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Effect of global warming on climate change, flora and fauna

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Abstract : *Everything on planet Earth is interconnected, and when one thing is changed, it alters everything else. This is known as the butterfly effect, and it is seen everyday. How does global warming set off a chain reaction effects plants and animals around the world? Like humans, plants and animals need certain conditions to be comfortable and productive. If the thermostat at office is set too low, than a person gets cold and cannot work as well. The same thing happens with plants and animals. If it is too warm or too cold, they cannot reproduce at the same rate. When plants slow down there growth, they are not replenished rapidly enough to support all the animals which usually feed on them. Fewer plants means that area can support fewer plant eating animals. Less plant eaters leads to a decrease in the number of predatory animals. If the growth of the trees are affected than the entire food chain is thrown off balance. Humans are a part of the food chain as well, and when we kill off plants and animals through the changes in the climate we have brought about, we ultimately shorten our own life spans.*

Key Words : Global warming, Climate change, Flora, Fauna.

Introduction

Global warming is the increase in the average temperature of Earth near- surface air and oceans since the mid-20th century and its projected continuation. According to the 2007a,b Fourth Assessment Report by the Intergovernmental Panel on Climate Change (IPCC), global surface temperature increased by 0.74 ± 0.18 °C (1.33 ± 0.32 °F) during the 20th century. Most of the observed temperature increase since the middle of the 20th century has been caused by increasing concentrations of greenhouse gases, which result from human activities such as the burning of fossil fuel and deforestation.

Climate model projections summarized in the latest IPCC report indicate that the global surface temperature is likely to rise a further 1.1 to 6.4 °C (2.0 to 11.5 °F) during the 21st century. This change appears to be small but this will change the climate to a great extent. There will be increase in hot days and many scientists believe that an increase in temperatures may lead to precipitation and change in weather patterns. Warmer ocean waters may result in more intense and frequent tropical storms and hurricanes. The uncertainty in this estimate arises from the use of models with differing sensitivity to greenhouse gas concentrations and the use of differing estimates of future greenhouse gas emissions. An increase in global temperature will cause sea levels to rise and will change the amount and pattern of precipitation, probably including expansion of subtropical deserts. Warming is expected to be strongest in the Arctic and would be associated with continuing retreat of glaciers, permafrost and sea ice. Other likely effects include more frequent and intense extreme weather events, species extinctions, and changes in agricultural yields. Warming and related changes will vary from region to region around the globe, though the nature of these regional changes is uncertain. As a result of

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contemporary increases in atmospheric carbon dioxide, the oceans have become more acidic, a result that is predicted to continue.

The scientific consensus is that anthropogenic global warming is occurring. Nevertheless, skepticism amongst the wider public remains. The Kyoto Protocol is aimed at stabilizing greenhouse gas concentration to prevent a "dangerous anthropogenic interference". As of November 2009, 187 states had signed and ratified the protocol. Proposed responses to global warming include mitigation to reduce emissions, adaptation to the effects of global warming, and geoengineering to remove greenhouse gases from the atmosphere. Scientists have looked at evidence about past changes in atmospheric CO_2 concentrations and atmospheric temperatures. They have also developed sophisticated mathematical models of the earth's climate system and made projections about possible future changes.

As a result of these studies and models, most climate scientists have come to an important conclusion. They believe that increased inputs of CO_2 and other greenhouse gases into the atmosphere from human activities will enhance the earth's natural greenhouse effect and raise the average global temperature of the atmosphere near the earth's surface. This enhanced greenhouse effect is global warming.

Climate change

Climate is a region's general pattern of atmospheric or weather conditions over a long period. Average temperature and precipitation are two main factors determining a regions climate and its effect on people.

Small amounts of certain gases play a key role in determining the average temperature and its climate. These gases include water vapour (H_2O), carbon dioxide (CO_2) and synthetic chlorofluorocarbon (CFCs).Together these gases are known as greenhouse gases, which allow mostly visible light and some infrared and ultraviolet radiation from the sun to pass through the troposphere. The earth's surface absorbs much of the solar energy. This transforms it to longer wavelength infrared radiation (heat) which then rises into the troposphere. Some of the heat escapes into space, and some is absorbed by molecules of greenhouse gases and emitted into the troposphere as even longer wave infrared radiation, which warms the air. This natural warming effect of troposphere is called the greenhouse effect.

