



Global Warming and Climate Change

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*“Making Our Actions Count:
Understanding the Relationships between Climate Change and
Environmental Stewardship”*

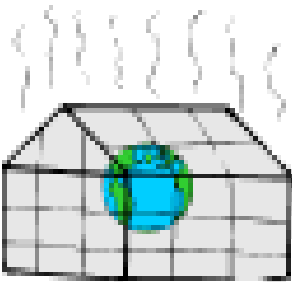


*Ministry of Local Government and Environment
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Defining Global Warming

Global warming relates to the emission of greenhouse gases, which affect climates. Greenhouse gases are naturally occurring and make up less than one tenth of one percent of the total atmosphere, which acts as a blanket around the earth, without which the earth's surface would be 30 degrees Celsius colder than it actually is.



The Greenhouse Effect

The Greenhouse effect is a natural phenomenon without which the earth's surface would be too cold (approximately 34 degrees Celsius colder than it is today) to enable habitation as we currently know it.

Most of the sun's energy, which is mainly short wavelength radiation, passes through the atmosphere and warms the earth's surface. Heat energy, in the form of long wavelength infrared radiation, is in turn released back into the atmosphere. While some of this heat escapes into space, most of it is absorbed or held by carbon dioxide, water vapour and other greenhouse gases that exist in low concentrations in the atmosphere.

By absorbing heat, these trace gases become warmer, and heat is sent out from the atmosphere in all directions. Some go back to earth to be stored whilst the rest passes into space. This process keeps the earth habitable. The composition of the atmosphere is however changing as the amount of carbon dioxide, methane, nitrous oxide and chlorofluorocarbons (CFCs) it contains is increasing. As a result of this, the increase in the greenhouse gases will cause less heat to be lost to space and instead be reflected back to earth causing an increase in temperature.

This change in the Earth's temperature will cause changes in precipitation patterns; while some areas get wetter others will become drier. There could also be changes in storm patterns. Sea level rise could also result because of changes in the earth's temperature.

If the atmospheric temperature near the land surface rises in the whole globe, there is a possibility that it will have serious effects on human life.

The following changes may occur due to global warming.

- Desertification in dry and in semi-dry areas would increase.
- Concentrated precipitation increases.
- Sea level rise due to the thermal expansion of seawater (melting of ice caps), giving rise to changes in coastlines. As such there would be immigration of residents near the sea coast and on the small islands, and the destruction of the port facilities
- More hurricanes and droughts

Causes Of Global Warming

All greenhouse gas concentrations are determined by a balance between sources and sinks. There are essentially two ways in which mankind can increase atmospheric concentrations of greenhouse gases, namely:

- By increasing the strength of greenhouse gas sources (processes that produce greenhouse gases)
- By decreasing the strength of greenhouse gas sinks (processes that remove greenhouse gases)


Therefore, through actions as continued deforestation (decreasing the strength of greenhouse gas sinks) and the burning of fossil fuels (increasing the strength of greenhouse gas sources) mankind is increasing carbon dioxide levels. The following table identifies the major contributors to global warming and lists them in order based on the percentage of global warming they have caused.

| Activity ¹ | Percent Contribution to Global Warming ² | How These Activities Contribute To Global Warming ³ |
|---------------------------|---|--|
| Energy use and production | 57% | Carbon dioxide is produced when coal, oil and natural gas (fossil fuels) are burned to produce energy. Methane is also emitted during coal mining and oil drilling and by leaky gas lines. |
| Chlorofluorocarbons | 17% | Contrary to popular perception, the depletion of the ozone layer does not cause global warming. Instead depletion of the ozone layer as a result of CFC and other gases have resulted in a cooling effect. |
| Agricultural practices | 14% | Activities such as rice cultivation, cattle and sheep ranching are responsible for increasing the emissions of methane. |
| Changes in land use | 9% | Changes such as clearing land for logging, ranching and agriculture lead to carbon dioxide emissions. |

¹ From: "Causes of Global Warming". Available at: http://www.library.thinkquest.org/26026/EnvironmentalProblems/global_warming_-_causes.html

