10 GLOBAL WARMING & CLIMATE CHANGE

The human activities that are transforming the biosphere include land use changes, industrial development, energy production from fossil fuels and urbanisation. The conversion of a forest to a grazing land or a cropland through deforestation causes loss of carbon stored in soil and vegetation to the atmosphere, and affects the global carbon cycle. Biomass burning associated with agricultural practices also releases CO_2 into the atmosphere. In recent times, due to domestic and industrial coal burning, huge amount of CO_2 is being pumped into the atmosphere. Similarly, the concentrations of gases like methane (CH_4), nitrous oxide (N_2O) and chlorofluorocarbons (CFCs) are increasing in the lower atmosphere. These gases (CO_2, CH_4, N_2O and CFCs) are radiatively active gases (also called greenhouse gases) because they can absorb long wave infrared radiation. The increased amounts of greenhouse gases in the atmosphere are affecting the global climate and this phenomenon is now recognised as Global Climatic Change.

GREENHOUSE GASES AND GLOBAL WARMING

The atmospheric cover around the earth acts like a window glass pane. It allows most of the solar radiation to enter right up to the earth's surface, but does not allow a substantial amount of the long-wave radiation emitted by the earth to escape in space. The outgoing long-wave infrared radiation is absorbed by the greenhouse gases normally present in the atmosphere. The atmosphere radiates part of this energy back to the earth. This downward flux of radiation, called greenhouse flux, keeps the earth warm. Thus, the atmospheric greenhouse gases forming a blanket over the earth, control the escape of heat from the earth's surface to outer space so as to keep it warm and hospitable. This phenomenon is referred to as greenhouse effect. The name is derived from the fact that inside a glass-enclosed greenhouse, temperature is warmer than outside. Such greenhouses are used for growing plants that require higher temperatures for growth. The mean annual temperature of the earth is about 15°C; however, in the absence of greenhouse gases in the. atmosphere, the earth's mean temperature would drop sharply to about -20°C. This capacity of the atmosphere to keep the earth warm depends upon the concentration of greenhouse gases. The excessive increase in concentrations of these gases in the atmosphere would retain more and more of the infrared radiation, resulting in enhanced greenhouse effect. The consequent increase in the global mean temperature is referred to as global warming. The Intergovernmental Panel on Climate Change (IPCC) periodically makes an assessment of the atmospheric abundance of greenhouse gases and its possible impact on climate and related issues. Much of what you will read in this section is based on IPCC assessment reports.

EVIDENCES OF GLOBAL WARMING

1. Increase in air temperatures: It has been estimated that the overall increase in the air temperature in 20^{lh} centuny has been about 0.5 to 0.7^{Q} C. The 1990s saw seven out of ten warmest years of last century. The global circulation models have shown rise of 0.4 to 0.8^{2} C in the 20th century. The increase in frequency of El Nino events, hurricanes and cyclones between 1970s to 2012 also denotes climatic changes due to warming of earth's surface and its atmosphere. IPCC report has shown that concentration of atmospheric $C0_2$ has increased.

2. Melting of Mountain and Continental Glaciers: Many reports have suggested that Himalayan Glaciers have receded. Similarly there have been reports of retreat of glaciers in

Alps, Andes, Russian Caucasus, Chinese Tien Shan mountains, Southern Alps of New Zealand. Mt. Kenya has lost its most extensive glaciers in the past century. The glaciers of Greenland too have been detaching and receding at fast pace.

3. Warming of Ocean Water and Melting of Ice Sheets and Ice Bergs in Antarctic and Arctic Sea: Due to rise of ocean water temperature in Indian Ocean, during 1997-98 catastrophic coral bleaching was observed caused death of'almost 7-% of the corals near Andaman and Nicobar and Lakshadweep Islands. An analysis suggests that average sea temperature has risen by 0.6% C during later half of 20th century.

4. Other Evidences :

- Thawing of permafrost areas.
- Greening of Taiga and Tundra Forests.
- Spreading of tropical diseases towards temperate and polar regions.
- Shifting of seasonal weather phenomena and changes in precipitation patterns.
- Increased frequency of extreme weather events.

APPROACHES TO DEAL WITH GLOBAL WARMING

Some of the strategies that could reduce the warming by global stabilising atmospheric concentrations of greenhouse gases include:

(i) Reducing the greenhouse gas emissions by limiting the use of fossil fuels, and by developing alternative renewable sources of energy (e.g., wind energy, solar energy, etc.).

(ii) Increasing the vegetation cover, particularly the forests, for photosynthetic utilisation of $C0_2$.

(iii) Minimizing the use of nitrogen fertilisers in agriculture for reducing N_2O emissions.

(iv) Developing substitutes for chlorofluorocarbons.

Apart from the above mitigation strategies, adaptations to address localised impacts of climate change will be necessary.

Global warming is the result of human developmental activities. Some of the factors responsible for global warming have been given below:

Carbon dioxide: CO_2 is the most abundant greenhouse gas in the atmosphere. The level of $C0_2$ in the atmosphere has increased from the pre-industrial level of 280 ppm to about 368 ppm in 2000. This has been largely the result of fossil fuel burning, deforestation and change in land use.

Methane: Methane concentration in atmosphere has more than doubled (1750 ppb) than its concentration during the pre-industrial times. Methane is largely a product of incomplete decomposition and is produced by a group of bacteria called methanogens, under anaerobic conditions. The major sources of methane include: freshwater wetlands, enteric fermentation in cattle, and flooded rice fields. Biomass burning also produces methane.

Chlorofluorocarbons (CFCs) *:* CFCs are non-toxic and non-flammable, highly stable and synthetic gaseous compounds of carbon and halogens. Although these compounds were synthesised during the 20th century, their concentration in the atmosphere has increased. For example, the concentration of CFC-11 and HFC-23 in the air is about 282 ppt. Major sources of CFCs are leaking air conditioners, refrigeration units and evaporation of industrial solvents, and production of plastic foams and propellants in aerosol spray cans. The CFCs persist for 45 to 260 years or more in the atmosphere.

Nitrous Oxide (N_2O)*:* The concentration of nitrous oxide in the atmosphere has increased from about 270 ppb in pre-industrial time to about 316 ppb in recent times. The main sources of N_2O are agriculture, biomass burning and industrial processes. N_2O is produced during nylon production, burning of nitrogen-rich fuels, livestock waste, breakdown of nitrogen-rich fertilisers in soil and nitrate-contaminated ground water.

It is estimated that $C0_2$ contributes about 60 per cent of the totaL global warming . The share of CH_4 and CFCs is 20 per cent and 14 per

cent, respectively. A smaller contribution to global warming is made by N_20 (6 per cent).

The increasing abundance of greenhouse gases in the atmosphere has the following possible effects:

(i) CO_2 fertilisation

(ii) Global warming

(iii) Depletion of ozone layer in the stratosphere.

CO_2 FERTILISATION EFFECT ON PLANTS

The measurements made at Mauna Loa Observatory in USA have shown that atmospheric CO_2 concentration has been rapidly rising since 1959. If this rising trend continues, it is expected that the atmospheric CO_2 concentration shall increase to a level between 540 and 970 ppm by the end of the 21st century.

