and led to measurable emission reductions.

b) Policies that provide a real or implicit price of carbon could create incentives for producers and consumers to significantly invest in low-GHG products, technologies and processes.

Such policies could include economic instruments, government funding and regulation. An effective carbon-price signal could realize significant mitigation potential in all sectors. Barriers to the implementation of mitigation options are manifold and vary by country and sector. Governments have a crucial supportive role in providing appropriate enabling environment, such as, institutional, policy, legal and regulatory frameworks, to sustain investment flows and for effective technology transfer – without which it may be difficult to achieve emission reductions at a significant scale. Mobilizing financing of incremental costs of low-carbon technologies is important. International technology agreements could strengthen the knowledge infrastructure. Greater cooperative efforts to reduce emissions will help to reduce global costs for achieving a given level of mitigation, or will improve environmental effectiveness.

- Improving, and expanding the scope of, market mechanisms (such as emission trading, Joint Implementation and CDM) could reduce overall mitigation costs.
- Efforts to address climate change can include diverse elements such as emissions targets; sectoral, local, subnational and regional actions; RD&D programmes; adopting common policies; implementing development oriented actions; or expanding financing instruments. These elements can be implemented in an integrated fashion, but comparing the efforts made by different countries quantitatively would be complex and resource intensive.
- Actions that could be taken by participating countries can be differentiated both in terms of when such action is undertaken, who participates and what the action will be. Actions can be binding or non-binding, include fixed or dynamic targets, and participation can be static or vary over time.
- They can be related to financial, technological, institutional, informational and behavioural aspects. Some key policies are given in the table below:

Sector	Policies, measures and instruments shown to be environmentally effective	Key constraints or opportunities
Energy supply	Reduction of fossil fuel subsidies Taxes or carbon charges on fossil fuels	Resistance by vested interests may make them difficult to implement
	Feed-in tariffs for renewable energy technologies Renewable energy obligations Producer subsidies	May be appropriate to create markets for low emissions technologies
Transport	Mandatory fuel economy, biofuel blending and CO_2 standards for road transport	Partial coverage of vehicle fleet may limit effectiveness

	Taxes on vehicle purchase, registration, use and motor fuels, road and parking pricing	Effectiveness may drop with higher incomes
	Influence mobility needs through land use regulations, and infrastructure planning Investment in attractive public transport facilities and non-motorised forms of transport	Particularly appropriate for countries that are building up their transportation systems
Buildings	Appliance standards and labelling Building codes and certification Demand-side management programmes Public sector leadership programmes, including procurement Incentives for energy service companies (ESCOs)	Periodic revision of standards needed Attractive for new buildings. Enforcement can be difficult Need for regulations so that utilities may profit Government purchasing can expand demand for energy efficient products Access to third party financing
Industry	Provision of benchmark information, Performance standards, Subsidies, tax credits Tradable permits Voluntary agreements	May be appropriate to stimulate technology uptake, Stability of national policy important in view of international competitiveness Predictable allocation mechanisms and stable price signals important for investments Success factors include: clear targets, a baseline scenario, third party involvement in design and review and formal provisions of monitoring, close cooperation between government and industry
Agriculture	Financial incentives and regulations for improved land management, maintaining soil carbon content, efficient use of fertilizers and irrigation	May encourage synergy with sustainable development and with reducing vulnerability to climate change, thereby overcoming barriers to implementation
Forestry	Financial incentives (national and international) to increase forest area, to reduce deforestation, and to maintain and manage forests	Constraints include lack of investment capital and land tenure issues. Can help poverty alleviation Land use regulation and enforcement
Waste management	Financial incentives for improved waste and wastewater management Renewable energy incentives or obligations Waste management regulations	May stimulate technology diffusion Local availability of low-cost fuel Most effectively applied at national level with enforcement strategies

1.7.4 Sustainable development and climate change mitigation

Making development more sustainable by changing development paths can make a major contribution to climate change mitigation, but implementation may require resources to overcome multiple barriers. There is a growing understanding of the possibilities to choose and implement mitigation options in several sectors to realize synergies and avoid conflicts with other dimensions of sustainable development.