² From: "Causes of Global Warming". Available at: http://www.library.thinkquest.org/26026/EnvironmentalProblems/global_warming_-_causes.html

³ Adapted From: "What Activities Contribute to Climate Change". Available at: <http://www.gcric.org/ipcc/qa/04.html>

| Activity ¹ | Percent Contribution to Global Warming ² | How These Activities Contribute To Global Warming ³ |
|---|---|---|
|  <p data-bbox="345 569 548 638">Image of Cattle Ranching</p> | | <p data-bbox="894 373 1360 478">Vegetation contains carbon that is released as carbon dioxide when the vegetation decays or burns.</p> <p data-bbox="894 520 1398 802">Normally, lost vegetation can be replaced by re-planting with little or no net emission of carbon dioxide. However, over the past several 100 years, deforestation and other land use changes have contributed significantly to increases in atmospheric carbon dioxide.</p> |
| Other industrial activities | 3% | |

These activities cause emissions of 6 different greenhouse gases into the atmosphere – the principal one being carbon dioxide, caused from the burning of fossil fuels. These activities thicken the atmosphere and are responsible for over half of the warming effect.

If emissions continue to grow at current rates, it is predicted that atmospheric levels of carbon dioxide will double from pre-industrial levels during this century and quite possibly triple by the year 2100.

The foremost effect of the increase in greenhouse gases is global warming, which translates to the increase in temperature of 1.5 to 4.5 degrees Celsius over the next 100 years.

Is Global Warming Really Underway?

According to NASA, the ice sheet surrounding the earth’s largest island is rapidly thinning at a rate of nearly one metre per year. The researchers estimate there is a 98% chance that the melt is due at least in part to global warming. NASA reports that Greenland’s ice sheet is losing approximately 51 cubic kilometres of ice per year, an amount sufficient to raise global sea level by 0.01cm per year.



Various other studies indicate that Arctic ice and mountain glaciers around the world have been reduced significantly on the past several decades and are continuing to diminish rapidly.

Also, in Lima, Peru, the entire water supply for 10 million people depends on the summer melt from a glacier that is now in rapid retreat. Some of the reasons for the retreat of the glacier are attributed to climate change.

The US EPA states that sea level is rising faster along US coasts than the worldwide average and fastest of all in the Chesapeake Bay, where researchers have documented the disappearance of at least 13 islands, with others losing half or more of their land. The islands are considered to represent a unique ecosystem where many waterfowl depend on them for nesting grounds; and they shelter aquatic vegetation which fish and crabs use for spawning.

Other evidence that global warming is underway includes rise in sea level of 10 to 25 cm (about 4 – 10 inches), a reduction in northern hemisphere snow cover (1973 to present) and increasing sub-surface ground temperatures⁴.

Climate Change

Climate change is considered to be the most pervasive and truly global of all issues affecting humanity, and poses a serious threat to the environment as well as to economies and societies.

Climate change is associated with the warming of the planet Earth as a result of emissions of carbon dioxide and other greenhouse gases.

The earth's climate is a complex balancing act and involving the sun, atmosphere, oceans and land. Solar radiation heats the earth and provides the energy that drives atmospheric circulation. The atmosphere screens out the sun's harmful rays and acts as a storehouse for various gases and particles. Both air circulation patterns and the make-up of the atmosphere have a major influence on climate and weather systems. Ocean currents and atmospheric circulation patterns help to moderate high-latitude climates such as Canada by transferring heat from the tropics toward the cooler poles.

Humans have altered many different aspects of this climate system through economic and social development. Industrial and agricultural emissions of carbon dioxide, methane and other greenhouse gases are contributing to this warmer planet. Reducing the output of these gases, also called climate changing gases, will require a fundamental shift in manufacturing processes, agriculture and energy production⁵.

Emissions of carbon dioxide grew 12-fold between 1900 and 2000, from 534 million metric tons per year in 1900 to 6.59 billion metric tons in 1997.

