* 1. **GLOBALWARMING**

The most significant global environmental problem faced by the world community is related to global environmental changes (GEC) consequent upon global warming resulting from a host of causal factors mainly anthropogenic factors such as changes in atmospheric chemistry, ozone depletion, emission of greenhouse gases at alarming increasing rate, urbanization, land use changes mainly deforestation etc. The probable net result of global warming and changes in atmospheric chemistry through air pollution and other natural sources would be climatic changes at local, regional and global levels including both short-term and long-term changes in weather and climate. The international communities are scared of catastrophic adverse effects of future climatic changes on different spheres of man and nature e.g. deglaciation and sea level changes, submergences of island nations and major coastal lowlands, atmospheric dynamics including evaporation and precipitation, global radiation balance, photosynthesis and ecological productivity, plant and animal community, human health and wealth and many more. The major sources of global environmental problems have been identified as changes in atmospheric chemistry through air pollution (both gaseous and solid particulates pollution) through rapid rate of industrialization and urbanization, population growth at alarming rate, advances in productive technology, major land use changes mainly deforestation etc. and efforts are afoot for tackling the problem of global warming leading to climatic changes at

International level.

It is, thus, necessary to discuss the evidences of global warming, trend of global warming, process of global warming including ozone depletion and emission of greenhouse gases, effects of global warming, air pollution leading to changes in atmospheric chemistry, and related environmental problems and international co operations to tackle the problems of global warming and climatic changes.

## Evidences of Global Warming

Global warming refers to gradual rise in atmospheric and ground surface air temperatures and consequent changes in global radiation balance caused mainly by anthropogenic processes (although natural processes also cause global warming and cooling) leading to climate changes at different levels (e.g. local, regional and global levels). It may be pointed out that the pattern of global rise in air temperatures has been studied and reported by different scientists and agencies, and a few computer models have been constructed, but their results are not uniform, rather a few are contrasting.

The radiative forcing and global warming potential (GWP) are used by the Intergovernmental Panel on Climatic Change (IPCC) to compare the relative warming effect of different gases. The radiative forcing as defined by the IPCC refers to the effects which greenhouse gases have in altering the energy balance of the earth- atmosphere system. On the other hand, the global warming potential is used as a tool to compare the relative warming effect of various gases emitted from anthropogenic sources such as carbon dioxide, carbon monoxide, nitrogen oxides, methane, sulphur dioxide, chlorofluorocarbon etc. The following evidences support the theory of gradual rise in air temperature and consequent global warming:

1. Temperature records,
2. Melting of mountain and continental glaciers,
3. Warming of ocean water at global level,
4. Rise in sea level,
5. Thawing of permafrost areas,
6. Upward shifting of snow lines of the tropical and subtropical mountains,
7. Spreading of tropical diseases towards temperate and polar regions,
8. Shifting of seasonal weather phenomena and changes in precipitation patterns etc.

## Increase in Air Pressure.

Various models have been developed to predict global rise in air temperature. (Schneider 1950) has pointed out that the temperature could rise upto 1.5oC to 3oC if the concentration of atmospheric carbon dioxide could be doubled from the 300 ppmv level to 600 ppmv. The General Circulation Model developed by S. Manabe and R.T. Wetherald (1975) predicts that if the present (1975 level) amount of carbon dioxide of the atmosphere is doubled, the temperature of the earth‟s surface will increase by 2.9oC.

The increase in the frequency of EI Nino events between 1970 and 2000 A.D. also denotes warming of the earth‟s surface and its atmosphere. On the basis of aforesaid trend of (Refer Table 5) temperatures in the past century it may be said that rising trend of temperatures denotes global warming.

### Projection of temperature and sea level rise due to global warming

|  |  |  |  |
| --- | --- | --- | --- |
|  | 2025 | 2050 | 2100 |
| CO2 concentration | 405-460ppmv | 445-640ppmv | 540-970ppmv |
| Global mean temperature change from  the year 1990 | 0.4-1.10C | 0.8-2.60C | 1.4-5.80C |
| Global mean sea level rise from the year  1990 | 3-14 cm | 5-32 cm | 9-88 cm |

