The Environmental Studies

A Review of Global Warming/Climate Change, Causes, Effects and Mitigations

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Abstract
This paper reviewed the concept of global warming and climate change, the causes of climate change and its associated effects and also went further to highlight some mitigating measures. The paper concluded that amidst global warming and climate change, man is at the center of it all. Man's production and consumption pattern, his waste management and disposal pattern, his industrial and agricultural productivity pattern and the production of nuclear warfare and above all his attitude towards the environment has been found to be the major contributory factors to climate change. It is therefore recommended among others that human consumption of goods should be checked, while the sources and type of energy for man's industrial productivity should be changed towards sustainable green energy like solar energy, wind, hydropower electricity, thereby reducing the release of green house gases into the atmosphere.
Keywords: climate change, global warming, ozone layer depletion, human consumption pattern, renewable energy, sustainable energy and green house gas emission.

Introduction

Man-environmental interaction began right from when man first found himself on the planet earth. In Christianity, we have the bible account of creation as recorded in Genesis 1: 26-28, where God after creation saw that it was good and then said man must be created in His own image and after the creation of man, he was given dominion over God's creation and commanded to eat everything and subdue nature (Gen 1:28). This is where the problem began for mankind. Beginning from the Industrial Revolution of the 1700 century and the Great Dust Bowl of early 1900s to 1940s where industrial activities began booming and the use of coal and fuel wood for energy generation and agricultural pesticides made so much impact on the environment and the resources thereof. This necessitated the raising of alarm by Rachael Carson in her book the ''*silent spring*'' where she drew the world's attention to the effect of agricultural pesticides, bye products of energy usage and their impacts on the environment. This outcry by Carson was met with stiff opposition by industrial owners and businessmen in this period.

The world attention was first drawn to the global climate change or global warming situation by Farman (1985). Farman, while doing his research in the Arctic and Antarctic regions of the world was fascinated by the extent to which he was discovering new phenomenon in the atmosphere, where he first saw a hole in the Ozone layer of the atmosphere. In his enthusiasm and fascination, he reported that he discovered a hole in the Antarctic region in the atmosphere and that hole he first called the ''*Atmospheric Window''*. As research and studies continued, it was then discovered that the hole Farman discovered and named ''atmospheric window'' was not a window in the atmosphere per se, but an area of the ozone lay depleted by human activities thereby creating a figment of a window which he reported earlier on. Nevertheless, this atmospheric window was then renamed Ozone layer depletion. Series of researches and studies were carried out and the outcome have clearly shown that man's industrial and agricultural activities have been the major drivers of the Ozone layer depletion resulting to global warming or green house effects.

Traditional with research endeavors, researchers became interested in knowing the cause of this window in the atmosphere or what was responsible for this depletion of the Ozone layer. In Farman's description of Ozone layer depletion, he likened the atmospheric cover call Ozone which is a combination of Oxygen and water vapor as a shield covering the earth atmosphere from the direct effects of sun light which has a very high content of Radioactive and Ultraviolent radiations capable of causing skin cancer and other form of impacts on human and animal health. Human activities have generated so much heat that it has weakened the lower coverage of the shield, thereby creating a gradual peeling of the lower section of the Ozone layer from the earth below, this continuous peeling or depletion has gradually led to the hole which now allows direct sun light to enter the earth's atmosphere.

Theoretical underpinning

Just as they are many scholars in this field of studies especially with different background, so also there exists different definition about the concept of climate change in the world. Global Climate Change or Global Warming can be defined as any consistent and quantitative addition or measurable increases in the average temperature of the earth's atmosphere, oceans, and landmasses which is above the normal ambient temperature of the surrounding environment. Scientist are of the wider opinion that the Earth is currently undergoing a traumatic period of rapid warming due to the rising levels of green house gases (heat-trapping gases) in the atmosphere. Other scholars see climate change from the perspective of the other name global warming which is primarily a problem of over accumulation of too much carbon dioxide (CO2) in the earth atmosphere—which acts as a blanket, trapping heat and warming the planet. This is caused when we burn fossil fuels like coal, oil and natural gas for energy or cut down and burn forests to create pastures and plantations. In this case, carbon accumulates and overloads our atmosphere. Certain waste management and agricultural practices aggravate the problem by releasing other potent global warming gases, such as methane and nitrous oxide (Allison, *et al.* (2009).

The Albedo effects of Greenhouse gases retaining the radiant energy (heat) transmitted from the Sun to the Earth is trapped and cannot escape back to the atmosphere, creating the process known as the greenhouse effect. This is what is responsible for the heating of the earth's atmosphere. The Greenhouse gases occur naturally without which the earth's planet would be too cold to sustain life. It is however observed that since the beginning of the Industrial Revolution in the mid-1700s, however, human activities have added more and more of these gases into the atmosphere (Eneji, et al. 2013). According to Good, *et al.* (2010) the levels of carbon dioxide, a powerful greenhouse gas, have risen by 35 percent since 1750, largely from the burning of fossil fuels such as coal, oil, and natural gas (Good, *et al.* (2010).

In order to get to the root of global climate warming, the United Nations brought together a group of scientists called the Intergovernmental Panel on Climate Change to bring to the fore the issues relating to these climate change (IPCC). The mandate of the IPCC was to meet regularly after some few years to review the latest scientific findings and write a report summarizing all that is known about global warming. Each report represents a consensus, or agreement, among hundreds of leading scientists (Watson, Zinyowera & Moss, 1996).

It is observed that right from the formation of the Earth, the Earth has warmed and cooled many times about 4.6 billion years ago. Global climate changes has been attributed to many factors, such as massive volcanic eruptions, earthquake, tornadoes etc, which increased the amount of atmospheric carbon dioxide leading to changes in the intensity of energy emitted by the Sun; and variations in Earth's position relative to the Sun, both in its orbit and in the inclination of its spin axis (Eneji, et al, 2011, Eneji, et al.2013). The variations in Earth's position which geoscientists have called Milankovitch cycles combine to produce cyclical changes in the global climate. These cycles are believed to be responsible for the repeated advance and retreat of glaciers and ice sheets during the Pleistocene Epoch (1.8 million to 11,500 years ago), during this time Earth went through fairly regular cycles of colder "glacial" periods (ice ages) and warmer "interglacial" periods. These Glacial periods occurred at roughly between 100,000-year intervals (US NRC, 2010; US NRC, 2011).