- Irrespective of the scale of mitigation measures, adaptation measures are necessary.
- Addressing climate change can be considered an integral element of sustainable development policies. National circumstances and the strengths of institutions determine how development policies impact GHG emissions. Changes in development paths emerge from the interactions of public and private decision processes involving government, business and civil society, many of which are not traditionally considered as climate policy. This process is most effective when actors participate equitably and decentralized decision making processes are coordinated.
- Climate change and other sustainable development policies are often but not always synergistic. There is growing evidence that decisions about macroeconomic policy, agricultural policy, multilateral development bank lending, insurance practices, electricity market reform, energy security and forest conservation, for example, which are often treated as being apart from climate policy, can significantly reduce emissions. On the other hand, decisions about improving rural access to modern energy sources for example may not have much influence on global GHG emissions.
- Climate change policies related to energy efficiency and renewable energy are often economically beneficial, improve energy security and reduce local pollutant emissions. Other energy supply mitigation options can be designed to also achieve sustainable development benefits such as avoided displacement of local populations, job creation, and health benefits.
- Reducing both loss of natural habitat and deforestation can have significant biodiversity, soil and water conservation benefits, and can be implemented in a socially and economically sustainable manner. Forestation and bioenergy plantations can lead to restoration of degraded land, manage water runoff, retain soil carbon and benefit rural economies, but could compete with land for food production and may be negative for biodiversity, if not properly designed.
- There are also good possibilities for reinforcing sustainable development through mitigation actions in the waste management, transportation and buildings sectors.
- Making development more sustainable can enhance both mitigative and adaptive capacity, and reduce emissions and vulnerability to climate change. Synergies between mitigation and adaptation can exist, for example properly designed biomass production, formation of protected areas, land management, energy use in buildings and forestry. In other situations, there may be trade-offs, such as increased GHG emissions due to increased consumption of energy related to adaptive responses.

Observed changes in climate and weather events in India

There are some observed changes in climate parameters in India. India's Initial National Communication, 2004 (NATCOM 1)[7] to UNFCCC has consolidated some of these. Some highlights from NATCOM I and others are listed here. No firm link between the documented changes described below and warming due to anthropogenic climate change has yet been established.

- **Surface Temperature**

[7] National Commutation to UNFCCC

At the national level, increase of 0.4° C has been observed in surface air temperatures over the past century. A warming trend has been observed along the west coast, in central India, the interior peninsula, and north-eastern India. However, cooling trends have been observed in north-west India and parts of south India.

- **Rainfall**

While the observed monsoon rainfall at the all-India level does not show any significant trend, regional monsoon variations have been recorded. A trend of increasing monsoon seasonal rainfall has been found along the west coast, northern Andhra Pradesh, and north-western India (+10% to +12% of the normal over the last 100 years) while a trend of decreasing monsoon seasonal rainfall has been observed over eastern Madhya Pradesh, north-eastern India, and some parts of Gujarat and Kerala (-6% to -8% of the normal over the last 100 years).

- **Extreme weather events**

Instrument records over the past 130 years do not indicate any marked long-term trend in the frequencies of large-scale droughts and floods. Trends are however observed in multi-decadal periods of more frequent droughts, followed by less severe droughts. There has been an overall increasing trend in severe storm incidence along the coast at the rate of 0.011 events per year. While the states of West Bengal and Gujarat have reported increasing trends, a decline has been observed in Orissa. Analysis of a daily rainfall data set, have shown (i) a rising trend in the frequency of heavy rain events, and (ii) a significant decrease in the frequency of moderate events over central India from 1951 to 2000.

- **Rise in Sea Level**

Using the records of coastal tide gauges in the north Indian Ocean for more than 40 years, it has been estimated that sea level rise was between 1.06-1.75 mm per year. These rates are consistent with 1-2 mm per year global sea level rise estimates of IPCC.

- **Impacts on Himalayan Glaciers**

The Himalayas possess one of the largest resources of snow and ice and its glaciers form a source of water for the perennial rivers such as the Indus, the Ganga, and the Brahmaputra. Glacial melt may impact their long-term lean-season flows, with adverse impacts on the economy in terms of water availability and hydropower generation. The available monitoring data on Himalayan glaciers indicates that while recession of some glaciers has occurred in some Himalayan regions in recent years, the trend is not consistent across the entire mountain chain. It is accordingly, too early to establish long-term trends, or their causation, in respect of which there are several hypotheses. Under the National Action Plan, these data will be updated and refined continuously and additional reliable data will be collected.