With a doubling of the atmospheric CO_2 concentration, the growth of many plants, particularly the C_3 species, under favourable conditions of wateiv nutrients, light and temperature, could increase by about 30 per cent on average, in the short-term (i.e., up to a few years). The response of plants to elevated concentrations of CO_2 is known as the *Carbon dioxide fertilisation effect.* Due to increased CO_2 concentration, the rate of photosynthesis will increase and the stomatal conductance will decrease (due to partial closure of stomata). Thus, the transpiration rate may be reduced and consequently, water-use efficiency will increase. This may allow many species to grow successfully in regions of water scarcity. Under higher atmospheric CO_2 conditions, plants slTall allocate a greater proportion of photosynthate to roots. Greater root production is expected to enhance mycorrhizal development and fixation of N_2 in root nodules, thereby enabling the plants to grow in nutrient- poor soils. However, under natural conditions, the beneficial effects of increased CO_2 may not be actually realised because of negative effects of global warming.

Possible Effects of Global Warming

The predicted global warming in near future has the potential to affect the weather and climate, sea level, and the distribution and phenology of organisms, food production and fishery resources in the oceans. Let us study some of these effects.

Effects on weather and climate : The global mean temperature has increased by approximately 0.6°C in the 20th century. The average temperature of the earth may increase by 1.4 to 5.8°C by the year 2100 from the 1990 level. Temperature changes are expected to be most marked in regions of middle and higher latitudes. Warming of atmosphere will considerably increase its moisture carrying capacity. While the troposphere warms up, the stratosphere will cool down. This would cause widespread changes in precipitation patterns due to 'changed pattern of air-mass movements. Precipitation is expected to increase at higher latitudes in both summer and winter and in southern and eastern Asia in summer. Winter precipitation may decrease at lower latitudes. Besides, the frequency of extreme events (e.g., droughts, floods, etc.) is expected to increase substantially. The climate change will increase threats to human health, particularly in tropical and subtropical countries, due to change in ranges of disease vectors, water-borne pathogens, etc.

Sea level change : Sea level has been raised by 1 to 2 mm per year during the 20th century. It is predicted that by the year 2100, the global mean sea level can increase up to

0.88 m over the 1990 level. The global warming may contribute to sea level rise due to the thermal expansion of ocean as it warms, and melting of glaciers and Greenland ice sheets. A rise of even half a meter in sea level would profoundly affect human population, one-third of which lives within 60 km of a coastline. Many of the world's important cities and coastal areas will come under the threat of flood. Several low-lying islands may be submerged. Inundation of coastal salt marshes and estuaries may deprive many important birds and fish their breeding grounds, forcing their extinction. Thus, sea-level rise is projected to have negative impacts on human settlements, tourism, freshwater supplies, fisheries, exposed infrastructure, agricultural lands, and wetlands.

Effects on range of species distribution: You may recall from chapter 16 that each plant or

animal species occurs within a specific range of temperature. The global warming is likely to shift the temperature ranges and, therefore, would affect altitudinal and latitudinal distribution pattern of organisms. With increasing global warming many species are expected to shift slowly poleward, or toward high elevations in mountain areas. For example, with a global temperature rise by 2 to 5°C during the 21st century, the temperate region vegetation may extend 250-600 km poleward. Since trees are sensitive to temperature stress, a rapid rise in temperature may cause large scale death of trees and their replacement by scrub vegetation. Many species may not be able to migrate fast enough to track temperature changes and may disappear.

Food production : Increased temperature will cause eruption of plant diseases and pests, explosive growth of weeds and increased basal rate of respiration of plants. A combination of all these factors will decrease the crop production. Small temperature increase may slightly enhance crop productivity in temperate regions, but larger temperature changes will reduce crop productivity there. In all tropical and sub-tropical regions, even a small temperature rise will have detrimental effect on crop productivity. Rice yield alone, in south-east Asia, will reduce by 5 per cent for each 1°C increase in temperature. Despite beneficial CO_2 fertilisation effect, the overall world crop productivity will, in-all probabilities, decline considerably due to projected global warming. This will have alarming consequences on world food supply.

Biodiversity loss

Thousands of species risk extinction from disappearing habitat, changing ecosystems and acidifying oceans. According to the IPCC, climate change will put some 20% to 30% of species globally at increasingly high risk of extinction, possibly by 2100.

Decline in polar bears

Arctic sea ice is the polar bear's feeding habitat. As sea ice disappears, bear mortality rises. In 2008, the polar bear became the first animal to be added to the Endangered Species Act list of threatened species because of global warming.

The U.S. Geological Survey has warned that two-thirds of the world's polar bear populations could be lost by mid-century as sea ice continues to retreat.

Acidifying oceans

About one-third of the CO_2 pollution from smokestacks and tailpipes is absorbed by the world's oceans, where it forms carbonic acid. A 2010 study published in Nature Geoscience warns that unchecked greenhouse gas emissions could cause oceans to acidify at a rate unprecedented in at least the last 65 million years.

Coral bleaching

Coral reefs are highly sensitive to small changes in water temperature. Heat triggers corals to shed the algae that nourish them—a bleaching event that leaves coral white.

In 1998, the world's coral suffered its worst year on record, which left 16% bleached or dead. Continued warming could cause mass bleachings to become an annual event within the next few decades, wiping out many reef ecosystems.

Shifting habitat

As the mercury rises, plants and animals are shifting their ranges toward the poles and to higher altitudes, and migration patterns for animals as diverse as whales and butterflies are being disrupted.

Threats to Western forests

The U.S. Geological Survey reports that slight changes in the climate may trigger abrupt ecosystem changes that may be irreversible.

All told, the Rocky Mountains in Canada and the U.S. have seen nearly 70,000 square miles of forest die – an area the size of Washington state – since 2000 due to outbreaks of tree-killing insects.

Thinning ice, rising seas

Rising seas are one of the most certain effects of global warming as warming ocean

waters expand and melting glaciers, ice caps and ice sheets add more water to the oceans. The IPCC estimates that melting ice caps and glaciers—which are some of our most visible indicators of climate change—accounted for about 25% of sea level rise from 1993 to 2003.

Arctic sea ice is shrinking

Satellite images show that the extent of Arctic summer sea ice has decreased by almost 9% per decade since 1979. The Arctic summer could be ice-free by mid-century, according to a study by the National Oceanic and Atmospheric Administration.

Melting glaciers

A 2005 survey of 442 glaciers from the World Glacier Monitoring Service found that 90% of the world's glaciers are shrinking as the planet warms.

Glacier National Park now has only 25 glaciers, versus 150 in 1910. At the current rate of retreat, the glaciers in Glacier National Park could be gone in a matter of decades, according to some scientists.

Threats to people around the globe

Extreme weather will become more frequent—and more dangerous.

The World Meteorological Organization reported that 2000-2009 was the hottest decade on record, with eight of the hottest 10 years having occurred since 2000.

It's not just the heat that poses threats. Scientists say global warming is speeding up the cycling of water between the ocean, atmosphere and land, resulting in more intense rainfall and droughts at the same time across the globe.

A surge in wildfires

Hot, dry conditions create a tinderbox ideal for wildfires. This could have a devastating impact on America's Southwest.

Increased flooding

The 2007 IPCC report concludes that intense rain events have increased in frequency during the last 50 years and that human-induced global warming has been a factor.

Increased drought

There have also been increased periods of drought, particularly in famine-stricken areas of Africa and Asia. According to the National Center for Atmospheric Research, the percentage of Earth's surface suffering drought has more than doubled since the 1970s. In Africa alone, the IPCC projects that between 75 and 250 million people will be exposed to increased water stress due to climate change.

More intense hurricanes

As the oceans warm, scientists predict that hurricane intensity could increase. The associated storm surge poses particular risk to low-lying coastal cities like Miami, Charleston (SC) and Wilmington (NC).