During interglacial periods, greenhouse gases such as carbon dioxide and methane naturally increase in the atmosphere from increased plant and animal life. But since 1750 greenhouse gases have increased dramatically to levels not seen in hundreds of thousands of years, due to the rapid growth of the human population combined with developments in technology and agriculture. Human activities now are a powerful factor influencing Earth's dynamic climate. The ice of the Polar Regions furnishes clues to the makeup of Earth's ancient atmosphere. Ice cores that scientists have bored from the ice sheets of Greenland and Antarctica provide natural records of both temperature and atmospheric greenhouse gases going back hundreds of thousands of years. Layers in these ice cores created by seasonal snowfall patterns allow scientists to determine the age of the ice in each core. By measuring tiny air bubbles trapped in the ice and properties of the ice itself, scientists can estimate the temperature and amount of greenhouse gases in Earth's past atmosphere at the time each layer formed. Based on this data, scientists know that greenhouse gases have now risen to levels higher than at any time in the last 650,000 years (Confalonieri, 2007; US NRC, 2010; US NRC, 2011).

Greenhouse gases are rising, and temperatures are following. Before the late 1800s, the average surface temperature of Earth was almost 15°C (59°F). Over the past 100 years, the average surface temperature has risen by about 0.7 Celsius degrees (1.3 Fahrenheit degrees), with most of the increase occurring since the 1970s. Scientists have linked even this amount of warming to numerous changes taking place around the world, including melting mountain glaciers and polar ice, rising sea level, more intense and longer droughts, more intense storms, more frequent heat waves, and changes in the life cycles of many plants and animals. Warming has been most dramatic in the Arctic, where temperatures have risen almost twice as much as the global average.

Some Causes of Global Climate Change or Global Warming

Burning of fossil fuel

Studies have shown that our ever increasing addiction and insatiable want for electricity from coal burning power plants releases enormous amounts of carbon dioxide into the atmosphere. More 40% of CO2 emissions come from electricity production globally, and burning coal accounts for 93% of emissions from the electric utility industry. Modern car culture and appetite for globally sourced goods is responsible for about 33% of emissions in the world. With the alarming growing rate of human population, the demand for more cars and consumer goods will ever increase the use of fossil fuels for transportation and manufacturing. Our consumption is outpacing our discoveries of ways to mitigate the effects, with no end in sight to our massive consumer culture.

Greenhouse gases occur naturally in the environment and also result from human activities. By far the most abundant greenhouse gas is water vapor, which reaches the atmosphere through evapo-transpiration from oceans, lakes, rivers and plants. The amount of water vapor in the atmosphere is not directly affected by human activities. Carbon dioxide, methane, nitrous oxide, and ozone all occur naturally in the environment, but they are being produced at record levels by human activities. Other greenhouse gases do not occur naturally at all and are produced only through industrial processes. Human activities also produce airborne particles called aerosols, which offset some of the warming influence of increasing greenhouse gases (Schneider, 2007).

According to Schneider, (2007) Carbon dioxide is the second most abundant greenhouse gas, after water vapor. Carbon dioxide constantly circulates in the environment through a variety of natural processes known as the carbon cycle. It is released into the atmosphere from natural processes such as eruptions of volcanoes; the respiration of animals, which breathe in oxygen and exhale carbon dioxide; and the burning or decay of plants and other organic matter. Carbon dioxide leaves the atmosphere when it is absorbed into water, especially the oceans, and by plants, especially trees. Through a process called photosynthesis, plants use the energy of light to convert carbon dioxide and water into simple sugar, which they use as food. In the process, plants store carbon in new tissue and release oxygen as a byproduct which is consumed by animals (both man and animals) during respiration. This is again shows the interrelationship between animals and plants in their ecosystems.

Humans are significantly increasing the amount of carbon dioxide released to the atmosphere through the burning of fossil fuels (such as coal, oil, and natural gas), solid wastes, and wood and wood products to heat buildings, drive vehicles, and generate electricity. At the same time, the number of trees available to absorb carbon dioxide through photosynthesis has been greatly reduced by deforestation, the widespread cutting of trees for lumber or to clear land for agriculture.

Nicholls, (2007) however observed that human activities are causing carbon dioxide to be released to the atmosphere much faster than Earth's natural processes can remove it. In addition, carbon dioxide can remain in the atmosphere a century or more before nature can dispose of it. Before the Industrial Revolution began in the mid-1700s, there were about 280 molecules of carbon dioxide per million molecules of air (abbreviated as parts per million, or ppm). Concentrations of carbon dioxide have risen since then as industrial production and fossil fuel-based transportation and electricity generation have spread around the world, accelerating in the last 50 years. In 2007 the Intergovernmental Panel on Climate Change (IPCC), a major scientific organization, reported that levels of carbon dioxide had risen to a record high of 379 ppm and are increasing an average of 1.9 ppm per year (Mimura, 2007). To stabilize atmospheric concentrations of carbon dioxide, global emissions would need to be cut significantly—on the order of 70 to 80 percent. If efforts are not made to reduce greenhouse gas emissions, carbon dioxide is projected to reach concentrations more than double or even triple the level prior to the Industrial Revolution by 2100. In a higher-emissions scenario carbon dioxide is projected to reach 970 ppm by 2100, more than tripling preindustrial concentrations. In a lower-emissions scenario, carbon dioxide is projected to reach 540 ppm by 2100, still almost doubling preindustrial concentrations.

In the last half of the 20th century, the use of chemical fertilizers instead of traditional farm yard manure has risen dramatically. The high rate of application of nitrogen-rich fertilizers has effects on the heat storage of cropland (nitrogen oxides have 300 times more heat-trapping capacity per unit of volume than carbon dioxide) and the run-off of excess fertilizers creates 'dead-zones' in our oceans. In addition to these effects, high nitrate levels in groundwater due to over-fertilization are cause for concern for human health.