Causes Of Climate Change

Climate change is caused by the following:

- Natural Events

⁴ Adapted from: "Has the World Warmed?". Available at: <http://www.gcrio.org/ipcc/qa/02.html>. March 23, 2001

⁵ Adapted from: "Introduction to Common Questions about Climate Change". Available at: <http://www.gcrio.org/ipcc/qa/01.html>

- Human Activities

Natural Events

Natural events such as volcanoes and variations in ocean currents can result in climate change. Over longer time spans, tens of hundreds and thousands of years natural changes in the geographical distribution of energy received from the sun and the amount of greenhouse gases and dust in the atmosphere have caused the climate to shift from ice ages to relatively warmer periods.

EXAMPLE:

Variations in ocean currents change the distribution of heat and precipitation. The el niño phenomenon, which is the periodic warming of the Central and Eastern tropical Pacific Ocean, typically lasts 1-2 years and changes weather patterns around the world, causing heavy rains in some places, droughts in others, more severe hurricanes, and more severe typhoons.

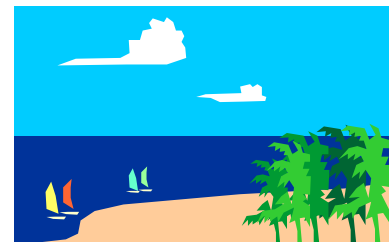
Human Activities

Human activities also contribute significantly to climate change, such as changes in land use (e.g. deforestation) and the burning of coal, oil and natural gases. These activities increase the amount of greenhouse gases, especially carbon dioxide, that are emitted into the atmosphere.

The accumulation of greenhouse gases in the atmosphere, due to human activities, will change the climate by enhancing the natural greenhouse effect, leading to an increase in the Earth's average surface temperature.

Impacts of Climate Change

Climate change has the potential to negatively impact on many of the Earth's natural ecosystems and functions over the next 100 years. It has been estimated that the loss of land, damage to fisheries, losses of agricultural and water supplies could cost the world more than US\$ 304.2 billion per year.



Climate Change and Sea Level Rise⁶

The global mean sea level may have already risen by about 15cm during the past century⁷. According to various scientific studies, the sea has been rising at the rate of 1-2 mm per year over the past 100 years.

Climate change is expected to cause a further rise in sea level of about 20cm by the year 2030. Forecasts of rising sea levels are based on climate model results which indicates

⁶ Adapted from: UNEP. "Climate Change and Sea Level" in Climate Change Information Kit.

⁷ Adapted from: UNEP/IUC. 1994. "Understanding Climate Change: A Beginner's Guide to the UN Framework Convention", UN/WMO Information Unit on Climate Change

that the earth's average surface temperatures may increase by 1.5 – 4.5°C over the next 100 years. The warming can cause the sea to rise in two ways, namely:

- Through thermal expansion of ocean water
- Through the sinking of ice caps and mountain glaciers

According to the Intergovernmental Panel on Climate Change (IPCC), if no specific measures are taken to abate greenhouse gas emissions the two aforementioned factors are likely to cause the sea to rise by about 65cm from current levels by the year 2100. This translates into an average 6cm per decade with an uncertainty range of 3-10 cm.

Sea levels would not rise by the same amount all over the globe as a result of the following factors:

- The effects of the earth's rotation
- Local coastline variations
- Changes in major ocean currents
- Regional land subsidence and emergence
- Differences in tidal waves
- Sea-water density

Sea level rise has many associated impacts, including:

- Damage to coastal areas and small islands
- Salinization of groundwater
- Disruption the flow of estuaries, coastal rivers as well as eroding and increasing the salinity of tidal wetlands and mangrove forests
- Increased damage caused by floods, storms and tropical cyclones

Other Impacts of Climate Change

Some of the most significant economic effects of the increases in temperature – between 1.4 to 5.8 degrees Celsius – will be on:

- Ecosystems
- Health
- Agriculture
- Tourism
- Water Resources
- The poor

Impacts Of Climate Change On Ecosystems

“Many ecosystems will not be able to adapt to the additional stresses of climate change without losing some of the species they contain or the services they provide, such as supplying sufficient clean water to drink, food to eat, suitable soils in which to grow crops or wood to use as fuel or in construction”⁸.