Threats to human health

A warming planet threatens people worldwide, causing deaths, spreading insect-borne diseases and exacerbating respiratory illnesses. Extreme weather will also put more people in harm's way.

The World Health Organization believes that even the modest increases in average temperature that have occurred since the 1970s are responsible for at least 150,000 extra deaths a year—a figure that will double by 2030, according to WHO's conservative estimate.

Devastating heat waves

Recent studies show extreme heat events that now occur once every 20 years will occur about every other year in much of the country, if current trends continue.

In 1995, Chicago suffered a heat wave that killed more than 700 people. Chicagoans could experience that kind of relentless heat up to three times a year by 2100.

Spread of disease

Diseases such as malaria and dengue fever could become more difficult to control in areas where it's currently too cold for them to spread year-round. The malaria parasite itself is

generally limited to certain areas by cooler winter temperatures since it is not able to grow below 16°C. As temperatures rise, diseases can grow and disease vectors (the carriers that transmit disease, such as mosquitoes) will mature more rapidly and have longer active seasons.

Worsening air quality

More hot days mean ripe conditions for ground-level ozone, or smog, which forms when pollutants from tailpipes and smokestacks mix in sunny, stagnant conditions. Higher temperatures cause higher emissions of one type of pollutant, namely hydrocarbons and other volatile organic compounds, as well as speeding up the chemical reactions that form ozone smog.

Smog triggers asthma attacks and worsens other breathing problems. The number of Americans with asthma has more than doubled over the past two decades to 20 million. Continued warming will only worsen the problem.

OZONE DEPLETION

What is Ozone?

Ozone is a natural gas composed of three atoms of oxygen. It chemical symbol is O3. It is blue in color and has a strong odor. Normal oxygen (O2), which we breathe, has two oxygen atoms and is colorless and odorless.

Ozone also called Stratospheric Ozone occurs naturally in the upper Stratosphere. The stratosphere is the layer of space 6 to 30 miles above the earth's surface.

Formation of Ozone

The air is full of gases reacting with each other, even though our eyes do not see. When UV light strikes (Oxygen) O2 molecules, they are split into two individual O atoms — O and O. When one of the O atoms combine with O2 molecule, ozone (O3) is created.

Even though Ozone is only a small part of the gases in this layer, it plays a vital role because it shields us from the sun's harmful UV rays. It is called Good Ozone, for obvious reasons—because it protects humans, life and animals on earth.

Ozone depletion describes two distinct but related phenomena observed since the late 1970s: a steady decline of about 4% per decade in the total volume of ozone in Earth's stratosphere (the ozone layer), and a much

OZONE DEPLETING SUBSTANCES (ODS)

There is a list of more than 20 substances that are controlled by the European law on ozone depleting substances and there are bans and restrictions on their production, import, export, placing on the market, use, recovery, recycling, reclamation and destruction. These substances are grouped and their common historical uses are presented for information:

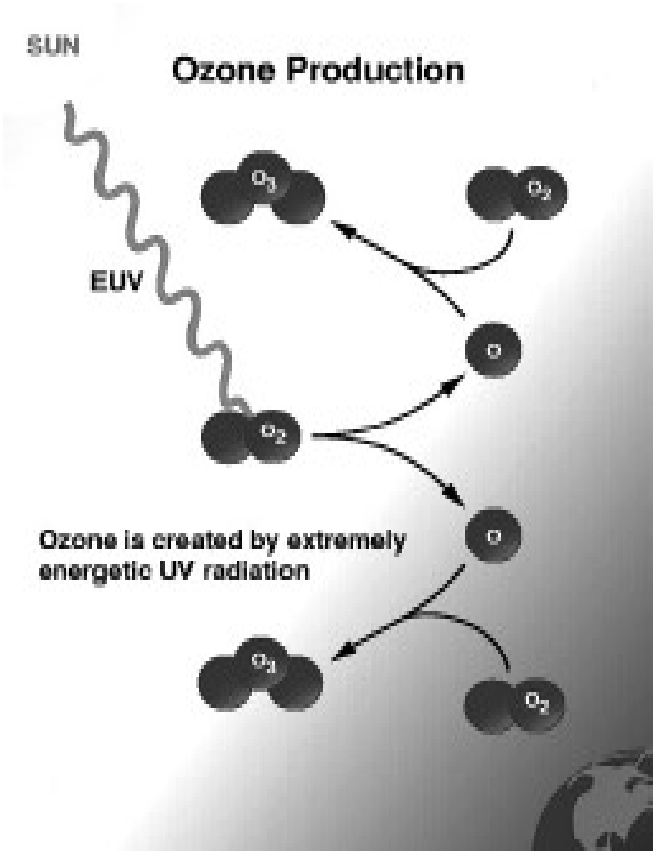
CFC and HCFCs - mostly used in refrigeration, air conditioning and heat pump systems. Only HCFCs can continue to be used for a limited period of time.

- **Halons** - used historically as fire suppression agents and fire fighting, but now only allowed in very limited situations
- **Carbon tetrachloride (Tetrachloromethane)** - limited solvent use in laboratories and chemical and pharmaceutical industry.
- **1,1,1,-trichloroethane** - limited solvent use in laboratories and chemical and pharmaceutical industry.
- **Methyl bromide** - historically used in fumigation, soil treatment, pest control, quarantine, market gardening. Methyl bromide is no longer registered for use in Ireland.
- **Hydrobromofluorocarbons** - historically used in fire suppression systems and fire fighting.
- **Bromochloromethane** - historically used in the manufacture of biocides.

larger springtime decrease in stratospheric ozone over Earth's polar regions. The latter phenomenon is referred to as the ozone hole. In addition to these well-known stratospheric phenomena, there are also springtime polar tropospheric ozone depletion events.

The details of polar ozone hole formation differ from that of mid-latitude thinning, but the most important process in both is catalytic destruction of ozone by atomic halogens.[1] The main source of these halogen atoms in the stratosphere is photodissociation of man-made halocarbon refrigerants, solvents, propellants, and foam-blowing agents (CFCs, HCFCs, freons, halons). These compounds are transported into the stratosphere after being emitted at the surface. Both types of ozone depletion have been observed to increase as emissions of halo-carbons increased.

CFCs and other contributory substances are referred to as ozone-depleting substances (ODS). Since the ozone layer prevents most harmful UVB wavelengths (280–315 nm) of ultraviolet light (UV light) from passing through the Earth's atmosphere, observed and projected decreases in ozone have generated worldwide concern leading to adoption of the Montreal Protocol that bans the production of CFCs, halons, and other ozone-depleting chemicals such as carbon tetrachloride and trichloroethane. It is suspected that a variety of biological consequences such as increases in skin cancer, cataracts, damage to plants, and reduction of plankton populations in the ocean's photic zone may result from the increased UV exposure due to ozone depletion.



OZONE DEPLETING SUBSTANCES

- Refrigeration
- Aerosol spray cans
- Air conditioning
- Foam insulation
- Cleaning agents
- Packing material etc

Ozone hole: During the period 1956- 1970, the spring-time O_3 layer thickness above Antarctica varied from 280 to 325 Dobson Unit (1 DU = 1 ppb). The thickness was sharply reduced to 225 DU in 1979 and to 136 DU in 1985. Later, the O_3 layer thickness continued to decline to about 94 DU in 1994.

The decline in spring-time ozone layer thickness is tenned Ozone hole. The ozone hole was first discovered m 1985 over Antarctica. The existence of ozone hole was also confirmed above Arctic in 1990. The global-average total column ozone amount for the period 1997-2001 was about 3 per cent below the pre-1980 average values.