Human activities such as burning fossil fuels, clearing forests and growing crops release carbon dioxide, methane, and nitrous oxide into the atmosphere. It is of great concern that large input of these gases into the troposphere can enhance the earth's natural greenhouse effect and lead to global warming.

The ozone layer also creates warm layers of the air that prevent churning gases in the troposphere from entering the stratosphere. This thermal cap is important in determining the average temperature of the troposphere and thus the earth's current climates. Various topographic features of the earth's surface create local climatic conditions, or microclimates that differ from the climate of a region. For example, mountains interrupt the flow of prevailing surface winds and movement of storms. When moist air blowing inland from an ocean reaches a mountain range, it cools as it is forced to rise and expands. This causes the air to loose most of its moisture as rain and snow on windward slopes. As the drier air mass flows down the leeward slopes, it draws moisture out of the plants and soil over which it passes. The lower precipitation and the resulting semiarid or arid conditions on the leeward side of high mountains are called rain shadow effect.

Cities also create distinct microclimates.

Bricks, concrete, asphalt and other building materials absorb and hold heat, and building blocks wind flow. Motor vehicles and the climate control systems of buildings release large quantities of heat and pollutants. As a result, cities tend to have more haze and smog, higher temperatures and lower wind speeds than the surrounding countryside. Land oceans interactions affect the local climates of coastal areas by creating ocean to land breezes during the day and land to ocean breezes at night.

According to the latest instalment of a report published by the Intergovernmental Panel on Climate change (IPCC), climate change is very likely to have an impact on our planet and its life. The future problems caused by rising seas, growing deserts and more frequent droughts all look set to affect the developing world more than rich countries.

Climate change is a global phenomenon; its negative effect are more severely felt by poor people in developing countries who depend heavily on natural resources base for their livelihoods. Rural poor communities depend greatly for their survival on agriculture and livestock as they are the most climate sensitive economic sectors. With increase of temperature approximatey 20 to 30 per cent of plant and animal species are expected to be at a risk of extinction with severe consequences for food security in developing countries.

Factors of Global Warming

Greenhouse Gases

A greenhouse gas is a gas in an atmosphere that absorbs and emits radiation within the thermal infrared range. This process is the fundamental cause of the greenhouse effect. The primary greenhouse gases in the Earth's atmosphere are water vapour, carbon dioxide, methane, nitrous oxide, and ozone. In the Solar System, the atmospheres of Venus, Mars, and Titan also contain gases that cause greenhouse effects. Greenhouse gases greatly affect the temperature of the Earth; without them, Earth's surface would be on average about 33 °C (59 °F) colder than at present. Since the beginning of the Industrial revolution, the burning of fossil fuels has contributed to the increase in carbon dioxide in the atmosphere from 280 ppm to 390 ppm. Unlike other pollutants, carbon dioxide emissions do not result from inefficient combustion: CO_2 is a product of ideal, stoichiometric combustion of carbon. The emissions of carbon are directly proportional to energy consumption.

Human activities increase greenhouse gases which is one of the cause of global warming. These greenhouse gases reabsorb heat reflected from the Earth's surface, thus trapping the heat in our atmosphere. Humans have been increasing the concentration of the gases namely carbon dioxide and methane. The United Nations Intergovernmental Pannel on Climate change has been studying global warming for years. They state that global increases in carbon dioxide concentration are due primarily due to fossil fuel use and land use change, while those of methane and nitrous oxide are primarily due to agriculture.

Solar Impact

Initially the magnitude of influence of the sun on Earth's climate was not well understood . Since the early 1990's extensive research was put in determining what role the sun had in global warming or climate change.