⁸ From: “Why Can't Ecosystems Just Adapt”. Available at: <http://www.gcrio.org/ipcc/qa/11.html>. (March 23, 2001)

“Global warming could result in approximately 1/3rd of the Earth’s forested area undergoing major changes in species composition”⁹. The projected rate of surface temperature change in many parts of the world will necessitate the migration of plant species if they are to survive. Many species may however be unable to move rapidly enough to prosper, leading to changes in vegetation and ecosystem structure.

As plant species are lost, they are likely to be replaced by fast-growing often non-native species which usually¹⁰:

- Provide a lower quality of habitat for many native animals
- Supply less and lower quality of food for wild and domesticated animals
- Supply less timber
- Increase the prevalence of weeds and vermin (e.g. rats, cockroaches, etc.)

Ecosystems that are most likely to suffer from the impacts of climate change include:

- Those at higher altitudes – far northern forests/tundra
- Where different habitat types converge – for example where grasslands meet forests
- Coastal ecosystems – especially saltwater marshes, mangrove forests, coastal wetlands, coral reefs, and river deltas

Impacts Of Climate Change On Public Health

Climate and weather affect human health in many ways. Public health depends on safe drinking water and secure shelter and extreme weather conditions kill many people every year. The major effects of climate change on health will be caused by:

- Heat stress – extreme temperatures will affect vulnerable groups such as; children, older people, and those with heart problems.
- Air and water pollution – warm temperatures can increase air and water pollution which in turn affects human health. High temperatures also increase ground level ozone which damages the lung tissue.
- Increased incidence of communicable disease – high temperatures increases the potential for the spread of vector borne diseases.
- Flooding – global warming can bring about changes in precipitation. An increase in rainfall as well as sea level rise near coastal cities, may cause flooding that can lead to the contamination of wells, pits and surface water. The flooding of sewage and sanitation systems could spread infectious diseases.



⁹ From: “Why Can’t Ecosystems Just Adapt”. Available at: <http://www.gcrio.org/ipcc/qa/11.html>. (March 23, 2001)

¹⁰ Adapted From: “Why Can’t Ecosystems Just Adapt”. Available at: <http://www.gcrio.org/ipcc/qa/11.html>. (March 23, 2001)

“Climate change is likely to have a wide ranging and mostly adverse effect on human health”¹¹, leading to increases “in the potential transmission of many infectious diseases including malaria, encephalitis, cholera, dengue, salmonellosis and yellow fever”¹².

Increased global warming will extend the range of organisms such as insects that carry these diseases into temperate zones, including parts of the USA, Europe and Asia. Projections indicate that the zone of potential malaria transmission, as a response to increases in global surface temperatures may enlarge from an area containing 45% of the world’s population to about 60% by the end of the 21st century, with this resulting in 50-80 million additional cases of malaria per year¹³.

EXAMPLE:

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Impact Of Climate Change On Agriculture¹⁴

Most of the world’s population depends on agricultural activities. Climate change would strongly affect agriculture in the following ways:

- Raising sea levels – a rise in sea levels will increase the potential for the flooding of farmland and increase the sodium chloride (salt) content of coastal groundwater (not many crops can survive high levels of salt). This is particularly true for the Caribbean where agricultural soils are located near coastlines.

- Amplifying extreme weather events – extreme weather events such as hurricanes and droughts can have a detrimental effect on crops as too much precipitation can cause disease infestation and while too little (droughts) can impact negatively on the development of crops and cause crop failure. For example, studies by the IPCC predicts declines in grain yields of between 10 and 15% in Africa, Latin America and Asia within the next 50 years, due to increased rainfall and desertification. If this happens, one in eight of the world’s population could be at risk of famine.