- **Projections of Climate Change over India for the 21st Century**

Some modeling and other studies have projected the following changes due to increase in atmospheric GHG concentrations arising from increased global anthropogenic emissions:

i) Annual mean surface temperature rise by the end of century, ranging from 3 to 5° C under A2 scenario and 2.5 to 4° C under B2 scenario of IPCC, with warming more pronounced in the northern parts of India, from simulations by Indian Institute of Tropical Meteorology (IITM), Pune.

ii) Indian summer monsoon (ISM) is a manifestation of complex interactions between land, ocean and atmosphere. The simulation of ISM's mean pattern as well as variability on interannual and intraseasonal scales has been a challenging ongoing problem. Some simulations by IITM, Pune, have indicated that summer monsoon intensity may increase beginning from 2040 and by 10% by 2100 under A2 scenario of IPCC.

iii) Changes in frequency and/ or magnitude of extreme temperature and precipitation events. Some results show that fine-scale snow albedo influence the response of both hot and cold events and that peak increase in extreme hot events are amplified by surface moisture feedbacks.

Impacts of climate change in India

- **Impacts On Water Resources**

Changes in key climate variables, namely temperature, precipitation, and humidity, may have significant long-term implications for the quality and quantity of water. River systems of the Brahmaputra, Ganga, and the Indus, which benefit from melting snow in the lean season, are likely to be particularly affected by the decrease in snow cover. A decline in total run-off for all river basins, except Narmada and Tapti, is projected in India's NATCOM I. A decline in run-off by more than two-thirds is also anticipated for the Sabarmati and Luni basins. Due to sea level rise, the fresh water sources near the coastal regions will suffer salt intrusion.

- **Impacts On Agriculture And Food Production**

Food production in India is sensitive to climate changes such as variability in monsoon rainfall and temperature changes within a season. Studies by Indian Agricultural Research Institute (IARI) and others indicate greater expected loss in the Rabi crop. Every 1 °C rise in temperature reduces wheat production by 4-5 Million Tonnes. Small changes in temperature and rainfall have significant effects on the quality of fruits, vegetables, tea, coffee, aromatic and medicinal plants, and basmati rice. Pathogens and insect populations are strongly dependent upon temperature and humidity, and changes in these parameters may change their population dynamics. Other impacts on agricultural and related sectors include lower yields from dairy cattle and decline in fish breeding, migration, and harvests. Global reports indicate a loss of 10-40% in crop production by 2100.

- **Impacts On Health**

Changes in climate may alter the distribution of important vector species (for example, malarial mosquitoes) and may increase the spread of such diseases to new areas. If there is an increase of 3.8°C in temperature and a 7% increase in relative humidity the transmission windows i.e., months during which mosquitoes are active, will be open for all 12 months in 9 states in India. The transmission windows in Jammu and Kashmir and in Rajasthan may increase by 3-5 months. However, in Orissa and some southern states, a further increase in temperature is likely to shorten the transmission window by 2-3 months.

- **Impacts On Forests**

Based on future climate projections of Regional Climate Model of the Hadley Centre show that 77% and 68% of the forest areas in the country are likely to experience shift in forest types, by the end of the century, with consequent changes in forests produce, and, in turn, livelihoods based on those products. Correspondingly, the associated biodiversity is likely to be adversely impacted. India's NATCOM I projects an increase in the area under xeric scrublands and xeric woodlands in central India at the cost of dry savannah in these regions.

- **Vulnerability To Extreme Events**

Heavily populated regions such as coastal areas are exposed to climatic events, such as cyclones, floods, and drought, and large declines in sown areas in aridand semi-arid zones occur during climate extremes. Large areas in Rajasthan, Andhra Pradesh, Gujarat, and Maharashtra and comparatively small areas in Karnataka, Orissa, Madhya Pradesh, Tamil Nadu, Bihar, West Bengal, and Uttar Pradesh are frequented by drought. About 40 million hectares of land is flood-prone, including most of the river basins in the north and the north-eastern belt, affecting about 30 million people on an average each year. Such vulnerable regions may be particularly impacted by climate change

- **Impacts On Coastal Areas**

A mean Sea Level Rise (SLR) of 15-38 cm is projected along India's coast by the mid 21st century and of 46-59 cm by 2100. In addition, a projected increase in the intensity of tropical cyclones poses a threat to the heavily populated coastal zones in the country (NATCOM, 2004).