Human Impacts on Climate

The Earth's climate is more clearly out of balance and is warming. Many components of the climate system –including the temperature of the atmosphere, land and ocean, the extend of sea, ice and mountain glaciers, the sea level, the distribution of precipitation and the length of seasons are now enormously changing and they are best explained by the increased

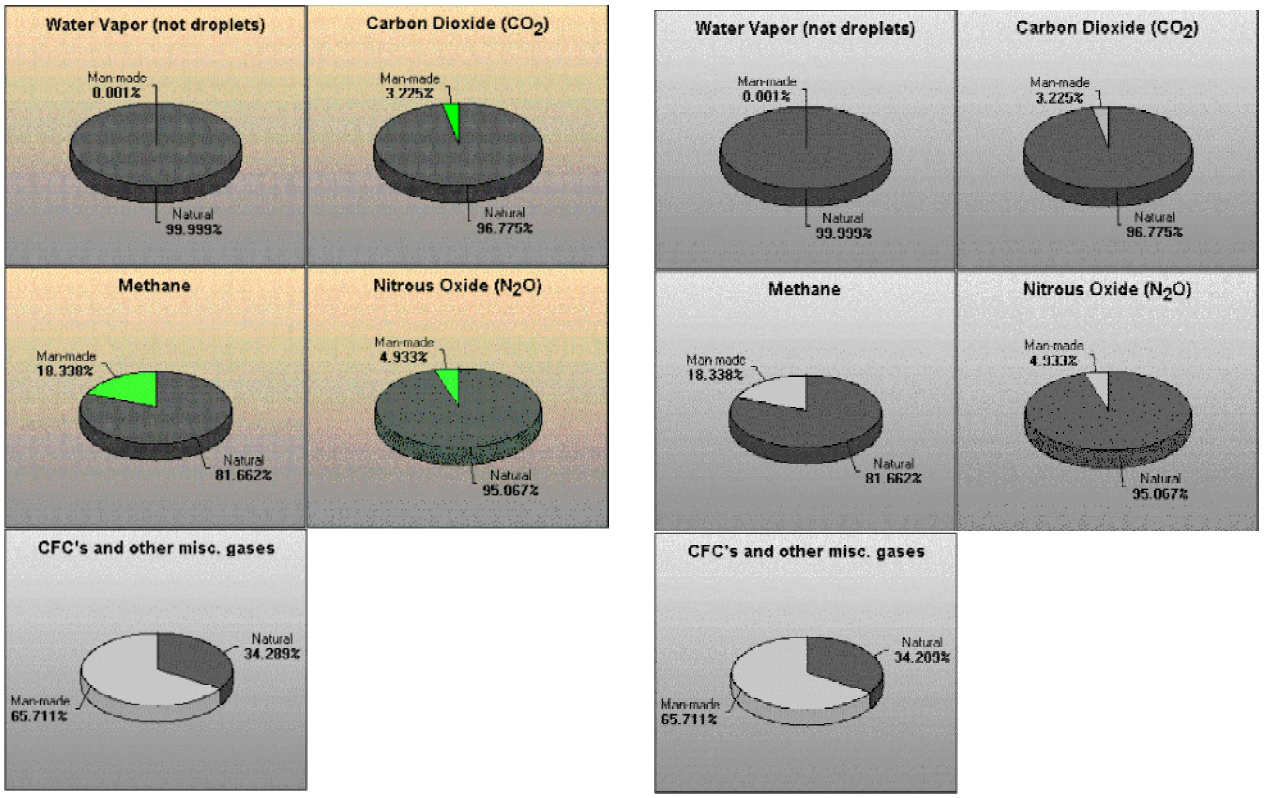

Fig 1. The factors contributing to the greenhouse gases

abundances of greenhouse gases and aerosols generated by humans in the twentieth century (Fig. 1; Table 1).

During recent millennia of relatively stable climate after civilization became established and population increased. An additional global warming of even 1^0C above the last decade is far beyond the range of climate variability experienced during the past thousand year also poses global problems in planning for adapting to it. The warming of the earth above 2^0C above 19^{th} century levels is projected to be disruptive, reducing global agricultural productivity, causing loss of biodiversity and if sustained over centuries melting much of the Greenland ice sheet with ensuring rise in sea level of several meters. In order to avoid this 2^0C of warming our net annual emissions of CO_2 must be reduced by more than 50 percent within this century.

The cause of disruptive climate change unlike, ozone depletion, is tied to energy rise and runs through modern society. Mitigation strategies and adaptation responses will call for collaboration across science technology, industry and government. As part of the duty the scientific community should collectively have special responsibilities to pursue research needed to understand it, to educate the public on the causes, risks and hazards and to communicate clearly and objectively with those who can implement policies to shape future climate.