CFCs, CH_4 and N_2O escape into the stratosphere and cause destruction of O_3 there. Most damaging is the effect of CFCs, which produce “active chlorine” (Cl and CIO radicals) in the presence of UV-radiation. These radicals catalytically destroy ozone, converting it into oxygen. CH_4 and N_2O also cause ozone destruction through a complicated series of reactions. For making these discoveries related to O_3 destruction, Sherwood Rowland and Mario Molina, along with Paul Crutzen, were honoured with Nobel Priz (for Chemistry in 1995.

THE IMPACTS OF OZONE DEPLETION

Stratospheric ozone filters out most of the sun's potentially harmful shortwave ultraviolet (UV) radiation. If this ozone becomes depleted, then more UV rays will reach the earth. Exposure to higher amounts of UV radiation could have serious impacts on human beings, animals and plants, such as the following:

Harm to human health

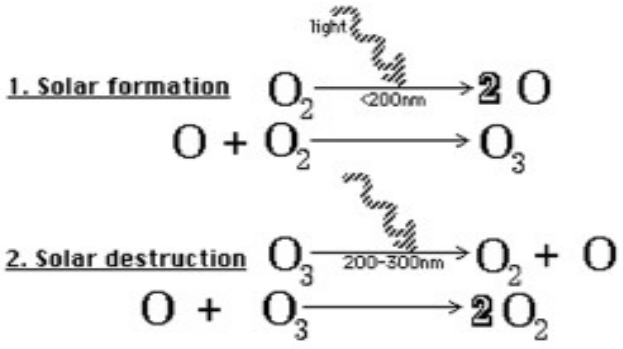
More skin cancers, sunburns and premature aging of the skin. More cataracts, blindness and other eye diseases: UV radiation can damage several parts of the eye, including the lens, cornea, retina and conjunctiva.

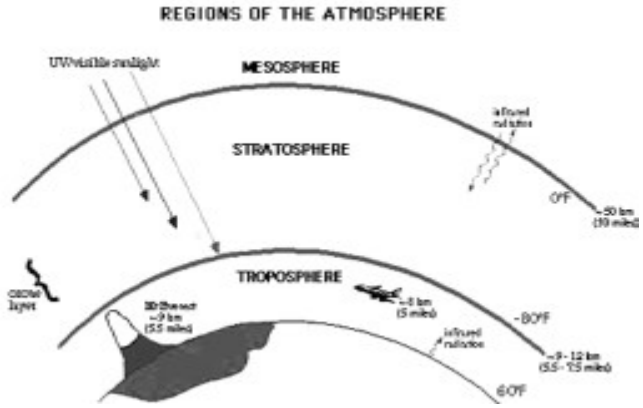
Cataracts (a clouding of the lens) are the major cause of blindness in the world. A sustained 10% thinning of the ozone layer is expected to result in almost two million new cases of cataracts per year, globally (Environment Canada, 1993).

Weakening of the human immune system (immunosuppression). Early findings suggest that too much UV radiation can suppress the human immune system, which may play a role in the development of skin cancer.

Adverse impacts on agriculture, forestry and natural ecosystems: Several of the world's major crop species are particularly vulnerable to increased UV, resulting in reduced growth, photosynthesis and flowering. These species include wheat, rice, barley, oats, corn, soybeans, peas, tomatoes, cucumbers, cauliflower, broccoli and carrots.

The effect of ozone depletion on the Canadian agricultural sector could be significant.





Only a few commercially important trees have been tested for UV (UV-B) sensitivity, but early results suggest that plant growth, especially in seedlings, is harmed by more intense UV radiation.

Damage to marine life

In particular, plankton (tiny organisms in the surface layer of oceans) are threatened by increased UV radiation. Plankton are the first vital step in aquatic food chains.

Decreases in plankton could disrupt the fresh and saltwater food chains, and lead to a species shift in Canadian waters.

Loss of biodiversity in our oceans, rivers and lakes could reduce fish yields for commercial and sport fisheries.

Animals

In domestic animals, UV overexposure may cause eye and skin cancers. Species of marine animals in their developmental stage (e.g. young fish, shrimp larvae and crab larvae) have been threatened in recent years by the increased UV radiation under the Antarctic ozone hole.

Materials

Wood, plastic, rubber, fabrics and many construction materials are degraded by UV radiation.

The economic impact of replacing and/or protecting materials could be significant.

MEASURES FOR MITIGATING GLOBAL WARMING

The long-term challenge of stabilising the atmospheric concentrations of greenhouse

gases requires that global emissions be significantly lowered than what they are today. In 1987,27 industrialised countries signed the Montreal Protocol, a landmark international agreement to protect the stratospheric ozone by agreeing to limit the production and use of ozone-depleting substances, phasing out of ozone-depleting substances and helping the developing countries to implement use of alternatives to CFCs. To-date, more than 175 countries have signed, the Montreal Protocol. The United Nations Conference on Environment and Development (UNCED, Earth Summit), held at Rio de Janeiro, Brazil in 1992, established the principles for reducing greenhouse gas emission. Tfie Kyoto Protocol, approved by a follow-up conference held in Kyoto, Japan, during December 1997, has specified the commitments of different countries to mitigate climate change. This protocol requires countries to take appropriate measures to reduce their overall greenhouse gas emissions to a level at least 5 per cent below the 1990 level by the commitment period 2008-2012.

MONTREAL PROTOCOL

The Montreal Protocol on Substances that Deplete the Ozone Layer (a protocol to the Vienna Convention for the Protection of the Ozone Layer) is an international treaty designed to protect the ozone layer by phasing out the production of numerous substances that are responsible for ozone depletion. The treaty was opened for signature on September 16th, 1987, and entered into force on January 1st, 1989, followed by a first meeting in Helsinki, May 1989. Since then, it has undergone seven revisions, in 1990 (London), 1991 (Nairobi), 1992 (Copenhagen), 1993 (Bangkok), 1995 (Vienna), 1997 (Montreal), and 1999 (Beijing). If the international agreement is adhered to, the ozone layer is expected to recover by 2050. Due to its widespread adoption and implementation it has been hailed as an example of exceptional international co-operation, with Kofi Annan quoted as saying that "perhaps the single most successful international agreement to date has been the Montreal Protocol". The two ozone treaties have been ratified by 197 parties, which includes 196 states and the European Union, making them the first universally ratified treaties in United Nations history.

Declaration of Helsinki

The Declaration of Helsinki is a set of ethical principles regarding human experimentation developed for the medical community by the World Medical Association (WMA). It is widely regarded as the cornerstone document on human research ethics.

It is not a legally binding instrument under the international law, but instead draws its authority from the degree to which it has been codified in, or influenced, national or regional legislation and regulations. Its role was described by a Brazilian forum in 2000 in these words "Even though the Declaration of Helsinki is the responsibility of the World Medical Association, the document should be considered the property of all humanity".

STOCKHOLM DECLARATION

The Stockholm Declaration Declaration of the Conference on the Human Environment of 1972 Because the Stockholm Declaration reinforced a preexisting law from Roman times, it did not result in a legal outcome. In 1971, the declaration was proposed by the Conference's Preparatory Committee, however, the draft declaration was officially produced from June 5-16 in 1972. The Stockholm Declaration is international because environmental problems that include minimizing human impact on the earth must be handled at a global level. This declaration has many different impacts on the environment including:

- temporarily stopping the discharge of harmful substances and heat release in large quantities in the air and water
- protecting wildlife and their habitats in marine and terrestrial ecosystems
- controlling the growth of the population as a whole The function of the Stockholm Declaration was to maintain and improve the natural environment while focusing mainly on supporting people and their overall needs throughout the process. An international institution of the United Nations that

arranges environmental activities and helps developing countries to become environmentally friendly and enforce their practices.