Agriculture Activities

Methane is another extremely potent greenhouse gas, ranking right behind CO_2. When organic matter is broken down by bacteria under oxygen-starved conditions (anaerobic decomposition) as in rice paddies, methane is produced. The process also takes place in the intestines of herbivorous animals, and with the increase in the amount of concentrated livestock production, the levels of methane released into the atmosphere is increasing. Another source of methane is methane clathrate, a compound containing large amounts of methane (CH_4) trapped in the crystal structure of ice. As methane escapes from the Arctic seabed, the rate of global warming will increase significantly. Another potent source of methane is waste garbage as observed in most parts of the world. The repugnant odor of mostly observed around waste garbage is methane.

Scholars have variously observed that Methane is emitted into the atmosphere during the mining of coal and the production and transportation of natural gas and oil. Methane also comes from rotting organic matter in landfills, rice paddies, and wetlands, as well as from certain animals, especially cows, as a byproduct of digestion. Live plants also emit small amounts of methane.

Scientists are increasingly concerned about the release of methane and carbon dioxide from melting permafrost, areas of frozen ground in the tundra (Arctic plains) of Alaska, Siberia, and other subpolar regions. Temperatures in the top layer of permafrost have increased, leading to a decrease in the area of seasonally frozen ground. Methane released from these areas as they melt would contribute to further warming and further melting, in what scientists call a feedback process (Mimura, 2007; Kundzewicz, 2007; Wilbanks, 2007). Methane traps nearly 30 times more heat than the same amount of carbon dioxide. Compared to carbon dioxide, methane appears in lower concentrations in the atmosphere and remains in the atmosphere for a shorter time. In total, methane contributes about a third as much as carbon dioxide to global warming. Nitrous oxide is a potent greenhouse gas that is released primarily by plowing farm soils and burning fossil fuels. Nitrous oxide traps about 300 times more heat than does the same amount of carbon dioxide. The concentration of nitrous oxide in the atmosphere has increased 18 percent over preindustrial levels. Nitrous oxide contributes about a tenth as much as carbon dioxide to global warming.

Burning of fuel for Industrial processes

Manufacturing processes use or generate many synthetic chemicals that are powerful greenhouse gases. Although these gases are produced in relatively small quantities, they trap hundreds to thousands of times more heat in the atmosphere than an equal amount of carbon dioxide does. In addition, their chemical bonds make them exceptionally long-lived in the environment.

Human-made greenhouse gases include chlorofluorocarbons (CFCs), a family of chlorine-containing gases that were widely used in the 20th century as refrigerants, aerosol spray propellants, and cleaning agents. Scientific studies showed that the chlorine released by CFCs into the upper atmosphere destroys the ozone layer (Wilbanks, 2007; Eneji, *et al,* 2011). As a result, CFCs are being phased out of production under a 1987 international treaty, the

Montréal Protocol on Substances that Deplete the Ozone Layer. CFCs were mostly banned in industrialized nations beginning in 1996 and were be phased out in developing countries after 2010.

Despite the singing of this protocol and charters, the extent of this phasing out in developing countries is yet to be ascertained. New chemicals have been developed to replace CFCs, but they are also potent greenhouse gases. The substitutes include hydrochlorofluorocarbons (HCFCs), hydrofluorocarbons (HFCs), and perfluorocarbons (PFCs).

Although HCFCs are less damaging to the ozone layer than CFCs, they also contain chlorine and are scheduled to be completely phased out by 2030 under amendments made in 2007 to the Montréal Protocol, while developed countries must end their use of HCFCs by 2020 under the amended protocol. Although HFCs and PFCs do not destroy the ozone layer, they are powerful greenhouse gases. In addition, they last longer in the atmosphere than CFCs, which have an average lifespan of 120 years. PFCs are exceptionally long-lived chemicals—they can persist in the atmosphere between 2,600 and 50,000 years, depending on the specific compound. Their accumulation in the atmosphere is therefore essentially irreversible. PFCs are used in the production of aluminum, in the manufacture of semiconductors, and as refrigerants (Wilbanks, 2007).Another human-made chemical, sulfur hexafluoride, is one of the most potentially destructive greenhouse gases ever produced. This synthetic gas compound has nearly 24,000 times the warming effect of an equal amount of carbon dioxide over a period of 100 years. It is an exceptionally stable gas with an estimated lifespan of 3,200 years once it is released in the atmosphere. Sulfur hexafluoride is used as insulation for high-voltage electrical equipment and in the production and casting of magnesium (IPCC 2007).

Studies further found out that fuel combustion, and to a lesser extent agricultural and industrial processes, produce not only gases but also tiny solid and liquid particles called aerosols that remain suspended in the atmosphere. Although aerosols are not considered greenhouse gases, they do affect global warming in several ways. Diesel engines and some types of biomass burning produce black aerosols such as soot, which absorb the Sun’s energy and therefore contribute to warming. Conversely, coal-fired power plants burning high-sulfur coal emit sulfate aerosols, which are light-colored aerosols that reflect incoming solar energy back to space. In this way, they have a cooling effect. Natural aerosols that also have a cooling effect are produced during volcanic eruptions and the evaporation of seawater. Aerosol particles also have an indirect cooling influence by acting as “seeds” for the condensation of water vapor into cloud masses. In general, the amount of solar energy reflected back to space is greater on cloudy days.

Overall, aerosols may roughly offset the net warming influence of non-carbon dioxide greenhouse gases, half through their direct cooling effect and half through their indirect cooling effect. However, considerable uncertainty in aerosol processes means that their cooling influence could be much larger or much smaller. Aerosols are one of the least-understood factors in climate change and their effects are still being debated. Scientists are more certain, however, about the net effect of all greenhouse gas and aerosol emissions, which is estimated to be roughly equal to the warming influence of carbon dioxide alone (IPCC 2007).