Impact of global warming on polar flora and fauna

In agreement with different climate models developed by the researchers and confirmed by IPCC (the Intergovernmental Panel on Climate change), the poles are the regions of the world where the climate change is more rapid. This

Table 1. Atmospheric Greenhouse Gases (except water vapour) adjusted for heat retention characteristics, relative to CO_2

Comparison of greenhouse gases equally with respect to CO_2.	Pre-industrial baseline (new)	Natural additions (new)	Man-made additions (new)	Tot. Relative Contribution	Percent of Total (new)
Carbon Dioxide (CO_2)	288,000	68,520	11,880	368,400	72.369%
Methane (CH_4)	17,808	12,117	6,720	36,645	7.199%
Nitrous Oxide (N_2O)	88,350	3,599	4,771	96,720	19.000%
CFC's (and other misc. gases)	2,500	0	4,791	7,291	1.432%
Total	396,658	84,236	28,162	509,056	100.000%

Table 2. Benefits of adopting sustainable farming practices

Benefit	Percent of farmers
Less chemicals in the environment	84%
Healthier lifestyle	80
More wholesome food	78
More profits	74
Better working conditions	70
More local foods	67
More farmers on the land	62
None	1
Other	1

development is not without impact on the organisms living in those regions, some of which are increasing concerns to the biologists.

The trends towards Arctic regions warming is generalized, and in some regions the temperature has risen by 3^0C over the past 50 years. This is ten times faster than the rest of the planet, where the average increase was 0.6^0C over the past century. On the Antartica peninsula only two flowering plants were seen on exceptional occasion in the past. But over the past thirty years, antartica grass and pearlwort have been developing in the south, as are several species of moss.

Other effects seen in the marine environment is due to spread of park ice. This ice is necessary to ensure the inter development of juvenile krill (a small crustacean which looks like a shrimp and upon which an impressive range of predators are dependent) and there has been reduction in the frequency of successful breeding years.

Arctic Climate Impact Assessment (ACIA) has made it clear that the effects of global warming on flora and fauna are even more pronounced in the Arctic. Due to warming there is melting of permafrost (permanently frozen ground) with the disappearance of hundreds of pools and lakes and flora and fauna which inhabit them. There is also spread of forest coverage to the north, to the detriment of tundra, where millions of migrating birds have their breeding. At the same time, there is increase in number of fires and massive swarms of insect pests.

The situation is no better in the Arctic ocean, the average surface area of packed ice has shrunken in thirty years by practically a million square kilometres. This gradual shrinkage is causing increasing problems for the species associated with sea ice, whether these are

single cell algae, the copepod crustaceans which gauze on them, the fish which hide in them and so on up the chain to that most emblematic animal of the North pole, the polar bear.

The shrinkage of packed ice has caused a reduction in number of ringed seals as well as their accessibility for polar bears, for whom they are principal prey. It is practically crucial for the female bears as they build up fat reserves before fasting for several months in winter and give birth to the young. Researches have shown that in Hudson Bay, each week the spring thaw advances represents a 10kg loss of weight for female bears by the time they enter the snow den where their young will be born. In addition warming also increases the frequency of winter rains and the collapses of these dens.

On the other hand of the globe, the formidable mass of the Antartica ice sheet may protect the Antartica ocean from global warming. But the rising temperature of the peninsula is a reason of concern. Research on several marine invertebrate species has shown that oxygen supply necessary for several vital functions, such as reproduction, is easily disturbed by rise of water temperature. Infact a 4^0C rise would be sufficient to condemn several populations, or even some species with a limited distribution to extinction.

Climate Change Health and Environmental Effects

Mammals which occupy diverse areas with the notable exceptions of whales of Earth and dolphins, are primarily terrestrial animals that inhabit diverse areas of the Earth. Mammalian responses are changing due to diverse climate changes. Many small animals are coming out of hibernation and breeding earlier in the year than they did several decades ago, while others are expanding their ranges to higher altitudes. Reproductive success in polar bears has declined due to melting Arctic sea ice (IPCC, 2002). In 2004 the Arctic Climate Assessment (ACIA) summarized some of the effects of warming temperatures on animals such as polar bears, seals, migratory birds, caribou and reindeer are all experiencing changes that could have dramatic changes on their species and ecosystem they inhabit (ACIA, 2004).