RIO–EARTH SUMMIT

Five years after the Brundtland Report, the UN General Assembly asked for a report on progress made towards sustainable development and convened the United Nations Conference on Environment and Development (UNCED). Held in June 1992 at Rio de Janeiro in Brazil, the Rio Earth Summit as it became known, was the largest environmental conference ever held, attracting over 30,000 people including more than 100 heads of state. The objectives of the conference were to build upon the hopes and achievements of the Brundtland Report, in order to respond to pressing global environmental problems and to agree major treaties on biodiversity, climate change and forest management. Perhaps for the first time, a major environmental conference adopted a more nature-centred approach towards environmental problems.

Despite its environmental focus, the biggest arguments at the Earth Summit concerned finance, consumption rates and population growth. The developed nations were calling for environmental sustainability, but the less industrialised developing nations were demanding a chance to allow their economies to catch up with the developed world.

The Earth Summit produced a number of outcomes including:

- The Convention on Biological Diversity;
- The Framework Convention on Climate Change;
- Principles of Forest Management;
- The Rio Declaration on Environment and Development; and Agenda 21.

Together these outcomes covered every aspect of sustainable development. Legislation was passed and many agreements made, committing nations, including the UK, to become more sustainable. These agreements and guidelines are still adhered to today and are influencing many political and business decisions.

KYOTO PROTOCOL, 1997 (COP-3)

This is a legally binding agreement. It set binding targets for 37 industrialised nations and the European Community for reducing green house (GHG) emissions. These reductions amount to an average of 5.3% against 1990 levels over the five year commitment period of 2008-2012. It was successful conference in imposing legally binding obligation on the part of developed countries.

USA and Australia did not sign this agreement. In order to transfer environment friendly technologies from developed countries to developing countries for checking the emissions of greenhouse gases, a Global Environment Facility (GEF) was established, with the help of World Bank, UNDP and UNEP. Also a Clean Development Mechanism (CDM) was initiated to bring in private participation and investment in the form of carbon trading.

Parties to UNFCCC are classified as:

- Annex I countries - industrialized countries and economies in transition
- Annex II countries - developed countries which pay for costs of developing countries
- Developing countries.

Annex I countries which have ratified the Protocol have committed to reduce their emission levels of greenhouse gasses to targets that are mainly set below their 1990 levels. They may do this by allocating reduced annual allowances to the major operators within their borders. These operators can only exceed their allocations if they buy emission allowances, or offset their excesses through a mechanism that is agreed by all the parties to UNFCCC.

Annex II countries are a sub-group of the Annex I countries. They comprise the OECD members, excluding those that were economies in transition in 1992.

Developing countries are not required to reduce emission levels unless developed countries supply enough funding and technology. Setting no immediate restrictions under UNFCCC serves three purposes:

- it avoids restrictions on their development, because emissions are strongly linked to industrial capacity.

- they can sell emissions credits to nations whose operators have difficulty meeting their emissions targets.
- They get money and technologies for low-carbon investments from Annex II countries.

Developing countries may volunteer to become Annex I countries when they are sufficiently developed.

Recognizing that developed countries are principally responsible for the currertt high levels of GHGs emission in the atmosphere as a result of more than 150 years of industrial activities, the Protocol places a heavier burden on developed countries under the principle of common but differentiated responsibilities. The Kyoto protocol was adopted in Kyoto in Japan on December 11, 1997 and entered into force on Feb 16, 2005.

Evaluation of Kyoto Protocol

The protocol has been described as socially unjust as it not based on per capita concept. This concept is necessary as about 20% of total population of the world residing in the developed nations is responsible for making 75% of the total GHGs emissions and that too to fulfill their luxury based needs. The per capita in North America and Western Europe is about 20 times more than in the developing countries.

Kyoto Protocol was signed in order to reduce GHGs emission but the flexibility mechanism like CDMs allows a developed country to take credit for the GHG emission reductions achieved in the developing countries with its assistance. It means the developed countries that are primarily responsible for increasing GHG emission can skip their reduction commitment only by spending money.

The sellers of GHG emission reductions credit may sell these credits on terms and conditions favorable to itself. Therefore the protocol is ecologically not very effective and it is seen more as a carbon trading agreement than an ecological agreement.

Carbon Trading

It is a name given to the exchange of emission permits. This exchange of emissions may take place within the economy or may take the form of international transactions. Emission permit is known alternatively as carbon credit. Carbon credits are certificate awarded to the countries that are[1] successful in reducing the emissions that caused global warming. Carbon credits are measured units of certified emission reduction and each CER is equivalent to 1 m^tffc ton of CO_2.

Methods/ Types of carbon trading

Emission trading/ Cap and Trade- When a country is able to reduce its emissions by more than the specified amount it can exchange some of its credit to another country who fails to reduce its emission level as per assigned amount. This kind of exchange of emission allowance is called emission trading.

Offset trading - In this a country can invest in carbon projects abroad to earn carbon credit and thereby meet its reduction commitment. Offset trading is thus nothing but investment abroad in Carbon-project. According to Kyoto protocol, if such a joint venture is between developed countries it is called Joint implementation, while if it is taken along with any developing and poor country it is called clean development mechanism (CDM).

Reducing GHG Emissions: Kyoto Mechanisms

The UN's Kyoto protocol established binding greenhouse gas emissions reduction targets for 37 industrialised countries and the European community. To help achieve these targets, the protocol introduced three "flexible mechanisms"- international emissions trading (IET), joint implementation (JI), and the clean development Mechanism (CDM).

CLEAN DEVELOPMENT MECHANISMS (CDM)

To date the CDM has arguably been the most successful of the three flexible mechanisms. It has two main goals: one, to assist countries without emissions targets (ie developing countries) in achieving sustainable development. Two, help those countries with emission reduction targets under Kyoto

(ie developed countries) in achieving compliance by allowing them to purchase offsets created by CDM projects.

A broad range of projects are eligible for CDM accreditation, with the notable exceptions of nuclear power and avoided deforestation projects. They vary from hydropower and wind energy projects, to fuel switching and industrial efficiency improvements. Crucially, to qualify for accreditation the project developers must prove 'additionality', defined as emissions reductions that are additional to what would have otherwise occurred. This is calculated by using an approved methodology to subtract the estimated emissions of a given project from a hypothetical 'business-as-usual' emissions baseline.

Once registered, projects are then issued Certified Emissions Reductions (CER), with each CER unit equal to a reduction of one tonne of carbon dioxide equivalent. These CERs, or offsets, can be bought and used by developed countries to meet their Kyoto commitments. Companies can also purchase CERs to contribute towards their own emission reduction targets under mandatory emissions trading schemes (such as the EU Emissions Trading Scheme, ETS) or voluntary schemes.

There are currently over 3000 registered projects delivering an average of 500 million CERs per year. The overwhelming demand for CERs comes from the Emissions Trading Scheme (ETS), the world's largest functioning compliance carbon market.

CDM projects are not without their controversies however. Questions surround the sustainable development credentials of certain projects, particularly in the case of industrial gas projects. HFC-23 projects, for example, seem to create perverse incentives to continue to produce the ozone depleting gas HCFC-22 in order to destroy the waste gas by-product HFC-23.