* + 1. **Melting of Ice Sheets and Glaciers**

The recent evidences have shown that the ice sheets of Antarctica and Greenland are breaking, the permanent ice covers of the arctic regions are melting, and continental and mountain glaciers are shrinking in both size and length as evidenced by their regular retreat. It may be mentioned that the Antarctica is well instrumented continent in terms of the study of various aspects of the continent e.g. surface and air temperatures, ice core analysis, size and thickness of ice sheets and glaciers, contraction and shrinking rate of ice sheets etc. The regular monitoring of Antarctic ice sheets has shown about 100 m annual rate of their shrinking. A rise of temperature of winter season by 4oC has been reported since 1950 in the west Antarctic Peninsula. In other words, the icebergs are formed when the ice shelves are disintegrated, thus huge voluminous mass of ice known as iceberg measuring several hundred square kilometres in area, floats independently in the sea. (i) It is significant to reported to have shrunk in their length and volume by more than 50% in the past century, (ii) the rate of upward retreat of Andean glaciers in Peru increased seven times in the last 3 decades of the 20th century, more precisely between 1978 and 2000 A.D., (iii) the Russian Caucases mountain glaciers have been shortened in their length by about 50% due to melting since 1960, (iv) the glaciers of Chinese Tien Shan Mountains have lost their ice volume by 25% on melting since 1960, (v) the glaciers of Southern Alps of New Zealand have moved upward by about 100 metres due to their retreat caused by thermal melting of ice, (vi) Mt. Kenya has lost its most extensive glacier in the past century etc.

Different studies have demonstrated faster rate of melting of the Himalayan glaciers in India, resulting into their upward retreat and negative mass balance. A recent study of 19 glaciers of the Baspa basin of Himachal Pradesh by the scientists of Marine and Water Resource Group of Space Application Centre (SAC), Ahmedabad during 2000-2002 on the basis of weekly satellite images and field data provided by

the Geological Survey of India (GSI) has revealed that their mass balance during 2001 and 2002 registered negative trend (i.e. -90m3 in 2001 and -78m3 in 2002).

## Processes of Global Warming

Major sources and processes of global warming include ozone depletion and greenhouse effects. Thus, it is necessary to understand the mechanism of creation, destruction and maintenance of ozone layer and sources and processes of intensification of greenhouse effects by increasing emission of carbon dioxide and methane for evaluation of global warming.

## Ozone Depletion

The mechanism of ozone depletion includes the aspects of creation of ozone, destruction of ozone and recreation or maintenance of ozone layer in the stratosphere. It is desirable to understand the mechanism of formation of ozone layer first so that the processes of its destruction and its impacts on global warming can be properly understood. It may be mentioned that the thinning of stratospheric ozone layer allows more ultraviolet solar radiation to reach the earth‟s surface and thereby increases the temperature of the earth‟s surface.

The stratospheric ozone layer mostly concentrated between the altitudes of 12km to 35km, considered as a protective shield and earth‟s umbrella because it prevents ultraviolet solar radiation from reaching the earth‟s surface. Thus, the presence of ozone layer in the stratosphere is of vital significance for all biota including plants, animals and man in the biosphere. In the absence of this layer no life is possible in the biosphere because all the ultraviolet rays of the sun will reach the earth‟s surface and consequently the temperature of the earth‟s surface and the lower atmosphere will rise to such an extent that the „**biological furnace**‟ of the biosphere will turn into a „**blast furnace**‟. It is, thus, desirable to study the various aspects or.

## Creation of Ozone Layer

Ozone defined as „a three-atom isotope (one of a set of chemically identical species of atoms which have the same atomic number but different atomic weight is called isotope) of oxygen (O3)‟, or „merely a triatomic form of oxygen (O3) is a faintly blue irritating gas with a characteristic pungent odour. Ozone is a strong oxidising agent

which can at high concentrations decompose with an explosion‟. There are contrasting opinions about the altitudes of the concentration of ozone. It may be pointed out that ozone is present almost at all altitudes in the atmosphere but the bulk of its concentration is present in a layer from 10km to 50km up in the atmosphere and within this ozone the highest concentration of ozone is between the altitudes of 12kilometre and 35kilometre in the stratosphere. This zone (12kilometre-35kilometre) of ozone is called **ozonosphere** or **ozone layer** or **stratospheric ozone layer**.

The ozone gas is unstable because it is created as well as destroyed or disintegrated. In other words, the creation and destruction of ozone gas is a gradual and continuous natural process. The oxygen molecules are broken up or separated in the atmospheric layer between the altitudes of 80 to 100kilometre by ultraviolet solar radiation or by an electric discharge in oxygen or air during a thunderstorm in the troposphere in the following manner.