In 2004 the Arctic Climate Impact Assessment (ACIA) summarized some of the effects of warming temperatures on animals and their habitats in polar regions. All the animals of polar regions such as polar bears, seals , migratory birds, Caribou and reindeer are experiencing changes that could have dramatic effects on their species and ecosystems (ACIA, 2004). For example polar bears are dependent on sea ice to hunt seals and to move from one area to another. Polar bears are unlikely to survive as a species if there is almost complete loss of summer sea ice cover. The seals and polar bears hunt are unlikely to be able to adapt to an absence of summer sea ice, because they give birth to and nurse their pups on the ice and use it as a place of resting.

According to the AICA, caribou and reindeer population could decline because of their dependence on tundra for vegetation. As tundra vegetation zones continue northward with the changing climate the caribou and reindeer could have a more difficult time in finding food and raising their calves.

Invertebrates and Insects

Invertebrates represent 97 per cent of all animal species . Though most of the invertebrates are small, their influence on the surrounding is enormous. Bees, ants, moths and other insects for example perform a critical role in life of seed plants by transferring pollen as insect pollination is particularly important for production of certain fruits and vegetables.

Both positive and negative impacts of climate change occur on invertebrates and insects. Recent working in Alaska has caused spruce

budworms to reproduce further north. In addition a range shift towards the pole (northward in Northern Hemisphere) or to higher elevations has occurred among invertebrates that are considered pests or disease organisms. Butterflies habitat ranges in North America have shifted northward and in elevation as temperature increased, the Editor's Checkerspot butterfly local populations have become extinct in the Southern portion of their range. Balance Climate change will alter the distribution of many species in different taxa and poiklothermic animals, whose distribution is ultimately determined by climatic factors. It has been recognized that global warming affects the individual species and communities in a range of shifts and extinctions. As a result of this temperature increase the range of species could expand pole ward and in the mountainous areas upward in elevation because the number of insect species is inversely related to latitude and elevation from sea level (Hickling *et al.,* 2006). The climate change may indirectly affect the forest ecosystem through the activity of phytophagous insects. The climate change has been claimed to be responsible of the range of expansion northward and upward of several insect species of northern temperate forests as well as of changes in the seasonal phenology. Increase in levels of CO_2 in the atmosphere involve an increase of the C/N balance of plant tissues, which in turn results in lower food quality for many defoliating insects. Some insects respond by increasing the level of leaf consumption and consequently damage of the tree. The level of plant chemical defenses may also be affected by a change of CO_2. The temperature is affecting either the survival of insects which are active during the cold period or the synchronization mechanism between the host and herbivores. An increase of temperature may alter the mechanism by which the insects adjust their cycles to local climate (diapause), resulting in faster development and higher feeding rate.

Environmental factors influenced by global climate change determine the distribution ranges of organisms. Especially the ectothermic animals are expected to shift their distribution ranges northwards in the next hundred years or so on. The future distribution ranges of two Central European serious pest species: the nun moth, *Lymantria monachal* L. and gypsy moth *L.dispar* (Lepidoptera : Lymantriidae). Three different climate warning scenarios were considered i.e. temperature increase of 1.4, 3.6 and 5.8^{0}C.The climate warning scenarios shifted the northern boundary of the distribution for both of these species north by 500-700km. Also the Southern edge of the ranges retracted northwards by 100-900 km (Vanhanen *et al*. 2007). Temperature and humidity influence the density of two stored grain pests *Tribolium confusum* (Herbst) and *Callosobrunchus chinensis* (L). *T.confusum* and *C.chinensis* show qualitatively different responses to the exogenous forcing of temperature and humidity respectively. Stimulations predict a change in the equilibrium density of *T.confusum* from 10 to 14% under the B2 scenario and 12 to 22% under the extreme A2 scenario to the period 2071-2100. Both results imply a severe change in the pest status of the species in southern region (Estay *et al*. 2008).

Birds

Birds play an important role in seed dispersal, pollination and as both predator and prey. Scientists have observed that birds are breeding and laying their eggs earlier and that migratory species have altered their wintering and/or critical stopover habitats. For example, warmer springs have led to earlier nesting for 28 migrating species in east coast of US (IPCC, 2007a,b).