Concerns have also been raised regarding the conduct of project owners, with certain CDM projects implicated in land rights issues and human rights abuses. Meanwhile, the geographical distribution of CDM projects, over 80% of which originate in China and India, calls into question the ability of the CDM to drive broad engagement with sustainable development across developing countries. What's more, critics would suggest a more fundamental flaw in the CDM is that it is impossible to prove the 'additionality' of a project in comparison to a hypothetical baseline.

In the course of CDM implementation, numerous complaints have been aired over such things as uneven distribution of benefits, difficult and lengthy registration process, high transaction costs, and inaccessibility to certain sectors. The more serious problems, however, are persistent issues that strike at the heart of the CDM and question its effectiveness as an instrument for climate justice and equity. Among these issues are:

- Trading in greenhouse gases turns them into a commodity, giving "owners" undue rights to pollute.
- Carbon trading allows companies and countries to claim to be reducing emissions, even as they continue to bum fossil fuels, destroy forests and pollute communities.
- Many companies are getting millions of dollars in CERs for projects they would have done anyway without the CDM incentive. This violates the "additionality" rule and means that these projects, rather than reducing overall emissions, are actually increasing them.
- CERs are awarded for reductions against a hypothetical baseline derived from future emission projections. This is extremely vulnerable to manipulation.
- The system rewards many projects for merely avoiding a part of the emissions that would have occurred under a business-as-usual scenario, but offers no incentive for choosing the best policy option.

Counter to this are the positive achievements of the CDM. It is expected to generate as much as 1 billion tonnes of emissions reductions up to 2012, with projects in 81 countries driving investment in a market worth $19.8 billion in 2010. The CDM has created a system where emission reduction

opportunities are actively sought out, and an institutional framework that stimulates secure and focused global investment in sustainable development projects.

In addition, the UN estimates that around 44% of all projects currently in the pipeline involve some form of technology transfer, with a significant proportion of this occurring in biomass energy and wind projects, methane avoidance projects, energy efficiency projects and landfill gas projects. The CDM can therefore be said to have made a considerable contribution to the development and transfer of knowledge and technology in developing countries, and positively impacted on local communities through the creation of jobs and infrastructure.

BALI ACTION PLAN (ROADMAP)

At the United Nations Framework Climate Change Conference (UNFCCC) on the island of Bali in Indonesia in December, 2007, the participating nations adopted the Bali Roadmap (also known as the Bali Action Plan) as a two-year process to finalizing a binding agreement in 2009 in Copenhagen.

Representatives from over 180 countries attended, together with observers from intergovernmental and nongovernmental organizations. Negotiations on a successor to the Kyoto Protocol dominated the conference.

Initial EU proposals called for global emissions to peak in 10 to 15 years and to decline to "well below half" of the 2000 level by 2050 for developing countries, and for developed countries to achieve emissions levels 20-40 percent below 1990 levels by 2020.

The United States strongly opposed these numbers, at times backed by Japan, Canada, Australia and Russia. The resulting compromise mandates "deep cuts in global emissions" with references to the IPCC's Fourth Assessment Report.

What was agreed?

Cutting Emissions

The nations acknowledged that "evidence for global warming is unequivocal, and that humans must reduce emissions to reduce the risks of "severe climate change impacts".

There was a strong consensus for updated changes for both developed and developing countries. Although specific numbers to cut emissions were not agreed upon, many countries agreed there was a need for "deep cuts in global emissions" and that "developed country emissions must fall 10-40% by 2020?.

Forests

The nations pledged "policy approaches and positive incentives" to protect forests.

Adaptation

The nations opted for enhanced co-operation to "support urgent implementation" of measures to protect poorer countries against climate change impacts.

Technology transfer

The nations said they would consider how to facilitate the transfer of clean technologies from industrialised nations to the developing countries.

Timescales

Four major UNFCCC meetings to implement the Bali Roadmap were planned for 2008. The first was held in either March or April and the second in June. The third was held in Berlin in September, followed by a major meeting in Poznan, Poland in December 2008.

The negotiations process is scheduled to conclude in November 2009 at a major summit in Copenhagen, Denmark.

COPENHAGEN SUMMIT (UFCCC COP 15, 2009)

The 2009 United Nations Climate Change Conference, commonly known as the Copenhagen Summit, was held at the Bella Center in Copenhagen, Denmark, between 7 and 18 December. The conference included the 15th Conference of the Parties (COP 15) to the United Nations Framework Convention on Climate Change (UNFCCC) and the 5th Meeting of the Parties (MOP 5) to the Kyoto Protocol. According to the Bali Road Map, a framework

for climate change mitigation beyond 2012 was to be agreed there.

On Friday 18 December, the final day of the conference, international media reported that the climate talks were "in disarray". Media also reported that in lieu of a summit collapse, only a "weak political statement" was anticipated at the conclusion of the conference. The Copenhagen Accord was drafted by the United States, China, India, Brazil and South Africa on 18 December, and judged a "meaningful agreement" by the United States government. It was "taken note of", but not "adopted", in a debate of all the participating countries the next day, and it was not passed unanimously. The document recognised that climate change is one of the greatest challenges of the present day and that actions should be taken to keep any temperature increases to below 2°C. The document is not legally binding and does not contain any legally binding commitments for reducing CO_2 emissions.

CANCUN SUMITT (COP-16)

The United Nations Climate Change Conference in Cancun, Mexico, took place from 29 November to 11 December 2010. The conference included the sixteenth session of the Conference of the Parties (COP 16) to the United Nations Framework Convention on Climate Change (UNFCCC) and the sixth session of Conference of the Parties serving as the Meeting of the Parties to the Kyoto Protocol (COP/MOP 6). Four subsidiary bodies convened: the thirteenth session of the Ad Hoc Working Group on Long-term Cooperative Action under the UNFCCC (AWG-LCA 13); the fifteenth session of the Ad Hoc Working Group on Further Commitments for Annex I Parties under the Kyoto Protocol (AWG-KP 15); and the 33rd sessions of the Subsidiary Body for Implementation (SBI 33) and Subsidiary Body for Scientific and Technological Advice (SBSTA 33). These events drew almost 12,000 participants, including almost 5200 government officials, 5400 representatives of UN bodies and agencies, intergovernmental organizations and non-governmental organizations, and 1270 accredited members of the press.

The focus in Cancun was on a two-track negotiating process aiming to enhance long-term cooperation under the Convention and the Protocol. The original deadline for completing these negotiations was the UN Climate Change Conference in Copenhagen, held in December 2009, but as many issues remained outstanding, the mandates of the two AWGs were extended until Cancun, where they were expected to report their respective outcomes to COP 16 and COP/MOP 6.

Expectations for Cancun were modest, with few anticipating a legally-binding outcome or agreement on each outstanding issue. Nevertheless, many still hoped that Cancun would produce meaningful progress on some of the key issues. In the lead-up to the conference, several matters were widely identified as areas where a balanced “package” of outcomes could be agreed. These issues included mitigation, adaptation, financing, technology, reducing emissions from deforestation and forest degradation in developing countries, including conservation, sustainable management of forests and enhancement of forest carbon stocks (REDD+) and monitoring, reporting and verification (MRV) and international consultation and analysis (ICA). Negotiations on these key issues took place throughout the two-week meeting, with parties meeting extensively in plenary, contact groups, informal consultations and bilateral meetings. During the second week, ministers from developed and developing countries were “paired” in an attempt to facilitate negotiations on the main issues. These negotiations continued all week, with regular informal “stocktaking” plenary sessions, which were held to maintain a degree of transparency and keep all participants informed about progress.