O2 O + O

(Oxygen breaks up into two separate oxygen molecules)

These separated oxygen atoms (O) are then combined with oxygen molecules (O2) and thus ozone (O3) is formed.

O2 + O + M

O3 + M

or

O2 + O O3 (Ozone)

Where M denotes energy and momentum balance produced by the collision of oxygen molecules (O2) with another individual atom or molecule. It may be pointed out that the collisions of 3 atoms or molecules or the collisions of oxygen (O2) with the third atom are not very common feature of regular occurrence between the altitudes of 80 to 100km (though O2 is very frequently broken up into individual atom or molecule in this layer as referred to above) because of very low density of gases in this part of the atmosphere and such collisions are also very rare in the atmosphere below the altitude of 35km because most of the solar ultraviolet rays have already been absorbed above this height. Thus, it is obvious that the formation of ozone (O3) due to collision of 3 atoms (O2 + O) through the process of **photomechanical reaction** triggered by the sunlight is more active in the atmospheric zone of 30 to 60 km height from the sea level. It is further important to note that the **ozone mixing ratio** (ozone mixing ratio = mass of ozone per unit mass of dry air) is maximum at the

height of about 35kilometre but the maximum **ozone density** (ozone density = mass of ozone per unit volume) is found between the height of 20kilometre to 25 kilometre. This is because of the fact that ozone is transported to lower height (upto 12 kilometre) by some upper air atmospheric circulation mechanisms which allow the ozone gas to accumulate between the heights of 12 kilometre to 35 kilometre.

## Depletion of Ozone Layer:

### An Environmental Concern

The presence of ozone layer in the atmosphere is very crucial and significant for plants and animals in general and human beings in particular because it provides a protective cover, known as earth‟ umbrella, to all of the organisms (including plants, animals, micro-organisms and man) in the biospheric ecosystem against their exposure to ultraviolet solar radiation. Infact, the ozone layer filters the solar radiation by absorbing unwanted ultraviolet rays and allowing only those radiation waves to reach the earth‟s surface which are essential for the maintenance of life of the planet earth. Any change in the equilibrium level of ozone in the atmosphere will adversely affect the life in the biosphere.

The data of ozone level variations coming through satellite monitoring since 1967 have revealed sharp depletion of ozone layer. The monitoring from NIMBUS 3, NIMBUS 4 satellites and EXPLORER 5 and TYROS 4 of the former U.S.S.R. indicated definite variations in the ozone level. The sharp decline in the ozone level during 1960‟s was attributed to the discharge and transport of nitrous oxides caused by numerous nuclear tests carried out by the developed nations like the Russia, the U.S.A., France etc. into the atmosphere. The original level of ozone was restored and the depleted ozone layer was gradually stabilized soon after the banning of nuclear tests in the atmosphere.

## Factors And Mechanisms of OzoneDepletion And Creation of Ozone Hole

Combining of atmospheric oxygen (O2) with individual oxygen molecule (O) results in the creations of ozone (O2 + O O3) whereas the breaking of ozone (O3) into O2 and O or re-creation of oxygen due to collision of ozone (O3) with monatomic oxygen (O) results in the depletion or destruction of ozone (O3 O2 + O or O3 + O

O2 + O2). The collective process of constant metamorphosis of oxygen into ozone (ozone formation) and ozone back into oxygen (ozone destruction or ozone depletion) is triggered by photochemical processes. If this is true, there must be maximum formation of ozone during June near the equator but the distributional pattern of ozone denotes its maximum concentration in the high latitudes (beyond 50o latitude in both the hemispheres) and minimum concentration over the equator. This anomalous distribution of ozone may be explained if we consider transport of ozone by the atmospheric circulation towards the polar areas.