The Arctic Climate Impact Assessment has stated that the timing of bird arrival may no longer coincide with the availability of their insect food sources (ACIA, 2004). As trees shift

northward the important breeding and nesting areas are projected to decrease sharply. As sea level is rising there are more tundra areas and thus more habitat for birds and their prey will disappear. This ultimately would affect the success or failure of the breeding of several hundred million birds that migrate to the Arctic each summer. This in turn would lead to less population sizes of birds at lower latitudes.

As the changing climate could impair the extent to which a bird's life cycle is synchronized with its food supply, in the same way rise in temperature could affect other ecological processes that are vital to the ecosystem health. The three factors that is, pollination, seed dispersal and pest control by birds are dependent on careful timing of birds arrival, atmospheric temperature and other climate related factors, and therefore could be distributed as the climate changes. (IPCC 2007a,b).Wetlands in coastal areas have decreased due to rising sea level where waterfowl spend their winter months. Sea level is rising along most of the US coast, and around the world, and is projected to continue throughout this century. In some areas where the wetlands cannot move inland due to topography or human development, these important habitats may be lost and the ecosystem in which they live may change forever.

Fish

According to IPCC certain fish species are becoming less abundant worldwide. Fish populations and other aquatic resources are likely to be affected by warmer water temperatures, changes in seasonal flow regimes, total flows, lake levels and water quality. These all inturn would affect the health of aquatic ecosystems, with impact on productivity, species diversity and species distribution (IPCC, 2007a,b). The Northern pike, which spawn in flooded meadows in early spring and whose young remain in meadows for about 20 days after hatching would be affected by the low spring water level. Higher winter temperatures have been observed to decrease the survival rates of yellow perch. On he other hand, the same temperature increase in summer caused negative effects (IPCC, 2007a,b).

Climate change can compound the impact of natural variation and fishing activity and make marine life management more complex. For example scientists have observed that elevated temperature have increased mortality of winter flounder eggs and larvae and later lead to spawning migrations. Climate change represents a threat to sustainability to capture fisheries and aquaculture development. The consequences of gradual warming on a global scale and associated physical changes will become increasingly evident, as will be the more frequent extreme weather conditions. The effects of increased pressure on fisheries, environmental pollution, environmental degradation.

A small increase in water temperature among sensitive fish like the South American pejerry can result in a population that is 98% males.

Positive and negative impact of climate change on fisheries

Positive impact : The projected climate change will generally be positive for aquaculture, which is often limited by cold weather. Since many of the changes will entail warmer nights and winters , there should be longer periods of growth and growth should be enhanced. The cost of making structures ice-resistant and of heating water to optimum temperatures should also be lowered. By developing appropriate technologies, farmers can use flooded and saline areas no longer suitable for crops to cultivate fish. Farmers can also recycle water used for fish culture to moderate swings between drought and flood.

Negative impacts : Climate change will have a negative impact on fisheries both directly and indirectly. Fisheries will be impacted by changing water levels and flooding events; temperature changes will cause a shift in the range of fish species and a disruption to the reproductive patterns of fish. Rising sea levels could also affect important fishery nursery areas. Warming can increase disease transmission and have an influence on marine pathogens. Because of their comparatively small or weak economies, a number of countries that are heavily dependent on fish have low capacity to adapt to change.

The effects of climate change on livestock : In pastoral and agropastoral systems, livestock is a key asset for poor people, fulfilling multiple economic, social and risk management functions. The impact of climate change is expected to heighten the vulnerability of livestock systems and reinforce existing factors that are affecting livestock production systems, such as rapid population and economic growth, rising demand for food and products, conflict over scarce resources. For rural communities losing livestock assets could trigger a collapse into chronic poverty and have lasting effect on livelihoods. The direct effects of climate change will include, for example, higher temperatures and changing rainfall patterns which could translate into the increased spread of existing vector-borne diseases and macroparasites, accompanied by the emergence and circulation of new diseases. In some areas, climate change could also generate new transmission models.

These effects will be evident in both developed and developing countries, but the pressure will be greatest on developing countries, because of their lack of resources, knowledge, veterinary and extension services, and research technology development. Some of the indirect effects will be brought about by changes in the feed resources linked to the carrying capacity of range lands, the buffering abilities of ecosystems, intensified desertification processes, increased scarcity of water resources, decreased grain production.