Trends of greenhouse gases emissions in India

a) Current emission trends:

Country	Per capita CO_2 emissions (in tonnes)	% share of global CO_2 emissions
World	4.5	
OECD	11.5	
Developing countries	2.4	
USA	20.6	20.9
UK	9.8	2
Germany	9.8	2.8
Japan	9.9	4.3
Canada	20	2.2
China	3.8	17.3
Brazil	1.8	1.1
South Africa	9.8	1.5
India	1.2	4.6
Source: HDR 2007		

b) Future trends:

Much of the global debate on climate change has been driven by the results of several types of complex analytical models. In the absence of a critical mass of model based studies from India and other developing countries, the terms of the debate have tended to be driven by researchers from the developed countries. With a view to making a contribution to the global debate, as well as providing such assessments for national policy-making on a formal basis, using rigorous, defensible methodologies, and nationally sourced data and estimated parameters, the Ministry of Environment and Forests, Govt. of India, launched and supported a Climate Change Modeling Forum in 2006. Results of of Phase I of three of these studies, together with those of two other recent studies, which focus on estimating the GHG emissions trajectory of India for the next two decades, using a number of different techniques indicate the following:

- Four studies have found that if no new GHG mitigation policies are put in place, India's per-capita CO_2 emissions in 2030/31 would be between 2.77 and 3.9 tons per-capita, which is well below the 2005 global average of 4.22 tons per-capita. The fifth study projects the 2031 emissions at 5 tons per-capita, i.e. a little above the 2005 global average.
- Both the energy intensity of the Indian economy, as well as the CO_2 intensity of the Indian economy fall continuously till 2030-31 in the Illustrative Scenarios, as revealed by all 5 studies.

Thus, even without any new policies for GHG abatement and given the structure of the Indian economy, its current and projected GHG growth rates, and its energy endowments, there can be no apprehension that its GHG emissions will increase in a runaway manner over time. India's energy use patterns and GHG emissions profile will continue to be among the most sustainable in the world for the next generation.

National Action Plan for Climate Change

The National Action Plan on Climate Change (NAPCC), introduced in 2009, identifies measures that promote India's development objectives while also yielding co-benefits for addressing climate change effectively. It outlines a number of steps to simultaneously advance India's development and climate-change related objectives of adaptation and mitigation.

NAPCC is guided by the following principles:

- Protecting the poor and vulnerable sections of the society through an inclusive and sustainable development strategy, sensitive to climate change.
- Achieving national growth objectives through a qualitative change that enhances ecological sustainability, leading to further mitigation of GHGs emissions.
- Devising efficient and cost-effective strategies for end use demand side management.
- Deploying appropriate technologies for both adaptation and mitigation of GHG emissions extensively as well as at an accelerated pace.
- Engineering new and innovate forms of market, regulatory and voluntary mechanisms to promote sustainable development.
- Effecting implementation of programmes through unique linkages, including with civil society and local government institutions through public-private-partnership.
- Welcoming international cooperation for research, development, sharing and transfer of technologies enabled by additional funding and a global IPR regime that facilitates technology transfer to developing countries under UNFCC.

There are 8 national missions, 2 of which are focus on 'Mitigation' and 5 on 'Adaptation'. These are National Solar Mission, National Mission for Enhanced Energy Efficiency, National Mission on Sustainable Habitat, National Water Mission, National Mission for Sustaining the Himalayan Ecosystem, National Mission for a Green India, National Mission for Sustainable Agriculture and National Mission on Strategic Knowledge for Climate Change.

Missions under NAPCC

1. **National Solar Mission:** The stated objective of the mission is to increase the share of solar energy and other renewable and non-fossil based energy sources in the total energy mix of the country and includes nuclear energy as a non-fossil option. NAPCC sets the solar mission a target of delivering 80% coverage for all low temperature (<150° C) applications of solar energy in urban areas, industries and commercial establishments, and a target of 60% coverage for medium temperature (150° C to 250° C) applications. The deadline for achieving this is the duration of the 11th and 12th five-year plans, through to 2017. To operationalise this, The Jawaharlal Nehru National Solar Mission was launched on the 11th January, 2010 by the Prime Minister. The Mission has set the ambitious target of deploying 20,000 MW of grid connected solar power by 2022 and is aimed at reducing the cost of solar power generation in the country through (i) long term policy; (ii) large scale deployment goals; (iii) aggressive R&D; and (iv) domestic production of critical raw materials, components and products, as a result to achieve grid tariff parity by 2022.

2. **National Mission for Enhanced Energy Efficiency:** This Mission is targeted at industry, which, according to the NAPCC, accounts for 42 % of the country's total commercial energy use (2004-2005) and 31 % of total CO_2 emissions. The Mission estimates that CO_2 emissions from fuel and electricity use in the industry sector could be reduced by 16 % from business as usual by end of 2031. Savings of 10,000 MW are targeted by projects already in operation at the end of the 11th Plan. The NAPCC also calls for (a) mandating specific energy consumption decreases in large energy consuming industries (b) innovative measures to make energy efficient appliances/products in certain sectors more affordable (c) creation of mechanisms to help finance demand side management programmes by capturing future energy savings and enabling public-private-partnerships in this area (d) developing fiscal measures to promote energy efficiency such as tax incentives for including differential taxation on energy efficient certified appliances.

