The world climate has always been highly variable. Many changes are driven by natural factors, but others are now the result of a single species (human beings), which is driving a significant shift in the global climate. People have been influencing the biosphere for at least 8000 years, since the invention of agriculture. But for several decades, it is the very composition of the global atmosphere that they have been modifying. We now know that there has indeed been a major change in climate since the arrival of people on earth, and 18000 years ago, the climate was radically different from what it is today.

It is worrying that the growth of human population and human technology is beginning to produce very perceptible effects, at faster paces, on the atmosphere. Compared to the geological and astronomical rhythms that seem to have governed the great climatic changes of the past, the pace at which the global atmosphere is changing today is therefore extremely rapid.

If we expand our perspective to take in the entire history of our planet, what is most striking is the relative stability of its climate. Of course it has undergone some major changes. The key to this paradox seems to be the “greenhouse effect”, which depends on the composition of our planet’s atmosphere. This brings us back to the problem of greenhouse gases particularly carbon dioxide. As the greenhouse gases build up in the atmosphere the earth gets hotter. It is indisputably true that in the last 30 years there has been a significant and fairly regular increase in the proportion of greenhouse gases particularly CO₂ in the atmosphere.

In short, we are modifying the physical state of our planet on a global scale, in a manner that can no longer be ignored. Organizations have quickly realized this and since 1980 there has been a huge research effort to explain probable effects on our environment. The research continues, as we try to discover what rates of change can be tolerated.

The ill effects of global warming are all too visible today. Do we keep on plundering the earth for our material benefits or make sure we protect it for our future generations?
**The Greenhouse Effect**

We all know that a greenhouse is a device intended to protect or accelerate, or even to force the development of certain plants. The infrared radiation that is thus trapped inside the greenhouse helps maintain an elevated temperature before it finally escapes to the outside world. Without it, the sun’s energy would just enter the planet, or bounce off it.

But the irony is that the sun’s energy by itself is not sufficient to make the planet warm enough for us to live on. The reason the earth is at just the right temperatures for humans and other species to develop and thrive is because of this miracle called the “greenhouse effect”. It is this phenomenon that keeps temperatures on the earth’s surface averaging 15°C. Without it the temperature would be –20°C – a cold in which humanity would never have been able to evolve.

Like the other planets in our solar system, the energy that the sun constantly emits strikes our planet, warming the surface. Because of the presence of an atmosphere having almost perfect composition, sustainability of life on earth is ensured. Venus, for instance, has a thick
It is important to slow the warming as much as possible. This means using less fossil fuels, eliminating CFCs altogether, and slowing down deforestation.

atmosphere (thicker than the earth), which is composed mostly of carbon dioxide. Combined with its closeness to the sun, the carbon dioxide levels on Venus send temperatures soaring to 460°C. On an average, the energy of sun’s radiation on the top of the earth’s atmosphere is 1355 W/m² (the solar constant). The effect this has on the earth’s climate is called the solar forcing of the climate system. This varies from season to season on a larger timescale. At the earth’s surface on a sunny day the incident energy would be about 1000 W/m². The greenhouse can be considered as an additional forcing factor, as it prevents some radiation from escaping to space.

It is clear that the evolution of the earth’s atmosphere has been intimately linked with the development of life on earth. Today both biological and geochemical processes are involved in maintaining its composition, but one species, human, has now become so numerous in numbers that it is beginning to affect the composition of the atmosphere, shifting it from its natural equilibrium. The greenhouse effect changes the way the sun impacts the earth. CO₂ and other gases in the atmosphere act like the glass in a greenhouse, trapping the heat from the sun. As more greenhouse gases are added to the atmosphere, more heat is trapped and the world’s climate grows warmer: ‘climate change’ occurs.

The greenhouse gases are trace gases that alter the heating rates in the atmosphere by allowing incoming solar energy to pass through but trapping the heat emitted back by the earth surface. They have strong radiative properties. Absorption of radiation is a property of a wide range of gas molecules, including CO₂, CH₄, CFCs, N₂O and SO₂. Among them CO₂ is the most important. These are all long-lived greenhouse gases. Inter Governmental Panel on Climate Change (IPCC) expresses the effectiveness of different greenhouse gases in terms of Global Warming Potentials (GWPs). These indicate the contribution of each greenhouse gases to likely global warming, relative to CO₂.