Deforestation, especially tropical forests for wood, pulp, and farmland

The use of forests for fuel (both wood and for charcoal) is one cause of deforestation, our appetite for wood and paper products, our consumption of livestock grazed on former forest land, and the use of tropical forest lands for commodities like palm oil plantations contributes to the mass deforestation of our world. Forests remove and store carbon dioxide from the atmosphere, and this deforestation releases large amounts of carbon, as well as reducing the amount of carbon capture on the planet.

Some Effects of Global Climate Change or Global Warming

Scientists have used different computer assisted satellite images or models of temperature trends, precipitation patterns, and atmosphere circulation to study global warming. Based on these models, scientists have made many projections about how global warming will affect weather, glacial ice, sea levels, agriculture, wildlife, and human health. Many changes linked to rising temperatures are already being observed. Scientist’s projected that the polar regions of the Northern Hemisphere will heat up more than other areas of the planet, and glaciers and sea ice will shrink as a result. Regions that now experience light winter snows may receive no snow at all. In temperate mountains, snowlines will be higher and snowpacks will melt earlier. Growing seasons will be longer in some areas.

Winter and nighttime temperatures will tend to rise more than summer and daytime temperatures. Many of these trends are already beginning to be observed. Arctic temperatures, for example, have increased almost twice as much as the global average over the past 100 years (IPCC 2007; Tol, 2008). .

Over the last century, global average temperature has increased by more than 1°F (0.7°C). The 2001-2010 decade is the warmest since 1880—the earliest year for which comprehensive global temperature records were available. In fact, nine of the warmest years on record have occurred in just the last 10 years. This warming has been accompanied by a decrease in very cold days and nights and an increase in extremely hot days and warm nights. Of course, land and ocean temperature is only one way to measure the effects of climate change. A warming world also has the potential to change rainfall and snow patterns, increase droughts and severe storms, reduce lake ice cover, melt glaciers, increase sea levels, and change plant and animal behavior and development patterns (Tol, 2008).

Scientists predict a global increase in sea levels worldwide due to the melting of two massive ice sheets in Antarctica and Greenland, especially on the East coast of the U.S. However, many nations around the world are experiencing the effects of rising sea levels, which has displaced millions of people (Eneji, et al., 2011; Tol, 2008). In Nigeria for example, between 2010 and 2015, more than fifteen cases of flooding has been recorded especially in the north eastern and Southern parts of the country. Though due to limited information and knowledge about the workings of global climate change, the causes of these flooding in Nigeria has always been adduced to the opening of the Lagdo Dam in the Republic of Cameroun. But one may ask if this dam is opened annually from Cameroun? With the rising temperatures, there is projection that there will more killer storms .Studies have shown that the degree or extent of severity of storms such as Tsunamis, hurricanes, tornadoes and cyclones is increasing, and scientists have come up with the firmest evidence so far that global warming will significantly increase the intensity of the most extreme storms worldwide (Tol, 2008).

Recent researches have shown that there are about 90% chances that 3 billion people worldwide will have to choose between moving their families to areas with milder climates or deciding to go hungry as a result of global agricultural crop failure due to climate change. One of the main causes of this will be the shortage in the amount of rainfall or precipitation resulting to widespread desertification with its attendant effects. “Climate change is expected to have the most severe impact on water supplies. “Shortages in future are likely to threaten food production, reduce sanitation, and hinder economic development and damage ecosystems. It causes more violent swings between floods and droughts. Scholars have observed that the rising temperatures might lead to the extinction of more than a million species, this is worrisome because man’s existence on the planet is tied to the presence of the diverse species and population of plants and animals in the ecosystems. A significant number of species have gone extinct or are under threat as a result of the global climate change. Modest rise in sea level will have huge impacts on coastal ecosystems. New marshes would eventually form in many places, but not where urban areas and developed landscapes block the way.

The WWF posited in a report that if this rate of global climate change continues, in worst cases, coral populations will collapse by 2100 leading to the extinction of coral reefs, due to increased temperatures and ocean acidification. This is because it has been observed that the ‘bleaching’ of corals from small but prolonged rises in sea temperature is a severe danger for ocean ecosystems, and many other species in the oceans rely on coral reefs for their survival (Yohe, 2007). For reefs, warming waters and acidification are closing in like a pair of jaws that threaten to make them the first global ecosystem to disappear. A warmer world will be generally more humid as a result of more water evaporating from the oceans. A more humid atmosphere can both contribute to and offset further warming. On the one hand, water vapor is a greenhouse gas, and its increased presence would further increase warming. On the other hand, more water vapor in the atmosphere will produce more clouds, which reflect sunlight back into space, thereby slowing the warming process (*see* Water Cycle). It is uncertain which of these effects will be greater in the future, and scientists factor in both possibilities when projecting temperature increases. This is one of the main reasons that projections include ranges of high and low temperatures for different emissions scenarios.

Fisher, (2007) however discovered that storms are expected to be more frequent and more intense in a warmer world. Water will also evaporate more rapidly from soil, causing it to dry out faster between rains. Some regions might actually become drier than before. Overall, higher latitudes are projected to receive more rainfall, and subtropical areas are projected to receive less. Shifting patterns of precipitation (both snow and rain) have been observed in many regions since 1900. Significantly wetter conditions have been recorded in the eastern parts of North and South America, northern Europe, and northern and central Asia. Drier conditions have prevailed in the Sahel region of western Africa, southern Africa, the Mediterranean, and parts of southern Asia. Droughts are projected to become longer and more intense; in fact, this has already been observed since the 1970s, particularly in the tropics and subtropics (Klein, 2007). Weather patterns are expected to be less predictable and more extreme. Storm tracks are projected to move toward the poles, shifting wind, rainfall, and temperature patterns. Heat waves will continue to become more frequent and intense, a trend already observed. Hurricanes, violent storms that draw their force from warm ocean water, are likely to become more severe. The intensity of hurricanes has already increased since the 1970s.

Warming temperatures are already causing significant changes to mountain glaciers around the world, ice sheets in Greenland and the Antarctic, and polar sea ice in the Arctic. From Europe to Africa to Asia to North America, mountain glaciers have receded over the 20th century, and melting is becoming more rapid. The large-scale melting of ice may accelerate the pace of global warming in what is known as a feedback process. Because ice reflects sunlight back out to space, it has a cooling effect. Water and land, which are darker than ice, absorb and retain more heat.