The mechanisms of ozone depletion include both (i) the **natural processes**, and

1. the **anthropogenic process**. The natural processes of ozone depletion involve the conversion of atmospheric nitrogen into nitrous oxides due to solar activity because of maximum sunspots at the end of every 11-year cycle. According to latest, the anthropogenic mechanisms of ozone depletion include a few processes on which the following hypotheses have been postulated viz.
   1. **Chlorine hypothesis:** The chlorofluorocarbon and halogen gases are released during the maintenance or operation of several devices using these synthetic chemicals (such as refrigerators, air conditioners, spray-can dispensers etc.), shredding of foam insulation and fire fighting into the atmosphere.
   2. **Sulphate hypothesis:** It is believed that the sulphate aerosols emitted through volcanic eruptions (natural) and numerous constantly active human volcanoes (chimneys of factories) accumulate in the atmosphere at all latitudes between the altitudes of 15 kilometre to 22 kilometre. It has been discovered that the concentration of sulphate aerosols is most prevalent over the populated and industrialized areas of the northern hemisphere.
   3. **The nitrogen oxides hypothesis** states that nitrogen oxides emitted from supersonic jets in the higher altitudes deplete ozone. The supersonic transport aircrafts (SST) flying at the speed of more than twice the speed of sound at the altitude of 18 to 20km release significant amount of nitrogen oxides from their exhausts.
   4. **Polar Stratospheric clouds hypothesis:** It was believed by the scientists that after the implementation of Montreal Protocol there would be substantial decrease in ozone depletion but this could not happen. Now the scientists believe that the increase in the number of clouds in the Arctic stratosphere leads to reduction in the concentration of stratospheric ozone. The green house effect causes warming of lower atmosphere but there is cooling of stratosphere. The phenomenon causes formation of ice clouds at

the height of 14-26km in the stratosphere. It may be remembered that there is also maximum concentration of ozone within this zone of the atmosphere. There are fast chemical reactions due to such ice clouds in ozone zone which cause depletion of ozone layer.

## Ozone Depletion and Global Warming

According to one school of thought the net effect of ozone depletion mainly because of the impact of chlorofluorocarbons on thermal conditions of the earth‟s surface and the lower atmosphere would be highly complicated and unpredictable because of two facts arising out of ozone depletion viz. (i) Because of weakening of ozone layer there will be less absorption of ultraviolet solar radiation and hence more ultraviolet rays will reach the earth‟s surface and consequently the temperature of the earth‟s surface will be increased. (ii) On the other hand, the heating of the stratosphere will be reduced because of reduced absorption of ultraviolet rays. This phenomenon would result in cooling of the earth‟s surface because of less thermal radiation from stratosphere to the earth‟s surface. These two factors will certainly complicate the effects of ozone depletion due to the effect of chlorofluorocarbons.

## Protection and Maintenance of Ozone Layer

The depletion of ozone layer and consequent imminent danger to biological communities in general and human society in particular have become a matter of serious environmental concern to governments, scientific communities and general public at local, regional and global levels. The remedial measures of ozone depletion at international level are being taken at two levels viz. (i) to promote reduction in the production and consumption of emission of ozone depleting chemicals, and (ii) to make serious efforts to produce and propagate the use of alternative chemicals which do not deplete ozone in the stratosphere.

## Greenhouse Effects and Global Warming

A greenhouse is meant for plants mainly in the cold countries where total insolation at least during winter season is not sufficient enough to support plant growth. The glasses of greenhouse are such that these allow the visible sunlight to enter but prevent the long wave infrared rays to go out. A greenhouse also does not

have any provision for artificial heating. The greenhouse effect means „progressive warming-up of the earth‟s surface due to the blanketing effect of man-made carbon dioxide in the atmosphere‟ (Oxford Dictionary).

„In a greenhouse, visible sunlight passes through the glass and heats up the soil and warms the plants. The warm soils emit radiation in longer wavelengths (long wavelengths of infrared radiation waves), it absorbs and reflects the infrared (radiation waves)‟ (D.B. Botkin and E.A. Keller, 1982). This mechanism keeps the greenhouse warmer than the outside environment. In nut shell it may be summarized that a greenhouse is the body which allows the short wave incoming solar radiation to come in but does not allow the long wave outgoing terrestrial infrared radiation to escape. Carbon dioxide and water vapour act as a greenhouse in that these allow visible light of the sun to reach the surface of the earth but absorbs and reflect back the long wave outgoing terrestrial radiation mainly infrared rays back to the earth‟s surface and thus help in keeping the earth‟s surface warmer. The gases with the properties of greenhouse are called **greenhouse gases** such as carbon dioxide. Halogenated gases such as chlorofluorocarbons (Refer Table 5) are also greenhouse gases because these absorb long wave terrestrial radiation in the 8 – 13 microns band and thus help in enhancing the carbon dioxide greenhouse effect. It may be, thus, Table 5: Emission of Green House Gases (GHG) in million tonnes), 1995