Water vapour is one of the most important greenhouse gases but its role is a bit complicated. When water vapour condenses into clouds it can either absorb long-wave radiation from the ground causing further warming or reflect radiation from the sun causing a cooling effect. Which of these predominates depends on the type of clouds and its height in the atmosphere.

Carbon dioxide contributes about 50% to the greenhouse effect. The primary source of the increase in CO₂ is use of fossil fuels, but land-use changes also make remarkable contribution to it. Since prehistoric times people have burnt wood and other plant remains to produce heat and light. As wood became scarce, the use of coal became increasingly important and ultimately oil and gas. The demand of energy increased sharply and this demand was largely met by the increased use of fossil fuels, ultimately releasing more and more greenhouse gases into the atmosphere, particularly CO₂.

The burning of fossil fuels is not the only way in which CO₂ can be released into the atmosphere. It is also produced in large amounts as a consequence of land-use change. Before the industrial revolution the rise in the concentration of CO₂ was largely ascribed to deforestation, and agricultural land-use. Till now 20% of the released CO₂ (carbon content only) has been contributed by land-use changes. Land-use changes can release CO₂ into the atmosphere by causing oxidation of carbon compounds in the vegetation or the soil. Due to deforestation, there is an increase in soil erosion, which exposes organic matter to rapid oxidation, which ultimately becomes the source of CO₂.

Deforestation is now out of control. It is estimated that the earth is losing more than 150,000 km² of tropical forest every year. Today the case of Amazon forest is the most spectacular (more than 120,000 km² lost in 1987, adding 500 million tonnes of CO₂ to the atmosphere) but we must not forget that in West Africa more than half the forest (about 80%) has been destroyed in less than 60 years, and that clearing operations still continue in south east Asia and Indonesia (more than a million hectares of forest was burned in 1997 in Indonesia). Deforestation of China occurred long ago; in America, vast stretches were deforested in the last century. This destruction of forests has major consequences. The loss of forests also means that there are fewer trees to absorb CO₂. However, deforestation releases less than half the yearly total of CO₂, the rest comes from the burning of fossil fuels.

Besides, every time we switch a light on we are adding to the greenhouse effect. Electricity is mainly created from burning of coal and oil. The concentration of CO₂ has increased 25% since the industrial revolution. Half of this rise has been in the last 30 years. It is expected to double within decades if it is not checked.

As a feedback process, about half the CO₂ released by burning fossil fuels is absorbed by the oceans. Recent research suggests that as the earth heats up, the ocean will be less efficient in absorbing CO₂ leaving more in the atmosphere and so adding further to global warming. Observations since 1961 show that the ocean has been absorbing more than 80% heat added to the climate system, and that ocean temperatures have increased at depths of around 3000 m. Hence, efficiency of absorbing CO₂ by oceans has been decreasing.

The concentration of methane in the atmosphere is also rising at a fast rate. It is produced by anaerobic respiration in a wide variety of environments, such as stomachs of animals, swamps, paddy fields, waterlogged soil, release of natural gas from landfills and vegetation rotting in the absence of oxygen. A considerable amount is also produced during mining and oil/natural gas extraction. Methane is constantly removed from the atmosphere by reaction with hydroxyl (OH) radicals in the air and by the activity of soil organism.
There has indeed been a major change in climate since the arrival of people on earth, and 18000 years ago, the climate was radically different from what it is today.

The problem is that as the world population increases, agricultural activity must increase for the sake of sustainability and ultimately the emission of methane also increases. Since 1960, the amount of methane in the atmosphere has increased by 1% per year – twice as fast as the build-up of CO₂. A methane molecule is 20 times more effective in trapping the heat than CO₂ molecules. Methane molecules survive for 10 years in the atmosphere. As the world warms, large quantities of methane stored in the frozen tundra of the north may be released. Methane trapped in the seabed may also be freed by rising of oceanic temperature.