Glaciers on Kilimanjaro, the highest mountain in Africa, have lost 82 percent of their ice since 1912 and are estimated to be gone completely by 2020 (Pearce, 2003). Glaciers in the lofty Himalayas of Asia are melting at a rate of 9 to 15 m (30 to 50 ft) per year. Annual runoff from these glaciers feeds major rivers such as the Ganges, Yangtze, and Mekong. Glacier National Park in Montana is projected to have no glaciers left by 2030, and the number of glaciers has already dropped from an estimated 150 in 1850 to 26 in 2007 (IPCC (2007a). In the Arctic annual average temperature has increased at almost twice the global rate over the past few decades. The area covered by sea ice during summer has declined by 15 to 20 percent in the last 30 years, and is projected to disappear almost completely late in the 21st century. Many species, including polar bears, seals, and walrus, depend on sea ice for their survival. The rapid loss of Alaskan glaciers represents almost half of the total loss of ice in glaciers worldwide, and makes a significant contribution to observed sea level rise. Melting of the Greenland ice sheet, which could raise sea level by 7 m (23 ft) if it melted completely, is also accelerating. The area that is experiencing at least some melting increased by 16 percent from 1979 to 2002, and scientists estimate that warming of more than a few degrees Celsius could cause widespread and possibly unstoppable melting, leading to significant sea level rise and subsequent flooding.

Fresh water flowing from melting Arctic ice into the North Atlantic Ocean could disrupt ocean circulation patterns, which have a significant influence on the global climate. According to scientific projections (Tol & Yohe, 2006) a collapse of ocean circulation patterns is unlikely to occur by 2100. According to McCarthy, Canziani, Leary, Dokken & White, (2001) the situation in the Antarctica is somewhat different than in the Arctic. The Antarctic Peninsula, the “tail” of land reaching toward South America, has experienced dramatic warming at a rate several times the global average over the past 50 years. However, other parts of Antarctica have not shown similar trends, with some areas warming and some cooling. Overall, Antarctica is estimated to be warming at about the global average rate. Unlike the Arctic, there has been no clear general trend in sea ice. In the Antarctic Peninsula, however, ten floating ice shelves have lost more than 14,000 sq km (5,400 sq mi) of ice, and probably have not been at such a low level in the past 10,000 years. As in Greenland, scientists estimate that warming of more than a few degrees Celsius could lead to widespread melting of the West Antarctica ice sheet. This melting alone would raise sea level by as much as 5 m (16 ft) (Tol & Yohe, 2006).

As the atmosphere warms, the surface layer of the ocean warms as well, expanding in volume and thus raising sea level. The melting of glaciers and ice sheets, especially around Greenland, further swells the sea. Sea level rose 10 to 25 cm (4 to 10 in) during the 20th century. Rising sea level will complicate life in many island and coastal regions. Storm surges, in which winds locally pile up water and raise the sea, will become more frequent and damaging.

Erosion of cliffs, beaches, and dunes will increase. As the sea invades the mouths of rivers, flooding from runoff will also increase upstream (Metz, Davidson, Swart & Pan, 2001).

Scientist in the IPCC panel showed the extent of global climate change and warming using the small island nations such as Tuvalu and Kiribati, where the highest land is only a few meters above sea level, are already experiencing saltwater intrusion, which is making groundwater undrinkable, and increased impacts from typhoons and heavy surf. These nations could literally cease to exist as the rise in sea level continues, and their governments are negotiating with other nations to transplant their populations. This will lead to cultural and value extinction, because the population will leave the territory of its borders to another country.

Plants and animals will find it difficult to escape from or adjust to the effects of global warming. Scientists have already observed shifts in the lifecycles of many plants and animals, such as flowers blooming earlier and birds hatching earlier in the spring. Many species have begun shifting where they live or their annual migration patterns due to warmer temperatures. With further warming, animals will tend to migrate toward the poles and up mountainsides toward higher elevations. Plants will also attempt to shift their ranges, seeking new areas as old habitats grow too warm. In many places, however, human development will prevent these shifts. Species that find cities or farmland blocking their way north or south may become extinct. Species living in unique ecosystems, such as those found in polar and mountaintop regions, are especially at risk because migration to new habitats is not possible. For example, polar bears and marine mammals in the Arctic are already threatened by dwindling sea ice but have nowhere farther north to go.

Projecting species extinction due to global warming is extremely difficult. Some scientists have estimated that 20 to 50 percent of species could be committed to extinction with 2 to 3 Celsius degrees (3.6 to 5.4 Fahrenheit degrees) of further warming. The rate of warming, not just the magnitude, is extremely important for plants and animals. Some species and even entire ecosystems, such as certain types of forest, may not be able to adjust quickly enough and may disappear (Metz, Davidson, Swart & Pan, 2001). Environmental disaster is also on the increase as warming melt the ice in the Polar Regions, there will be sea level rise leading to the inundation and submerging of lands, where crops are flooded and they die of suffocation. In most cases, properties and infrastructures are destroyed leading to the loss of human lives and money. Diseases incidence will increase and human lives will be lost due to these diseases in the areas where there were not originally there (Eneji, et al., 2012). At the same time, there will be some decreases in the number of cold-related deaths. Diseases such as malaria, now found in the tropics and transmitted by mosquitoes and other animal hosts, are projected to widen their range as these animal hosts move into regions formerly too cold for them. Other tropical diseases may spread similarly, including dengue fever, yellow fever, and encephalitis. Scientists also project rising incidence of allergies and respiratory diseases as warmer air grows more charged with pollutants, mold spores and pollens.