- Shifting climate zones towards the poles - average temperatures are expected to increase more near the polar regions. This shift in climate zones will be more pronounced in North America and Europe. Climate belts, which are each optimal

¹¹ From: “Why Should a Few Degrees of Warming Be a Cause for Concern?”. Available at: <http://www.gcric.org/ipcc/qa/10.html> (March 23, 2001)

¹² From: “Why Should a Few Degrees of Warming Be a Cause for Concern?”. Available at: <http://www.gcric.org/ipcc/qa/10.html> (March 23, 2001)

¹³ Adapted from: “Why Should a Few Degrees of Warming Be a Cause for Concern?”. Available at: <http://www.gcric.org/ipcc/qa/10.html> (March 23, 2001)

¹⁴ Adapted from: UNEP. “The Impact of Climate Change on Agriculture” in Climate Change Information Kit.

for particular crops, and the tolerance ranges for plant species, including crops will shift northward, by 200 – 300 km for each 1 degree Celsius rise in global temperature. Crops for which temperature is the limiting factor will be significantly impacted. A warmer climate might interfere with crop germination or with other key stages of plant life-cycle.

- Reduced soil moisture – higher air temperatures will cause higher soil temperatures, which will accelerate the decay of soil organic matter. Evaporation rates increase by about 5% for every 1 degree rise in average annual temperature making the soil drier.

Impact Of Climate Change On Tourism

Climate change could cause severe repercussions on the tourist industry through:

- Accelerated erosion and flooding causing; loss of beach, loss of amenity value, infrastructure damage which can cause massive losses, structural damage to cruise ship ports
- More intense weather activities destroying the coastal zones
- Increases stress on coastal ecosystems from land-based pollution, storm water run-off and siltation
- Loss of coral reefs due to hurricanes and bleaching from higher temperatures. In addition, warming ocean waters are currently activating previously unknown bacteria and viruses which are killing or infecting corals, shellfish and fish.



Impact Of Climate Change On Water Resources¹⁵

Today, rapid population growth and expanding economic activity are putting enormous pressures on global water resources. Then large water requirements of households, industries, and farms are exceeding local supplies in many countries. Industrial wastes and intensive use of fertilizers continues to overload water supplies with dangerous chemicals, while poor irrigation practices are raising soil salinity and evaporation rates, putting even greater pressure on declining water resources.

Climate change would impact water resources as a result of alterations in regional precipitation and evaporation patterns. The expected higher temperatures will increase evaporation and therefore precipitation as well. Climate models indicate that a doubling of atmospheric concentrations of carbon dioxide would increase global precipitation by about 5%. The models also indicate that it is quite likely that precipitation would increase in some areas and decline in other areas.

¹⁵ Adapted from: UNEP. "The Impact of Climate Change on Water Resources" in Climate Change Information Kit.

In areas where climate change is expected to cause reduced precipitation, freshwater storage reserves, primarily in the form of groundwater will shrink steadily. Areas where more precipitation is not matched by increased evaporation would experience floods and higher lake and river levels. Diminished snow accumulation in winter would reduce the spring run-off that can be vital to replenishing lakes and rivers.

Worsening droughts combined with the over exploitation of water resources could cause salt to leach from the soil, this raising the salinity of the unsaturated zone (that layer between the ground and the underlying water table).

In coastal zones, the lower water table would also draw salt-water from the sea in to the fresh groundwater. At the same time, higher levels of carbon dioxide in the atmosphere are expected to improve the efficiency of photosynthesis in plants which could in turn cause more rapid evapo-transpiration. All these various effects would have negative consequences for watersheds, lake levels, aquifers and other sources of freshwater.

Leaching and intrusions of salt-water into freshwater stores would cause groundwater unfit for household as well as agricultural consumption. This is already occurring in many parts of the world. Reduced precipitation and increased evaporation in some parts of the world would damage croplands, forests, marshes and other ecosystems.

Conflicts over water resources are likely to worsen in fertile basins such as the Nile and in regions with rapid population growth and increasing problems of drought. Also, because freshwater is vital to health, some developing countries could face a reduction in their health standards and worsening epidemics.