Nitrous oxide contributes about 6% to greenhouse effect at the moment. It comes from both natural and man-made processes. N₂O is contributed about 45% by man-influenced sources mainly through fossil fuel consumption, nitrogenous fertilizers, burning rain forests and animal wastes. Atmospheric concentration is quite low at around 0.31ppm, and they are rising much more slowly than methane.

Chlorofluorocarbons are extremely effective greenhouse gases. Although there are lower concentrations of CFCs in the atmosphere than CO₂, they trap more heat. A CFC molecule is 10,000 times more effective in trapping heat than a CO₂ molecule. CFC molecules survive for 110 years because they are very stable and decay slowly. CFCs rise and gradually accumulate in the stratosphere where they are broken down by the sun’s ultraviolet light, releasing chlorine atoms. Chlorine attacks ozone (O₃); one chlorine atom can help to destroy 100,000 ozone molecules. Hence it is necessary to achieve the global phase-out of CFCs at the earliest.

Although SO₂ is a greenhouse gas, its accumulation in the atmosphere has probably had a net cooling effect. SO₂ released in the gas phase is converted to aerosol particles of sulphate. These aerosol particles absorb short-wave radiations and are the main condensation nuclei for water vapour, which ultimately becomes the source of clouds. Sulphate aerosols last for short periods in the troposphere but their lifetime in the stratosphere is several years.

The source of sulphate in stratosphere is volcanic eruptions. The eruption of Elchino (1982) and Pinatubo (1991) produced a cooling effect for several years because of the presence of sulphate aerosol in stratosphere. Dimethylsulphide (DMS) is produced in large amounts by some marine phytoplankton, and could act in a feedback loop to stabilize temperature. High sea temperature could lead to more DMS being produced: this increases cloud cover, reflecting solar radiation and trapping heat radiated from the earth.

Impacts of Warming
Because of the combined effect of greenhouse gases, the changes that are happening now are certainly rapid enough. If no action is taken the greenhouse effect could lead to rise in average global temperatures between 1.5°C to 4.5°C as early as the year 2030. Experts from the IPCC confirmed that the 1990s have been the hottest decade since records began 150 years ago. According to them, eleven of the twelve years in the period (1995-2006) rank among the top 12 warmest years in the instrumental record. They also found that the average temperatures had risen by roughly 0.74°C since 1900. And forecasts for the future are even more alarming.

These rises will be greater towards the poles and less at the tropics. There will also be more warming in winter than summer. Such increases will make the world hotter than it has been for more than 100,000 years. The rise will also be faster than ever before. Overall effects are more horrifying. Storms, cyclones, gales, hurricanes and typhoon will become more frequent and stronger as oceans heat up causing more water to evaporate. Evidence is building up at an alarming rate.

In the same way, continental heartlands will face droughts. Ethiopia, suffered one of the worst heat waves and droughts in the recent past.

With sea levels rising at a rate of 1 to 2 mm each year due to the melting of the polar ice and mountain glaciers it could lead to major flooding in the coastal areas, estuaries and low lying islands such as Bangladesh, Nile delta, and Maldives. Other likely impacts are on human health. Warmer temperatures would enable insects and other disease (such as malaria) carriers to expand their range.

Unfortunately, as our economies continue to grow, we are using more fossil fuels than ever before. Around four-fifths of the world’s energy comes from them. And forecasts suggest their dominance would not end any time soon, either. On current trends, the world’s use of energy is set to almost double in the first 30 years of this century, with about 90% of the growth likely to be met by gas, oil and coal. Oil is in demand than ever, and supplies are expected to jump by double. Both oil and coal will maintain their current shares of the total energy, while natural gas is actually expected to rise than ever before.

It is clear that things are starting to heat up, and that the number of droughts, storms, floods, heat waves, and other extreme events are on the rise, too. So it is important to slow the warming as much as possible. This means using less fossil fuels, eliminating CFCs altogether, and slowing down deforestation. This can be achieved best through energy conservation, including better use of public transport and through renewable energy such as solar, wave and wind energy.

Do we plunder the earth or make sure we protect it for future generations? The choice is ours.

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