3. **National Mission on Sustainable Habitats:** The Mission comprises 3 components: (i) Improvements in energy efficiency of buildings in residential and commercial sector and use of energy efficient options could help achieve 30% electricity savings in new residential buildings and 40% in new commercial buildings. For existing buildings the corresponding savings are 20% and 30% respectively. (ii) Management of Municipal Solid Waste (MSW) : NAPCC lists some policy reforms such as common regional disposal facilities for smaller towns and villages in a particular region, and integrated system for collection, transport, transfer, treatment and disposal facilities to facilitate better management of MSW in India. (iii) Promote urban public transport: The NAPCC supports mass transit such as buses, railways and mass rapid transit systems and the use of CNG, ethanol blending in gasoline and bio-diesel and use of Hydrogen in the future.

4. **National Water Mission:** NAPCC states that many states are water stressed and by 2050, India is likely to be water scarce. The problem will be magnified by Climate Change. National Water Mission thus aims at conserving water, minimising wastage and ensuring more equitable distribution through integrated water resource management. It also aims to

optimize water use efficiency by 20% by developing a framework of regulatory mechanisms having differential entitlements and pricing. In addition, the Water Mission calls for strategies to tackle variability in rainfall and river flows such as enhancing surface and underground water storage, rainwater harvesting and more efficient irrigation systems like sprinklers or drip irrigation.

5. **National Mission for Sustaining the Himalayan Ecosystem:** NAPCC recognises the Himalayan ecosystem as vital to preserving the ecological security of the country and calls for empowering local communities especially Panchayats to play a greater role in managing ecological resources. It also reaffirms measures mentioned in the National Environment Policy, 2006, some of which are: adopting appropriate land-use planning and water-shed management practices for sustainable development of mountain ecosystems, adopting best practices for infrastructure construction in mountain regions to avoid or minimize damage to sensitive ecosystems and despoiling of landscapes, encouraging cultivation of traditional varieties of crops and horticulture by promoting organic farming, enabling farmers to realise a price premium, promoting sustainable tourism based on best practices and multi-stakeholder partnerships to enable local communities to gain better livelihoods, taking measures to regulate tourist inflows into mountain regions to ensure that the carrying capacity of the mountain ecosystem is not breached, Developing protection strategies for certain mountain scapes with unique "incomparable values" etc.

6. **National Mission for a Green India:** The Mission aims at responding to climate change through a combination of adaptation and mitigation measures which include enhancing carbon sinks in sustainably managed forests and other ecosystems, adaption of vulnerable species/ecosystems to the changing climate, and adaptation of forest-dependent communities. NAPCC states that the Greening India programme has already been announced and under the programme, 6 million hectares of degraded forest land would be afforested with the help of Joint Management Committees with funds to the extent of ` 6000 crore being provided to from the accumulated additional funds for compensatory afforestation under the decision of the Supreme Court in respect of land diverted for non-forest uses. It also suggests measures like training on silvicultural practices for fast-growing and climate-hardy tree species; reducing fragmentation of forests by provision of corridors for species migration, both fauna and flora; revitalizing and up-scaling community-based initiatives such as Joint Forest Management and Van Panchayat committees for forest management, formulation of forest fire management strategies, in-situ and ex-situ conservation of genetic resources, especially of threatened flora and fauna etc.

7. **National Mission for Sustainable Agriculture:** The aim is to make Indian agriculture more resilient to climate change by identifying new varieties of crops, especially thermal resistant ones and alternative cropping patterns. This Mission focuses on rain-fed agricultural zones and suggests development of drought and pest resistant crop varieties; improving methods to conserve soil and water; financial support to enable farmers to invest in and adopt relevant technologies to overcome climatic related stresses etc. In addition, the Mission lists measures for safeguarding farmers against increased risk due to climate change by means of strengthening agricultural and weather insurance; creation of web-enabled, regional language based services for facilitation of weather-based insurance; mapping vulnerable regions and disease hotspots; and developing and

implementing region-specific, vulnerability based contingency plans. NAPCC also suggests greater access to information and use of biotechnology applications in agriculture.

8. National Mission on Strategic Knowledge for Climate Change: This Mission will strive to work with the global community in research and technology development and collaboration through a variety of mechanisms, supported by a network of dedicated climate change related institutions and universities and a Climate Research Fund. The Mission also included measures like research in key substantive domains of climate science to improve understanding of key phenomena and processes, global and regional climate modelling to improve the quality/accuracy of climate change projections for India, private sector initiatives for developing innovative technologies for adaptation and mitigation; strengthening of observational networks and data gathering; creation of essential research infrastructure, such as high performance computing; promoting data access and developing human resources in this area.