By early Saturday morning, parties had finalized the “Cancun Agreements.” The Agreements include decisions under both the Convention and Protocol negotiating tracks, and contain provisions on adaptation, REDD+, technology, mitigation and finance. While the substantive outcome was viewed by many as far from perfect and Bolivia went as far as to oppose the adoption of the Agreements, most participants were satisfied with the outcome that restored confidence in the UNFCCC process. However, in spite of the sense of relief felt by

many at securing a result, most participants acknowledged that it was a relatively small step in combating climate change.

In addition to the Cancun Agreements, the COP and COP/MOP adopted 20 other decisions on matters ranging from capacity building to administrative, financial and institutional matters. As well, the SBI and SBSTA adopted over 20 conclusions on a range of topics, including the financial mechanism, arrangements for intergovernmental meetings, and a wide range of methodological issues.

DURBAN SUMMIT – COP 17, 2012

The United Nations Climate Change Conference in Durban, South Africa, was held from 28 November - 11 December 2011. The conference involved a series of events, including the seventeenth session of the Conference of the Parties (COP 17) to the UN Framework Convention on Climate Change (UNFCCC) and the seventh meeting of the Conference of the Parties serving as the Meeting of Parties to the Kyoto Protocol (CMP 7).

In support of these two main bodies, four other bodies convened: the resumed 14th session of the Ad hoc Working Group on Long-term Cooperative Action under the Convention (AWG-LCA); the resumed 16th session of the Ad hoc Working Group on Further Commitments for Annex I Parties under the Kyoto Protocol (AWG-KP); and the 35th sessions of the Subsidiary Body for Implementation (SBI) and the Subsidiary Body for Scientific and Technological Advice (SBSTA).

The Conference drew over 12,480 participants, including over 5400 government officials, 5800 representatives of UN bodies and agencies, intergovernmental organizations and civil society organizations, and more than 1200 members of the media.

The meetings resulted in the adoption of 19 COP decisions and 17 CMP decisions and the approval of a number of conclusions by the subsidiary bodies. These outcomes cover a wide range of topics, notably the establishment of a second commitment period under the Kyoto Protocol, a decision on long-term cooperative action under the Convention, the launch of a new process towards an agreed outcome with legal force applicable to all parties to the Convention, and the operationalization of the Green Climate Fund.

After the frustrations at the Copenhagen conference and the struggle to rescue the multilateral climate regime in Cancun, negotiators in Durban turned a corner and not only resuscitated the Kyoto Protocol but, in doing so, adopted a decision that will lead to negotiations on a more inclusive 21st century climate regime. There was a strong sense that elements of the Durban package, guided by a need to fulfill long overdue commitments that go back to the Bali Roadmap, restored sufficient momentum for a new negotiation process, one that will continue to witness a series of differentiated interests across and within the traditional lines of division between developed and developing countries. Many welcomed the adoption decisions including on the Green Climate Fund, and the Durban Platform, as well as the process to launch an agreement with legal force, while others continued to insist on the urgent need to significantly scale up the level of ambition to address the gap between existing mitigation pledges and the needed emission reductions recommended by science.

This report summarizes the discussions, decisions and conclusions based on the agendas of the COP, CMP and the subsidiary bodies.

DOHA SUMMIT – COP 18, 2012

The United Nations Climate Change Conference in Doha, Qatar, took place from 26 November to 8 December 2012. It included the eighteenth session of the Conference of the Parties (COP 18) to the United Nations Framework Convention on Climate Change (UNFCCC) and the eighth session of the Conference of the Parties serving as the Meeting of the Parties to the Kyoto Protocol (CMP 8). The conference also included meetings by five subsidiary bodies: the thirty-seventh sessions of the Subsidiary Body for Scientific and Technological Advice (SBSTA 37) and the Subsidiary Body for Implementation (SBI 37), the second part of the seventeenth session of the Ad hoc Working Group on Further Commitments

for Annex I Parties under the Kyoto Protocol (AWG-KP 17), the second part of the fifteenth session of the Ad hoc Working Group on Long-term Cooperative Action under the UNFCCC (AWG-LCA 15) and the second part of the Ad hoc Working Group on the Durban Platform for Enhanced Action (ADP 1).

Marking the first time that UN climate change negotiations took place in the Middle East, the conference drew approximately 9,000 participants, including 4,356 government officials, 3,956 representatives of UN bodies and agencies, intergovernmental organizations and civil society organizations, and 683 members of the media.

Negotiations in Doha focused on ensuring the implementation of agreements reached at previous conferences. The package of "Doha Climate Gateway" decisions adopted on the evening of Saturday, 8 December, included amendments to the Kyoto Protocol to establish its second commitment period. Having been launched at CMP 1 in 2005, the AWG-KP terminated its work in Doha. The parties also agreed to terminate the AWG-LCA and negotiations under the Bali Action Plan. Key elements of the outcome also included agreement to consider loss and damage, "such as" institutional mechanism to address loss and damage in developing countries that are particularly vulnerable to the adverse effects of climate change.

While developing countries and observers expressed disappointment with the lack of ambition in outcomes on Annex I countries' mitigation and finance, most agreed that the conference had paved the way for a new phase, focusing on the implementation of the outcomes from negotiations under the AWG-KP and AWG-LCA, and advancing negotiations under the ADP.

INDIA'S EFFORTS TO MITIGATE GLOBAL WARMING

India is quite aware to the danger of climate change and increase in GHG emission. India has already declared that even as it pursues its social and economic development objectives, it will not allow its per capita GHGs emissions (1.1 tonne) to exceed the average per capita emission of the developed countries. India has also declared to bring it's carbon intensity to 20-25% of 2005 base level by 2020. India has also proposed REDD+ mechanism. India has also come up with an ambitious proposal that major developing and developed nations set up a network of research and development initiations under the name of CLEAN NET which would specialize jn technological innovation in the field of climate change.

India has been trying to take comprehensive measures to combat climate change with an ambitious National Action Plan on Climate Change (NAPCC) adopted in June 2008, which includes 8 core national missions. It is also for enhancement of ecological sustainability of India's development path and addressing climate mitigation and adaptation. These missions are—

Jawaharlal Nehru national Solar mission targets 20,000 MW by 2022

The Jawaharlal Nehru National Solar Mission, also known as National Solar Mission, is one of the eight key National Mission's which comprise India's National Action Plan on Climate Change (NAPCC). NAPCC was launched

PRESENT SCENARIO

A total of 106 projects accounting a total of 40.648 MW has been sanctioned during 2010-11 under off Grid SPV application of JNNSM.

NVVN, which is the nodal agency for Solar Projects during the next three years, i.e., before March 2013 and are connected to the grid at a voltage level of 33 kV and above has selected 37 projects accounting for a total of 1480 MW(32 projects – 5MW each; 1 project – 20 MW; 3projects – 100MW each).

The projects sanctioned under NVVN, has to submit financial closure details by July, 9 but the ministry has received financial closure details of 17 photovoltaic (PV) and two concentrated solar power (CSP) projects only till June 30, 2011.

on 30th June 2008 which identified development of solar energy technologies in the country as a National Mission. Finally on January 11, 2010 GoI approved National Solar Mission.

The Solar Mission recommends the implementation in 3 stages leading up to an installed capacity of 20,000 MW by the end of the 13th Five Year Plan in 2022. It serves twin purposes:

(i) Long term energy Securty

(ii) Ecological Security

Objective of the National Solar Mission: is to establish India as a global leader in solar energy, by creating the policy conditions for its diffusion across the country as quickly as possible.