Efforts to Control Global Warming /Climate Change

Scholar have found out that responding to the challenge of controlling global warming or climate change will require fundamental changes in energy production, transportation, industry, government policies, and development strategies around the world. These changes take time. The challenge today is managing the impacts that cannot be avoided while taking steps to prevent more severe impacts in the future (Solomon, Qin, Manning, Chen, Marquis, Averyt, Tignor & Miller, 2007). Reducing emissions of greenhouse gases, also called greenhouse gas mitigation, is a necessary strategy for controlling global warming. There are two major approaches to slowing the buildup of greenhouse gases. One is to reduce the consumption of fossil fuels, thereby reducing greenhouse gas emissions. The other is to keep carbon dioxide out of the atmosphere by storing the gas or its carbon component somewhere else, a strategy known as carbon sequestration or carbon capture.

One way to keep carbon dioxide emissions from reaching the atmosphere is to preserve and plant more trees. Trees, especially young and fast-growing ones, soak up a great deal of carbon dioxide from the atmosphere and store carbon atoms in new wood. Worldwide, forests are being cleared at an alarming rate, particularly in the tropics. In many areas, there is little regrowth as land loses fertility or is changed to other uses, such as farming or housing developments. In addition, when trees are burned to clear land, they release stored carbon back into the atmosphere as carbon dioxide. Slowing the rate of deforestation and planting new trees (afforestation and re-afforestation) and the Tuangya system can help counteract the buildup of greenhouse gases.

Carbon dioxide gas can also be captured directly; Carbon dioxide has traditionally been injected into depleted oil wells to force more oil out of the ground or seafloor. The same process can be used to store carbon dioxide released by a power plant, factory, or any large stationary source. For example, since 1996 this process has been used at a natural gas drilling platform off the coast of Norway. Carbon dioxide brought to the surface with the natural gas is captured, compressed, and then injected into an aquifer deep below the seabed from which it cannot escape. In most cases, the process of carbon capture would also involve transporting the gas in compressed form to suitable locations for underground storage. Deep ocean waters could also absorb a great deal of carbon dioxide, although the environmental effects may be harmful to ocean life. The feasibility and environmental effects of these options are under study by international teams. It is observed that the total global consumption of fossil fuels is increasing by several percent per year, however, energy use around the world is slowly shifting away from fuels that release a great deal of carbon dioxide toward fuels that release somewhat less of this heat-trapping gas.

Gas –electric hybrids

Wood was the first major source of energy used by humans. With the advent of the Industrial Revolution in the mid-1700s, coal became the dominant energy source. By the mid-1800s oil had replaced coal in dominance, fueling the internal combustion engines that were eventually used in automobiles. By the 1900s, natural gas began to be used worldwide for heating and lighting. In this progression, combustion of natural gas releases less carbon dioxide than oil, which in turn releases less of the gas than do either coal or wood. However, a reversal of this trend may be seen as reserves of oil are used up. Other fuel sources such as tar sands (also known as oil sands) are beginning to be utilized. Producing oil from tar sands involves extraction and refining processes that release carbon dioxide. In addition, the relative abundance of coal reserves in countries such as China and the United States may lead to a new upswing in the use of coal for generating electricity. Newer technologies for cleaner coal-burning power plants may help offset the effects.

Significant reductions in carbon dioxide emissions can only be achieved by switching away from fossil-fuel energy sources. Nuclear power plants release no carbon dioxide at all, but nuclear energy is controversial for reasons of safety, security, and the high costs of nuclear waste disposal. Solar power, wind power, and hydrogen fuel cells also emit no greenhouse gases. These energy sources can be practical, low-pollution alternatives to fossil fuels. Other alternatives include fuels made from plants, such as biodiesel (made from used and new vegetable oil) and ethanol (a plant-based gasoline additive). Use of these fuels can help reduce total carbon dioxide emissions from automobiles. The hybrid electric vehicle (HEV), which uses both an electric motor and a gasoline or diesel engine, emits less carbon dioxide than conventional automobiles.

International Agreements

International cooperation is required for the successful reduction of greenhouse gases. The first international conference addressing the issue was held in 1992 in Rio de Janeiro, Brazil. At the United Nations Conference on Environment and Development, informally known as the Earth Summit, 150 countries pledged to confront the problem of greenhouse gases by signing the United Nations Framework Convention on Climate Change (UNFCCC). To date, more than 180 nations have ratified the UNFCCC, which commits nations to stabilizing greenhouse gas concentrations in the atmosphere at a level that would avoid dangerous human interference with the climate. This is to be done so that ecosystems can adapt naturally to global warming, food production is not threatened, and economic development can proceed in a sustainable manner (Karl, Melillo & Peterson, 2009; Stocker, et al., 2013).

The nations at the Earth Summit agreed to meet again to translate these good intentions into a binding treaty for emissions reductions. In 1997 in Japan, 160 nations drafted an agreement known as the Kyōto Protocol, an amendment to the UNFCCC. This treaty set mandatory targets for the reduction of greenhouse gas emissions. Industrialized nations that ratify the treaty are required to cut their emissions by an average of 5 percent below 1990 levels. This reduction is to be achieved no later than 2012, and commitments to start achieving the targets are to begin in 2008. Developing nations are not required to commit to mandatory reductions in emissions. Under the Kyōto rules, industrialized nations are expected to take the first steps because they are responsible for most emissions to date and have more resources to devote to emissions-reduction efforts (Karl, Melillo & Peterson, 2009).

The recommendations and enforcement of the protocol cannot be implementation unless industrialized nations accounting for 55 percent of 1990 greenhouse gas emissions ratified it. That requirement was met in November 2004 when Russia approved the treaty, and it went into force in February 2005. By the end of 2006, 166 nations had signed and ratified the treaty. Notable exceptions included the United States and Australia. In 1998 the United States, then the world's single largest contributor to greenhouse gas emissions became a signatory to the Kyōto Protocol.

However, in 2001 U.S. president George W. Bush withdrew support for the treaty. He claimed that the treaty's goals for reducing carbon dioxide emissions would be too costly and would harm the U.S. economy. He also claimed the treaty put an unfair burden on industrialized nations. Opposition to the treaty in the United States was spurred by the oil industry, the coal industry, and other enterprises that manufacture or depend on fossil fuels. These opponents claimed that the economic costs to carry out the Kyōto Protocol could be as much as $300 billion, due mainly to higher energy prices (Field, *et al.,* 2014). Proponents of the Kyōto Protocol believed the costs would prove more modest ($88 billion) or less much of which would be recovered as Americans switched to more efficient appliances, vehicles, and industrial processes.