Other Initiatives

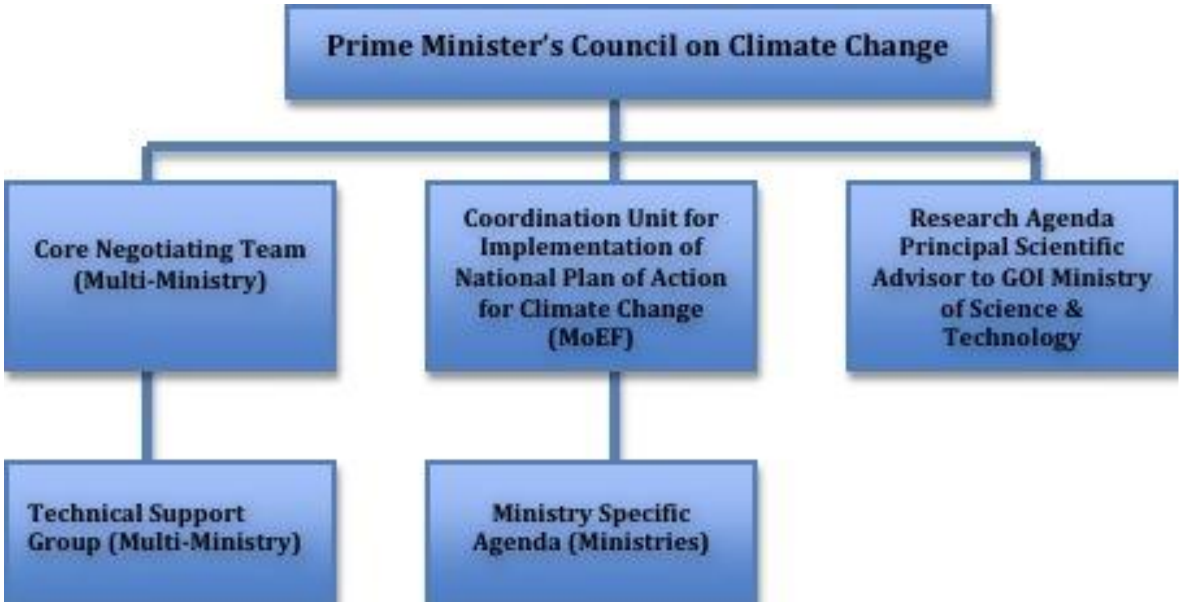
- **GHG mitigation in power generation:** The government is mandating the retirement of inefficient coal-fired power plants and supporting the research and development of Integrated Gasification Combined Cycle and supercritical technologies, natural gas based power plants, closed cycle three stage nuclear power programme, development of hydropower and more efficient transmission and distribution.
- **Other Renewable Energy Technologies Programme:** NAPCC talks about biomass based power generation technologies, small scale hydropower, wind energy and research needed in these areas to make them more viable. Under the Electricity Act 2003 and the National Tariff Policy 2006, the central and the state electricity regulatory commissions must purchase a certain percentage of grid-based power from renewable sources. NAPCC states that a dynamic minimum renewable purchase standard be set, with escalation every year, till a pre-defined level is reached. NAPCC further suggests that starting 2009-10, the national renewables[8] standard maybe set at 5 % of total grid purchase, to increase by 1 % each year for 10 years.
- **Energy Efficiency:** Under the Energy Conservation Act 2001, large energy-consuming industries are required to undertake energy audits and an energy labelling program for appliances has been introduced.

Implementation

According to the NAPCC, the 8 National Missions are to be institutionalised by "respective ministries" and will be organised through inter-sectoral groups including, in addition to related Ministries, Ministry of Finance and the Planning Commission, experts from industry, academia and civil society. Each Mission has been given the task of evolving specific objectives for the remaining duration of the 11th Plan and the 12th Plan period (through to 2017). These objectives were to be stated in comprehensive documents along with strategies, plans of action, timelines and monitoring and evaluation criteria, which

[8] Excluding hydropower with storage capacity in excess of peaking capacity, or based on agriculture based renewable sources that are used for human food

were to be submitted to the Prime Minister's Council on Climate Change by December 2008. The Council is to periodically review the progress of these Missions and the each Mission is to report its performance publically every year.