Impact Of Climate Change On The Poor¹⁶

The predicted impacts of climate change would affect the poor by:

- Exacerbating hunger and poverty around the world - new and fluctuating weather patterns could have a strong negative impact on economic activity, particularly for those persons employed in the natural resources sector and who are highly dependent on farming, fishing or forestry. Some of these persons might actually see their livelihoods destroyed as a result of reduced rainfall, degraded soils and impoverished forests and fishing grounds.



¹⁶ Adapted from: UNEP. "Climate Change Scenarios: Why the Poor are most Vulnerable" in Climate Change Information Kit.

- Increasing mass migration – where climate change has severe impacts, persons, including refugees and immigrants would move from the most affected regions to those which are least vulnerable. The likeliest patterns would be from rural to urban areas within national boundaries and from the South to the North across national boundaries.

The poor would suffer most in many countries because they have fewer options for responding to climate change. For example, they would find it more difficult to change over to new crops that require less water, to pump water and irrigate to extend their cultivatable land or to adopt more intensive fishing methods. These solutions require expensive inputs such as machinery or fossil-fuel energy that the poor may not be able to afford.

The urban poor would also be at risk, as their food supplies could be disrupted and the shelters and city's infrastructure upon which they depend may prove to be inadequate in changed and volatile weather conditions.

Relationship Between Human Activities and Climate Change

Humans actively and productively use and manipulate large portions of the land surface of the Earth. Humans have altered the structure of many of the world's ecosystems by:

- Cutting down forests
- Ploughing soils
- Using rangelands to graze domesticated animals
- Introducing non native species to many regions
- Intensively fishing lakes rivers and oceans
- Constructing dams



Furthermore, the increasing emissions of greenhouse gases are as a consequence of:

- The burning of coal, oil and natural gas (fossil fuels)
- Deforestation
- Bad agricultural and industrial practices

continues to contribute to climate change. These human activities are leading to increases in atmospheric concentrations of greenhouse gases such as, carbon dioxide, methane, nitrous oxide, CFCs, and ozone in the lower parts of the atmosphere.

Human impacts on the world's ecosystem have made them less resilient to further changes. If the effects of climate change and global warming are to be undermined, both developing and developed nations will have to make concerted efforts to reduce carbon emissions. This will mean making changes to patterns of energy consumption and a reduction in the burning of fossil fuels.

Energy And Climate Change

The energy sector is the major cause of global climate change. Energy use is responsible for approximately $\frac{3}{4}$ of mankind's carbon dioxide emissions, $\frac{1}{5}$ th of methane emissions, and most of the nitrous oxides emitted.

Oil, coal and natural gas supply the energy needed for automobiles, heat, factories, etc. when these fossil fuels are burnt greenhouse gases are released. Thus, in addition to energy being produced, by products such as water vapour and carbon dioxide are also produced. When the fuels are burnt completely, the only by-product containing carbon is carbon dioxide. However, since combustion is often incomplete, other carbon containing gases are also produced – methane, carbon monoxide, etc.

The production of biomass (the burning of wood) contributes less to climate change than does the burning of fossil fuel, although a large amount of carbon dioxide is released. When plants are burned as fuel, their carbon is recycled back into the atmosphere at roughly the same rate at which it was removed, and as a result makes no net contribution to the pool of carbon dioxide in the air. This is not the case of fossil fuels, as the carbon contained in fossil fuels, which has been stored in the earth for as long as millions of years, is now being released over mere decades.

The extraction, processing, transportation and distribution of fossil fuels release greenhouse gases when:

- Natural gas is flared or vented from oil wells
- Accidents occur in oil well heads and pipe fittings
- There are leaks in natural gas pipelines - carbon dioxide and hydrocarbons are released
- Coal is mined or pulverised – methane appears naturally in coal seams as pockets of gas and is released during mining
- Oil and natural gas are refined into end products
- Coal is crushed and washed to remove ash, sulphur and other impurities
- There are oil spills from tanker ships during transportation and distribution of liquid fuels