The Kyōto Protocol, which expires in 2012, is only a first step in addressing greenhouse gas emissions. To stabilize or reduce emissions in the 21st century, much stronger and broader action is required. In part this is because the Kyōto provisions did not take into account the rapid industrialization of countries such as China and India, which are among the developing nations exempted from the protocol's mandatory emissions reductions. However, developing nations are projected to produce half the world's greenhouse gases by 2035. Leaders of these nations argue that emissions controls are a costly hindrance to economic development. In the past, prosperity and pollution have tended to go together, as industrialization has always been a necessary component of an economy's development (Field, *et al.,* 2014). Whether or not an economy can grow without increasing greenhouse gas emissions at the same time is a question that will be critical as nations such as China and India continue on the path of industrialization.

In 2007 the European Union (EU) took the initiative in coming up with a new international plan to address global warming. At a "green summit" held in March, the 27 nations of the EU reached a landmark accord that went above and beyond the Kyōto Protocol in setting targets to reduce greenhouse gas emissions. The agreement set ambitious targets for the EU overall, but goals for individual EU nations and rules of enforcement were to be determined through additional negotiations. In the accord EU leaders agreed to reduce emissions by 20 percent from 1990 levels by 2020 or by as much as 30 percent if nations outside the EU joined in the commitments. They also agreed that renewable sources of energy, such as solar and wind power, would make up 20 percent of overall EU energy consumption by 2020 (an increase of about 14 percent). The accord also called for a 10 percent increase in the use of plant-derived fuels, such as biodiesel and ethanol. In addition to these targets, EU leaders agreed to work out a plan to promote energy-saving fluorescent light bulbs, following the example of countries such as Australia and Chile that are officially phasing out less-efficient incandescent light bulbs (Edenhofer, *et al.* 2014; IPCC, 2014). At a national level, the United States has so far relied on voluntary programs to reduce emissions. For example, the Department of Energy, the Environmental Protection Agency, product manufacturers, local utilities, and retailers have collaborated to implement the Energy Star program. This program rates appliances for energy use and gives some money back to consumers who buy efficient machines.

Global climate change future

Damage can be curbed locally in various ways. Coastlines can be armored with dikes, levies, and other barriers to block encroachment of the sea. Alternatively, governments can assist coastal populations in moving to higher ground, although such a process is extremely costly, especially in heavily populated areas. Some extremely low-lying countries would face rising sea level with huge populations at risk. Wealthy countries like The Netherlands may need to spend huge amounts of money to protect their shorelines, while poor countries like Bangladesh may be forced to simply abandon low-lying coastal regions.

Individuals, too, can take steps to curb their own emissions. The same choices that reduce other kinds of pollution work against greenhouse gases. Every time a consumer buys an energy-efficient appliance, uses energy-saving light bulbs, adds insulation to a house, recycles materials, chooses to live near work, or commutes by public transportation, he or she is fighting global warming. Global warming of a few degrees may increase agricultural production, but not necessarily in the same places where crops are grown now. Southern Canada, for example, may benefit from more rainfall and a longer growing season. At the same time, the semiarid tropical farmlands in some parts of Africa may become further impoverished. Farming regions such as California's Central Valley that bring in irrigation water from distant mountains may suffer as the winter snowpack, which functions as a natural reservoir, melts before the peak growing months. Crops and woodlands may also be afflicted by more insects and plant diseases. Agricultural areas will need to adapt to changing conditions, such as by shifting the types of crops grown or investing in drought-tolerant or heat-tolerant varieties. Scientists estimate that warming of up to about 3 Celsius degrees (5.4 Fahrenheit degrees) could increase global agricultural potential, but that further warming is likely to decrease this potential (IPCC, 2014).

Conclusions

Scholars observed that for many years global warming was portrayed in the media as an issue with two sides, with some scientists arguing that global warming is occurring and others arguing that it is not. However, this portrayal was an oversimplification of the scientific debate. Those who were skeptical about global warming, including some scientists, observed that there are some unanswered scientific uncertainties question whether global warming is actually occurring. However, there is now undeniable evidence that global temperatures are increasing, based on direct temperature measurements and observations of other impacts such as melting glaciers and polar ice, rising sea level, and changes in the lifecycles of plants and animals. As the scientific evidence on rising global temperature became indisputable, skeptics focused their argument on whether human activities are in fact the cause of global warming. They argued that the observed warming could be caused by natural processes such as changes in the energy emitted by the Sun. However, the Sun's influence has been found to have contributed only slightly to observe warming, particularly since the mid-20th century. In fact, there is overwhelming evidence that greenhouse gas emissions from human activities are the main cause of the warming.

Fourth Assessment Report, released in 2007of IPCC convened by United Nations Environment Program (UNEP) and the World Meteorological Organization (WMO) offered the strongest scientific consensus to date on global warming. The panel concluded that it is "very likely" (more than 90 percent probability) that human activities are responsible for most of the warming since the mid-20th century; that it is "extremely unlikely" (less than 5 percent probability) that the warming is due to natural variability; and that it is "very likely" the warming is not due to natural causes alone. This level of certainty is extremely high, given the complexity of the climate system and of the influence of human activities on the climate.

References

Allison, I. (2009). The Copenhagen Diagnosis, 2009: Updating the world on the Latest Climate Science, Sydney, Australia: The University of New South Wales Climate Change Research Centre (CCRC), retrieved 8 June 2014.

Confalonieri, U. (2007). *"Human health. In: Climate Change 2007: Impacts, Adaptation and Vulnerability.* Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [M.L. Parry et al., Eds.]". Cambridge University Press, Cambridge, UK, and New York, N.Y., U.S.A.