|  |  |  |  |
| --- | --- | --- | --- |
| Developed Countries | | Developed Countries | |
| U.S.A. | 1,433 | China | 846 |
| Russia | 414 | India | 250 |
| Japan | 308 | South Korea | 104 |
| Germany | 241 | South Africa | 95 |
| U.K. | 151 | Mexico | 94 |
| Canada | 115 | Iran | 76 |
| Italy | 107 | Brazil | 65 |
| Poland | 95 | Saudi Arabia | 63 |
| Ukraine | 92 | Indonesia | 62 |
| France | 91 | Kazakhastan | 48 |
| Australia | 87 | Taiwan | 48 |
| Spain | 60 | Turkey | 38 |

Source : Down to Earth, April 30, 1998

concluded that the net result of greenhouse effect of carbon dioxide, water vapour and halogenated gases is the increase in the temperature of the earth‟s surface and the lower atmosphere because these gases allow solar radiation to reach the earth‟s surface but absorb most of the long wave terrestrial radiation and reradiate back to the earth and thus regularly warm the earth‟s surface and its immediate atmosphere.

## Major Sources of Greenhouse Gases

The most significant greenhouse gas is carbon dioxide which is released to the atmosphere by burning of fossil fuels for different purpose in various ways e.g. (i) Electric power stations based on fossil fuels mainly coal and mineral oil emit huge amount of carbon dioxide which reaches the atmosphere every year. These power stations are the most significant and widespread major sources of man-induced carbon dioxide. (ii) Numerous factories spread all over the world burn immense quantity of coal, mineral oil and natural gas and spew huge amount of carbon dioxide together with other undesirable gases through their chimneys into the atmosphere. (iii) The third major source is the transport sector which includes various types of vehicles run on coal and petroleum. For example, railways are large consumers of coal mainly in the developing countries, in India coal operated locomotives have been phased out and many developing countries are trying to phase out coal operated rail engines. Similarly, large fleets of automobiles (truck, buses, cars and two wheeler motor cycles, scooters etc.), agricultural implements like tractors, combines etc. and aircrafts all over the world burn immense quantity of diesel and petroleum each year. (iv) The fourth major source of the production of carbon dioxide is deforestation and burning of fire woods. The people are acquainted with the first three major sources of carbon dioxide but the mechanisms of the release of carbon dioxide through deforestation are little understood by common man.

Minor greenhouse gases like halogenated gases (chlorofluorocarbons) and halons are released to the atmosphere during the operation and maintenance of appliances and equipments using chlorofluorocarbons as coolants and propellants (e.g. air conditioners, refrigerators, several cosmetic goods, plastic foam, fire extinguishers etc.). Besides, methane, nitrous oxides, and ozone are also green house gases.

## Emissions of Carbon Dioxide

The climatic changes caused by global greenhouse effect due to higher concentration of carbon dioxide in the atmosphere are primarily related to the pattern of energy transfer and uses the world over. It may be pointed out that here only that part of climatic changes is being considered which is caused by greenhouse effect only. It is significant to note that the pre-industrial level of atmospheric content of carbon dioxide (CO2) was fixed at 280 to 290 p.p.m. (parts per million) or (0.028% to 0.029%) by volume (the base year of the beginning of the industrial revolution in 1860 A.D.). Thus, the atmospheric content of carbon dioxide increased from the pre- industrial level of 280-290 p.p.m. (1860 A.D.) to 350-360 p.p.m. during 1988, registering an overall increase by 25% from the pre-industrial level. It is believed that the rate of increase of atmospheric carbon dioxide through anthropogenic sources as referred to above will be accelerated due to ientless march of developing countries towards industrial development and urbanisation. It is, therefore, necessary to examine the pattern of emission of carbon dioxide through the use and burning of fossil fuels (coal, petroleum and natural gas). The following trend of consumption of fossil fuels and emission of carbon dioxide may the high lighted.