States like West Bengal, Kerala, Rajasthan, Madhya Pradesh, Andhra Pradesh, Arunachal Pradesh, Haryana, Uttar Pradesh, Punjab, Orissa etc., have also drafted State level plans for tackling effects of Climate Change.

Key Players in climate change

Ministry of Environment and Forests (MoEF) is the key ministry in charge of policy measures in the area of climate change. However, other ministries, including MoEF are involved in implementation of plans for climate change. These are described below.

Ministry	Responsibility
PM's Council on Climate Change	
MoEF	Key negotiator in climate change issues in UNFCCC, Key role in making policy for climate change Coordination unit for implementation of NAPCC National Mission for Sustaining the Himalayan Ecosystem National Mission for a Green India
Ministry of Science and Technology	Research activities on climate change
Ministry of New and Renewable Energy	National Solar Mission of NAPCC
Ministry of Power	National Mission for Enhanced Energy Efficiency of NAPCC

Ministry of Urban Development	National Mission on Sustainable Habitat of NAPCC
Ministry of Water Resources	National Water Mission of NAPCC
Ministry of Agriculture	National Mission for Sustainable Agriculture of NAPCC
Ministry of Science and Technology	National Mission on Strategic Knowledge for Climate Change of NAPCC

Clean Development Mechanism

The Clean Development Mechanism (CDM), provided for under Article 12 of the Kyoto Protocol, enables developing countries to participate in joint greenhouse gas (GHG) mitigation projects. Under this Protocol, Annex I countries (developed countries and economies in transition) are required to reduce GHG emissions to below their 1990 levels.

The CDM enables these countries to meet their reduction commitments in a flexible and cost-effective manner. It allows public or private sector entities in Annex I countries to invest in GHG mitigation projects in developing countries. In return the investing parties receive credits or certified emission reductions (CERs) which they can use to meet their targets under the Kyoto Protocol. While investors profit from CDM projects by obtaining reductions at costs lower than in their own countries, the gains to the developing country host parties are in the form of finance, technology, and sustainable development benefits. The basic rules for the functioning of the CDM were agreed on at the seventh Conference of Parties (COP-7) to the UNFCCC held in Marrakesh, Morocco in October-November 2001. Projects starting in the year 2000 are eligible to earn CERs if they lead to "real, measurable, and long-term" GHG reductions, which are additional to any that would occur in the absence of the CDM project. This includes afforestation and reforestation projects, which lead to the sequestration of carbon dioxide.

At COP-7, it was decided that the following types of projects would qualify for fast-track approval procedures:

- Renewable energy projects with output capacity up to 15 MW
- Energy efficiency improvement projects which reduce energy consumption on the supply and/or demand side by up to 15 GWh annually
- Other project activities that both reduce emissions by sources and directly emit less than 15 kt CO_2 equivalent annually.

CDM will be supervised by an executive board, and a share of the proceeds from project activities will be used to assist developing countries in meeting the costs of adaptation to climate change.

2.6.1 Steps involved in a CDM project

- **Project identification:** The process of developing a CDM project starts by identifying an idea that will reduce GHG emissions. The initial steps require the project proponent to examine the emissions reduction resulting from the project and to ascertain if it contributes to the development priorities of the nation.

- **Government endorsement:** Once the project proponent is convinced the project is relevant under the CDM, a project idea note is prepared and submitted for endorsement to the nodal agency of the country. For India the designated nodal agency is the Ministry of Environment and Forests. After endorsement, the project idea can be developed further.
- **Project development:** To establish the 'additionality' of a project, it is necessary to first define a baseline against which project emissions can be measured. This baseline study is carried out in accordance with provisions in the Kyoto Protocol and Marrakesh Accord, and estimates the quantum of GHG reductions in terms of tonnes of carbon dioxide equivalents.
- **Validation:** The project idea note, the baseline study, and other relevant details are submitted for validation by an independent agency identified by the CDM Executive Board as a DOE (designated operational entity). Validation is the independent evaluation of a project activity against the requirements of the CDM. The DOE checks whether the proposed project activity meets all the requirements of the CDM and submits its validation report to the Executive Board.
- **Registration:** Registration is the formal acceptance by the Executive Board of a validated project as a CDM project activity.
- **Monitoring:** Once registered, the project proponents are responsible for monitoring the actual GHG emissions reduced by the project. A DOE may be approached periodically to verify and certify the reduction in GHG emissions.
- **Verification:** Verification is the periodic independent review and ex post determination of monitored emissions reductions
- **Certification:** Certification is written assurance by the designated operational entity that, during a specified time period, a project activity achieved the GHG emissions reductions as verified
- **Issuance of CERs:** The DOE along with its certification report submits a request to the Executive Board for the issuance of certified emission reductions (CERs). A project can continue to earn CERs for a maximum of either 10 years (with no change of the baseline) or 7 years with at most two renewals (i.e. up to 21 years). 2% of the share of proceeds from the CERs must be forwarded towards the adaptation fund of the Kyoto Protocol.