Other than energy and ecological security the Solar mission will also has the advantage of permitting the decentralized distribution of energy, thereby empowering people at the grassroot level". Also "India is a tropical country, where sunshine is available for longer hours per day and in great intensity. The daily average solar energy incident over India varies from 4 to 7 kWh/m2 with about 1500–2000 sunshine hours per year, depending upon location resulting in an aggregate incident radiation of about 5000 trillion Kwh/yr. This is far more than current total energy consumption. For example, even assuming 10% conversion efficiency for PV modules, it will still be thousand times greater than the likely electricity demand in India by the year 2015. Solar energy, therefore, has great potential as future energy source. Based on this vision a National Solar Mission is being launched under the brand name "Solar India".

The Mission will adopt a 3-phase approach,

- spanning the remaining period of the 11th Plan and first year of the 12th Plan (up to 2012-13) – Phase 1,
- the remaining 4 years of the 12th Plan (2013-17) – Phase 2 and
- the 13th Plan (2017-22) – Phase 3

The immediate aim of the Mission is to focus on setting up an enabling environment for solar technology penetration in the country both at a centralized and decentralized level. Also the Mission anticipates achieving grid parity by 2022 and parity with coal-based thermal power by 2030.

Mission Targets

To achieve the above mentioned target of 20,000 MW by 2022 by 3 phase approach under prevailing conditions is not an easy job, in short the mission needs supporting policies and incentives to achieve the target. The mission targets are:

- To create an enabling policy framework for the deployment of 20,000 MW of solar power by 2022.
- To ramp up capacity of grid-connected solar power generation to 1000 MW within three years – by 2013; an additional 3000 MW by 2017 through the mandatory use of the renewable purchase obligation by utilities backed with a preferential tariff. This capacity can be more than doubled – reaching 10,000MW installed power by 2017 or more, based on the enhanced and enabled international finance and technology transfer. The ambitious target for 2022 of 20,000 MW or more, will be dependent on the 'learning' of the first two phases, which if successful, could lead to conditions of grid-competitive solar power. The transition could be appropriately up scaled, based on availability of international finance and technology.
- To create favourable conditions for solar manufacturing capability, particularly solar thermal for indigenous production and market leadership.
- To promote programmes for off grid applications, reaching 1000 MW by 2017 and 2000 MW by 2022 .
- To achieve 15 million sq. meters solar thermal collector area by 2017 and 20 million by 2022.
- To deploy 20 million solar lighting systems for rural areas by 2022.

National Mission for Sustainable Agriculture

This mission would devise strategies to make Indian agriculture more resilient to climate change. It would identify and develop new varieties of crops and especially thermal resistant crops and alternative cropping pattern, capable of withstanding extremes of weather, long dry spells, flooding and variable moisture availability. Agriculture will need to be progressively adapted to projected climate change and our agricultural research systems must be oriented to monitor and evaluate climate change and recommend changes in agricultural practices accordingly.

This will be supported by the convergence and integration of traditional knowledge and practice system, information technology, geo-spatial technology and bio-technology. New credit and insurance mechanisms will be devised to facilitate adoption of desired practices. Focus would be on improving productivity of rainfed agriculture. India will spearhead efforts at the international level to work towards an ecologically sustainable green revolution.

National Mission for Enhanced Energy Efficiency

This Mission is basically 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 CO2 emissions (1994).

The Government of India already had a number of initiatives to promote energy efficiency in place before the NAPCC such as the star labelling system and energy conservation building code and had also passed the Energy Conservation Act of 2001. In addition to these, the NAPCC calls for:

Mandating specific energy consumption decreases in large energy consuming industries and creating a framework to certify excess energy savings along with market based, mechanisms to trade these savings. This is aimed at enhancing cost effectiveness of improvements in energy efficiency in energy-intensive sectors.

- Innovative measures to make energy efficient appliances/products in certain sectors more affordable.
- Creation of mechanisms to help finance demand side management programmes by capturing future energy savings and enabling public-private-partnerships for this.
- Developing fiscal measures to promote energy efficiency such as tax incentives for including differential taxation on energy efficient certified appliances.

National Mission on Sustainable Habitat

The aim of the Mission is to make habitats more sustainable through a threefold approach that includes.

- Improvements in energy efficiency of buildings in residential and commercial sector
- Management of Municipal Solid Waste (MSW)
- Promote urban public transport

The NAPCC claims that use of energy efficient options could hep 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.

The authors call for a wide and diverse range of policy instruments to overcome the barriers to adoption of energy efficient options in residential and commercial sectors, highlight the need for more a more competitive market for energy efficient products and advocate an involving all stakeholders. In addition, they once again stress on the need for technology transfer from developed countries.

With regards to MSW, the Plan suggests 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.

Finally, with regards to urban public transport, the NAPCC endorses mass transit such as buses, railways and mass rapid transit

systems and the use of CNG, ethanol blending in gasoline and bio-diesel. Hydrogen is something that is mentioned for the future. In addition, the Plan proposes the promotion of costal shipping and inland waterways, increasing attractiveness of railways, introducing appropriate transport pricing measures to influence purchase and use of vehicles in respect of fuel efficiency and fuel choice, tightening regulatory standards in fuel-economy of automobiles.

As with the other Missions, the Plan emphasises the need for R&D for all the components of the Sustainable Habitat Mission.

National Water Mission

According to the NAPCC, out of the 4000 billion m3 of precipitation that India receives annually, only 1000 billion m3 is available for use, which comes to approx. 1000 m3 per capita per annum. Further, by 2050 it states that India is likely to be water scarce. The 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.

National Mission for Sustaining the Himalayan Ecosystem

The NAPCC recognises the Himalayan ecosystem as vital to preserving the ecological security of the country. It consists of forests; perennial rivers which are a source of drinking water, irrigation, and hydropower; rich biodiversity; and is a major tourist attraction. All these are in danger from climate change through increases in temperature, changes in precipitation patterns, drought and glacier melt.

The Plan calls for empowering local communities especially Panchayats to play a greater role in managing ecological resources. It also reaffirms the following measures mentioned in the National Environment Policy, 2006.

- 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 scopes with unique "incomparable values".

In particular the Mission focuses on rain-fed agricultural zones and suggests:

- Development of drought and pest resistant crop varieties
- Improving methods to conserve soil and water
- Stakeholder consultations, training workshops and demonstration exercises for farming communities, for agro-climatic information sharing and dissemination
- Financial support to enable farmers to invest in and adopt relevant technologies to overcome climatic related stresses

In addition, the Mission makes suggestions for safeguarding farmers against increased risk due to climate change. These suggestions include, strengthening agricultural and

weather insurance; creation of web-enabled, regional language based services for facilitation of weather-based insurance; development of GIS and remote sensing methodologies; mapping vulnerable regions and disease hotspots; and developing and implementing region-specific, vulnerability based contingency plans.

Finally, it suggests greater access to information and use of biotechnology.

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 and, in addition, will also have its own research agenda supported by a network of dedicated climate change related institutions and universities and a Climate Research Fund. The Mission will also encourage private sector initiatives for developing innovative technologies for adaptation and mitigation.

The Mission includes:

- 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 and accuracy of climate change projections for India
- Strengthening of observational networks and data gathering and assimilation to increase access and availability to relevant data
- Creation of essential research infrastructure, such as high performance computing

Other Programmes

The NAPCC also describes other ongoing initiatives, including:

Power Generation: The government is mandating the retirement of inefficient coal-fired power plants and supporting the research and development of IGCC and supercritical technologies.

Renewable Energy: 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.

Energy Efficiency: Under the Energy Conservation Act 2001, large energy-consuming industries are required to undertake energy audits and an energy labeling 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.