1. According to the report of the Oak Ridge National Laboratory (Tennessee, U.S.A.,) based on the analysis of the 37-year time series of emission, the total emission of carbon dioxide through the burning of fossil fuels were dominated by a few developed and highly industrialised countries by 1950 (e.g. U.S.A. former U.S.S.R., U.K., Germany, France etc.). Only the U.S.A. contributed about 42% of the total world emissions of carbon dioxide in the year 1950. The former U.S.S.R., U.K., Germany and France occupied 2nd, 3rd, 4th and 5th positions in the global output of carbon dioxide through the burning of fossil fuels. The contributions of the developing countries towards the total emissions of carbon dioxide upto 1950 were negligible because of exceedingly now pace of industrialization in such countries. For example, India stood only 13th in the hierarchy of carbon dioxide emitting countries.
2. The situation drastically changed by 1986 that is after a lapse of 36 years from 1950 base. The relative percentage of the contribution of carbon dioxide from the burning of fossil fuels by the developed and highly industrialized countries declined while the relative contribution of the emissions of carbon dioxide by the developing countries increased because of rapid rate of industrial development taking

place in the developing countries after 1950. The data of the emissions of carbon dioxide from the burning of fossil fuels during 1986 reveal that the U.S.A., and the former U.S.S.R. (first and second respectively) still remained the largest contributors of atmospheric carbon dioxide but a few developing countries like China (advanced to 3rd place from the 10th place during 1950) and India (occupied 7th place in comparison to its 13th place in 1950) became major contributors of atmospheric carbon dioxide during 1986. Japan (4th place) has also become a very significant contributor of carbon dioxide. It may be pointed out that South Korea, a fast developing country, has moved from its 53rd position during 1950 to 20th place during 1986 in the hierarchical order of carbon dioxide emitting nations.

1. It is important to state that though the relative contributions of carbon dioxide from the combustion of hydrocarbons by developed and highly industrialized nations have declined because of the increase of carbon dioxide emissions from the developing nations but the total emissions based on per capita basis are still dominated by the developed nations. The per capita emission of carbon dioxide is highest in the U.S.A. (5 tonnes per person per year). If we compare this figure with the figure of a major developing nation, say India (occupying 7th place among the carbon dioxide emitting nations and producing 0.2 tonnes of carbon dioxide per capita per year), the U.S.A. still emerges the main culprit followed by Russia.
2. On the regional basis of the emission of carbon dioxide it is clear that the total emissions are steadily increasing in China, most of Asia and Latin America.

The IPCC (Intergovernmental Panel on Climate Change) constituted by the United Nations Environment Programme (UNEP) and World Meteorological Organisations (WMO) in 1988 has been assigned the main task on the study of climatic changes, and of presenting reports on the effects of greenhouse gases on the earth from time to time (the IPCC submits its reports after every four-year period).

For example, there is vast variation in the data of emission of greenhouse gases (16.1) in the developed and developing countries (for 1995) as released by Climate Action Report of the Framework Convention on Climate Change (FCCC), U.S.A. and the data of carbon dioxide emission in 1995 as reported in the Citizen‟s Fifth Report of the Centre for Science and Environment, New Delhi, based on Anon, 1998. Knowledge for Development, World Development Report, 1998-99 (Refer Table 6) (16.7) and hence it becomes very difficult for comparative analysis and understanding of real picture.

Table 6 : Emission of Carbon Dioxide during 1980 and 1995

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Country | Total (Million tonnes) | | Per capita emission (tonnes) | |
|  | 1980 | 1995 | 1980 | 1995 |
| World | 13,385.7 | 22,702.2 | 3.4(w) | 4.0(w) |
| U.S.A. | 4,515.3 | 5,468.6 | 19.9 | 20.8 |
| China | 1476.8 | 3,192.5 | 1.5 | 2.7 |
| Canada | 420.9 | 435.7 | 17.1 | 14.7 |
| India | 347.3 | 908.7 | 0.5 | 1.0 |
| Australia | 202.8 | 289.8 | 13.8 | 16.0 |
| Regions |  |  |  |  |
| East Asia and Africa | 1,832.7 | 4,140.0 | 1.4 | 2.5 |
| Europe and Central Africa | 886.9 | 3,722.0 | - | 7.9 |
| Latin America and |  |  |  |  |
| Caribbeam | 850.5 | 1,219.8 | 2.4 | 2.6 |
| Middle East and North |  |  |  |  |
| Africa | 500.5 | 982.9 | 2.9 | 3.9 |
| South Africa | 392.4 | 1,024.1 | 0.4 | 0.8 |
| Sub-Saharan Africa | 350.5 | 477.1 | 0.9 | 0.8 |

Source : Anon, Knowledge for Devlopment Report, 1998-99, reported in the Citizen‟s Fifth Report, 1999, Centre for Science and Environmental. new Delhi, Vol. 2, p. 239. w =weighted mean.