2.6.2 Government of India interim approval criteria

- **Purpose:** The purpose of the clean development mechanism (CDM) is defined in Article 12 of the Kyoto Protocol to the United Nations Framework Convention on Climate Change. The CDM has a two-fold purpose: (a) to assist developing country Parties in achieving sustainable development, thereby contributing to the ultimate objective of the Convention, and (b) to assist developed country Parties in achieving compliance with part of their quantified emission limitation and reduction commitments under Article 3. Each CDM project activity should meet the above two-fold purpose.

- **Eligibility**: The project proposal should establish the following in order to qualify for consideration as a CDM project activity:

- **Additionalities**

  i) Emission Additionality: The project should lead to real, measurable and long term GHG mitigation. The additional GHG reductions are to be calculated with reference to a baseline.

  ii) Financial Additionality: The funding for CDM project activity should not lead to diversion of official development assistance. The project participants may demonstrate how this is being achieved.

  iii) Technological Additionality: The CDM project activities should lead to transfer of environmentally safe and sound technologies and know-how.

- **Sustainable development indicators**

  It is the prerogative of the host Party to confirm whether a clean development mechanism project activity assists it in achieving sustainable development. The CDM should also be oriented towards improving the quality of life of the very poor from the environmental standpoint.

  The following aspects should be considered while designing CDM project activities:

  i) **Social well-being:** The CDM project activity should lead to alleviation of poverty by generating additional employment, removal of social disparities and contributing to provision of basic amenities to people leading to improvement in their quality of life.

  ii) **Economic well-being:** The CDM project activity should bring in additional investment consistent with the needs of the people.

  iii) **Environmental well-being:** This should include a discussion of the impact of the project activity on resource sustainability and resource degradation, if any, due to the proposed activity; biodiversity-friendliness; impact on human health; reduction of levels of pollution in general;

  iv) **Technological well-being:** The CDM project activity should lead to transfer of environmentally safe and sound technologies with a priority to the renewables sector or energy efficiency projects that are comparable to best practices in order to assist in upgradation of the technological base.

- **Baselines**

  The project proposal must clearly and transparently describe the methodology of determination of the baseline. It should conform to following:

  i) Baselines should be precise, transparent, comparable and workable; Should avoid overestimation;

  ii) The methodology for determination of baseline should be homogeneous and reliable;
  Potential errors should be indicated;

  iii) System boundaries of baselines should be established;

iv) Interval between updates of baselines should be clearly described;

v) Role of externalities should be brought out (social, economic and environmental);
Should include historic emission data-sets wherever available;

vi) Lifetime of project cycle should be clearly mentioned;

vii) The baseline should be on a project-by-project basis except for those categories that qualify for simplified procedures. The project proposal should indicate the formulae used for calculating GHG offsets in the project and baseline scenario. Leakage, if any, should be described. For the purpose of Project Idea Notes (PIN), default values may be used with justification. Determination of the base project which would have come up in the absence of the proposed project should be clearly described in the project proposal.

- **Financial indicators**
  The project participants should bring out the following aspects:

  i) Flow of additional investment

  ii) Cost effectiveness of energy saving

  iii) Internal Rate of Return (IRR) without accounting for CERs, IRR with CERs Liquidity, N.P.V., cost/benefit analysis, cash flow etc., establishing that the project has good probability of eventually being implemented

  iv) Agreements reached with the stakeholders, if any, including power purchase agreements, Memoranda of Understanding, etc.

  v) Inclusion of indicative costs related to validation, approval, registration, monitoring and verification, certification, share of proceeds

  vi) Funding available, financing agency and also description of how financial closure seeks to be achieved

- **Technological feasibility**
  The proposal should include following elements:

  i) The proposed technology/process

  ii) Product/technology/material supply chain

  iii) Technical complexities, if any

  iv) Preliminary designs, schematics for all major equipment needed, design requirement, manufacturers name and details, capital cost estimate Technological reliability

  v) Organizational and management plan for implementation, including timetable, personnel requirements, staff training, project engineering, CPM/PERT chart etc.

- **Risk analysis**

The project proposal should clearly state risks associated with it including apportionment of risks and liabilities; insurance and guarantees, if any.

- **Credentials**
  The credentials of the project participants must be clearly described.