Eneji, V.C.O, Ogar, D.A, Omoogun, C.A, Ojikpong, C, Dunnamah, A.Y and Ekpo, C. (2013). Interactions of Market Horticultural Productivity on Climate and Weather Variations in the Northern Senatorial District of Cross River State, Nigeria. *Environment and Natural Resources Research,* 3(3), 1-9,

Eneji, V.C.O., Ben, C.B., Headboy P., Okongor-Eno O., Zemba A.A., Mubi M.A., and Oko P.E.(2011). Ecological Implication of Market Gardening in the Old Ogoja Zone of Nigeria. *International Journal of Physical Sciences* 6(22), 5309-5316

Fisher, B.S. (2007). *Issues related to mitigation in the long term context. In: Climate Change 2007: Mitigation.* Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [B. Metz et al. Eds.]". Cambridge University Press, Cambridge, UK, and New York, N.Y., U.S.A.

Good, P. (2010). *An updated review of developments in climate science research since IPCC* AR4. A report by the AVOID consortium (PDF), London, UK: Committee on Climate Change .

IPCC (2007a). "Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, Pachauri, R.K and Reisinger, A. (eds.)]". IPCC, Geneva, Switzerland. p. 104.

IPCC 2007, Summary for Policymakers, in *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change,* Cambridge University Press, Cambridge, UK, p. 17.

IPCC AR4 WG1 (2007), Solomon, S.; Qin, D.; Manning, M.; Chen, Z.; Marquis, M.; Averyt, K.B.; Tignor, M.; and Miller, H.L., ed., Climate Change 2007: The Physical Science Basis, Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, ISBN 978-0-521-88009-1 (pb: 978-0-521-70596-7).

IPCC AR5 WG1 (2013), Stocker, T.F.; et al., eds., Climate Change 2013: The Physical Science Basis. Working Group 1 (WG1) Contribution to the Intergovernmental Panel on Climate Change (IPCC) 5th Assessment Report (AR5), Cambridge University Press. Climate Change 2013 Working Group 1 website.

IPCC AR5 WG2 A (2014), Field, C.B.; et al., eds., Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II (WG2) to the Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC), Cambridge University Press. Archived 20 October 2014.

IPCC AR5 WG3 (2014). Mitigation of Climate Change in Edenhofer, O.; et al., eds., Climate Change 2014: Contribution of Working Group III (WG3) to the Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC), Cambridge University Press. Archived 29 June 2014.

IPCC press release (2014), Press Release: IPCC Report: A changing climate creates pervasive risks but opportunities exist for effective responses - Responses will face challenges with high warming of the climate (PDF), IPCC, retrieved 29 May 2014. Archived file. Also available in Arabic, Chinese, French, Russian and Spanish, 31st March

IPCC SAR WG2 (1996). Climate Change 1995 in Watson, R.T.; Zinyowera, M.C.; and Moss, R.H., ed., Impacts, Adaptations and Mitigation of Climate Change: Scientific-Technical Analyses, Contribution of Working Group II to the Second Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, ISBN 0-521-56431-X (pb: 0-521-56437-9 pdf.

IPCC TAR WG2 (2001). Climate Change 2001in McCarthy, J. J.; Canziani, O. F.; Leary, N. A.; Dokken, D. J.; and White, K. S., ed., Impacts, Adaptation and Vulnerability, Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, ISBN 0-521-80768-9 (pb: 0-521-01500-6).

IPCC TAR WG3 (2001). Climate Change 2001in Metz, B.; Davidson, O.; Swart, R.; and Pan, J., ed., Mitigation, Contribution of Working Group III to the Third Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, ISBN 0-521-80769-7 (pb: 0-521-01502-2).

Karl, Thomas R.; Melillo, Jerry M.; Peterson, Thomas C., (2009). Global Climate Change Impacts in the United States (PDF). New York: Cambridge University Press. ISBN 978-0-521-14407-0.

Klein, R.J.T. (2007). "Inter-relationships between adaptation and mitigation. In: Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [M.L. Parry et al. Eds.]". Cambridge University Press, Cambridge, UK, and New York, N.Y., U.S.A. pp. 745–777.

Kundzewicz, Z.W. (2007). "Freshwater resources and their management. In: Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [M.L. Parry et al. Eds.]". Cambridge University Press, Cambridge, UK, and New York, N.Y., U.S.A. pp. 173–210.

Mastrandrea, M. & Schneider, S.H (2009). "*Global Warming."* Redmond, WA: Microsoft Corporation, 2008.

Mimura, N. (2007). "Small islands. In: Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [M.L. Parry et al., Eds.]". Cambridge University Press, Cambridge, UK, and New York, N.Y., U.S.A. pp. 687–716.

Nicholls, R.J. (2007). Coastal systems and low-lying areas. In: Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [M.L. Parry et al., Eds.]". Cambridge University Press, Cambridge, UK, and New York, N.Y., U.S.A. pp. 315–356.

Pearce, D. (2003). "The Social Cost of Carbon and its Policy Implications" (PDF). *Oxford Review of Economic Policy* 19 (3): 362–384.

Schneider, S. H. (2007). "Assessing key vulnerabilities and the risk from climate change. In: Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [M.L. Parry et al., Eds.]". Cambridge University Press, Cambridge, UK, and New York, N.Y., U.S.A.

Tol, B. & and Yohe, A. (2006). "A Review of the Stern Review". *World Economics* 7(4): 233-50.

Tol, R.S.J. (2008). "Why Worry about Climate Change? A Research Agenda" (PDF). *Environmental Values* 17 (4): 437–470. doi:10.3197/096327108X368485.

US NRC (2010). Advancing the Science of Climate Change. A report by the US National Research Council (NRC). Washington, D.C., USA: National Academies Press. ISBN 0-309-14588-0.

US NRC (2011). Climate Stabilization Targets: Emissions, Concentrations, and Impacts over Decades to Millennia. A report by the US National Research Council (NRC), Washington, D.C., USA: National Academies Press Archived 27 March 2014.

Wilbanks, T.J. (2007). "Industry, settlement and society. In: Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [M.L. Parry et al., Eds.]". Cambridge University Press, Cambridge, UK, and New York, N.Y., U.S.A. Pg 357–390.

Yohe, G.W. (2007). "Perspectives on climate change and sustainability. In: Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [M.L. Parry et al., Eds.]". Cambridge University Press, Cambridge, UK, and New York, N.Y., U.S.A.