Methane is another significant greenhouse gas which is produced from the biodegradation of organic matter i.e. biomass. The animal excreta and paddy fields have been accepted as major sources of methane. It may be pointed out those developing countries of tropical region account for 90% of global rice production. Consequently, tropical developing (rice producing) countries have been held responsible for producing largest amount of global warming methane by the industrialized countries.

## Greenhouse Effect and Climatic Change

The carbon dioxide is, in fact, a natural constituent of the earth‟s atmosphere. It is not necessarily a pollutant at least in the lower atmosphere but its increased concentration in the atmosphere leaves adverse effects on biological communities through changes in the thermal conditions and global radiation and heat balance. As stated in the beginning the carbon dioxide, present in gaseous form in the atmosphere, has unique properties in that it allows the solar radiation to reach the surface of the earth but tends to prevent long wave terrestrial radiation (such as infrared heat radiation from the earth) from the earth‟s surface from escaping into outer space. This mechanism results in the increase of temperature of the surface of the earth and the

lower atmosphere. It may be pointed out that about 50% of the total carbon dioxide produced by anthropogenic sources (combustion of fossil fuels and burning of wood) is dissolved into the oceans and fixed by the plants in their biomass whereas the remaining 50% is stored in the atmospheric storage pool and thus the concentration of carbon dioxide in the atmosphere steadily increases. The trend of increasing atmospheric carbon dioxide increases the greenhouse effect which raises the temperature of the earth‟s surface.

## Impact of Climate Change in India

India, being a party of U.N. Framework Convention on Climate Change (FCCC) published its first official document on impact of emission of green house gases on present and future climate of the country on June 1, 2004. The total annual emission of GH gases amounted to one million tonnes giving per capita emission of 1.3 tonnes/year. The over all global rise of temperature of 0.4oC has caused 10 to 12% increase in monsoon rain in the west coast, northwest regions and north Andhra Pradesh but 6-8% decline in Madhya Pradesh and adjoining areas, north-east regions and parts of Gujarat and Kerala. The temperature is likely to increase by 2-4oC from 1994 level by 2040 AD. Minimum temperature will rise by 4oC across the country by 2040. there will be decrease in rainy days by 15 days over major parts of the country. The rising temperature would dry up key river basins of India after 2040 AD (Down to Earth, July 31, 2004).

## Global Warming and International Co-Operations

The international communities are well aware and are seized of the global environmental and ecological problems and various efforts have been initiated to control global warming and halt probable climatic changes. There are several organizations, government agencies, intergovernmental agencies, non-governmental organizations (NGO) which have undertaken various action plans and projects to study the relationships between man and nature, the environmental problems resulting there from and remedial measures therefore. It is heartening to note that now international co-operationa are forthcoming for the amelioration of the environmental and ecological problems. Efforts are being made to control ozone depletion and greenhouse effects at global level. The formulation of **Montreal Protocol** in

September, 1987 under the leadership of UNO-sponsored **United Nations Environment Programme** (UNEP), the international conference on „depletion of ozone layer‟ in London, held from March 5 to 7, 1989, wherein government officials, scientists and industrialists of 180 countries participated, international conference on **ozone depletion** held in London in 1990 etc. for restricting the production and consumption of ozone depleting chlorofluorocarbons (CFCs) etc. are a few examples which reveal the seriousness of international communities for their active co- operations in tackling the global environment.

## SUMMARY

Since climate refers to the atmosphere conditions of the earth over a long period of time. It is one of the most important aspects of the natural environment. It represents the living atmosphere with which hydrosphere, lithosphere and biosphere constitute the natural environment. Climate sets limits to the distribution of different kinds of plants and animals lives. It has therefore, a great significance to man. Global warming influence human activities both directly and indirectly. Agriculture, irrigation, forestry, construction of houses, land use transportation and other economic activities are greatly influenced by the climatic conditions. Increase in burning of fossil fuels during past several decades has caused increase in the amount of carbon dioxide in the atmosphere. This has raised the temperature of the atmosphere to some extend.