Reptiles and Amphibians

The ability of reptiles and amphibians to adapt to changes in climate depends in part on their ability to move to more suitable habitats. In the mountaineous cloud forest of Costa Rica, the base of the clouds has been climbing in altitude as the climate warms. Studies have shown a strong connection between decline in frequency of mist days and decline in amphibian population (IPCC, 2007a,b). Sea turtles and crocodiles have been affected by the impact of climate change on coral reefs and mangroves. Sea turtle population is also affected by tropical storms. In North America, many amphibians, such as some species of frogs and salamanders, lay there eggs in temporary pools that are formed in early springs after the snow melts. If ponds dry earlier during the season amphibian population could suffer (IPCC, 2007a,b).

Effects on Wildlife and Habitat

Our country is home to a diverse array of wildlife ranging from the highest peaks, to the driest deserts, to freshwater and marine environments and to all the places in between. The abundant and diverse wildlife resources, which are so important to our culture and well-being, face a bleak future if we do not address global warming.

Wildlife depends on healthy habitats. They need:

- the right temperatures
- fresh water
- food sources
- places to raise their young

Climate change is altering key habitat elements that are critical to wildlife's survival and putting natural resources in jeopardy.

Temperature

Melting arctic ice removes hunting ground from Polar Bears.

- Warmer water temperatures will cause population declines for trout, salmon and many other species that require cold water to survive.
- Rising ocean temperatures have already caused massive coral bleaching, leading to the collapse of these ecosystems which sustain huge numbers of fish.

Water

- Larger floods are expected to increase erosion levels, reducing water quality and degrading aquatic habitat.
- Severe drought stress can kill plants on which wildlife depend for food and shelter, and deprives wildlife of water sources.

Food

- Climate change has altered food availability for migratory species; birds arrive on schedule to find their food sources—insects, seeds, flowering plants—have hatched or bloomed too early or not at all.
- Milder winters cause seasonal food caches to spoil, so wildlife species like the Gray Jay depending on food stores to survive the winter are left without sustenance.

Places to Raise Young

- Droughts caused by global warming could dry up 90 percent of central U.S. wetlands, eliminating essential breeding habitat for ducks, geese and other migratory species.
- Rising sea level and changes in salinity could decimate mangrove forests, leaving many fish, shellfish, and other wildlife without a place to breed, feed or raise offspring.

Often overlooked, just as important as the many ways in which our climate is changing, is that it is changing so fast and thus the need to address global warming. Species may not be able to adapt to this rapid climate change or to move fast enough to more suitable areas as their current areas become less suitable for them. Unless significant action is taken now, global warming will likely become the single most important factor to affect wildlife since the emergence of mankind.

Global Warming Has Devastating Effect on Coral Reefs

The biologists say that eight years after warming seas caused the worst coral die-off on record, coral reefs in the Indian Ocean are still unable to recover. Many reefs have been reduced to rubble, a collapse that has deprived fish of food and shelter.

The first long-term study of the effects of warming-caused bleaching on coral reefs and fish and as a result fish diversity has tumbled by half in some areas.

Warming Oceans

Small but prolonged rises in sea temperature force coral colonies to expel their symbiotic, food-producing algae, a process known as bleaching. While the dying reefs, which turn ghostly white, can recover from such events, many do not.

Climate change and sustainable agricultural productivity

The Intergovernmental Panel on climate change makes it clear that warming of the climate system is “unequivocal” as observations of increases in air and ocean temperatures, widespread melting of snow and ice, and sea level rise have made evident (IPCC, 2007a,b).

Agriculture therefore, has to cope with increased climate variability and more extreme weathers.

Climate change, coincident with increasing human population and consequent demand for food, feed, fibre and fuel, has the potential to irreversibly damage the natural resource base on which agriculture depends and is a resultant threat to food insecurity. The relationship between climate change and agriculture is manifold and climate change adversely affects climate. Agriculture in this scenario has to find ways to feed the world with an environmentally, socially and economically sustainable manner. The path that agriculture practices at present is not sustainable nor it can feed the world without destroying the planet.

The Green Revolution drove widespread shifts in agriculture sector from subsistence and low external input agriculture to monocropping with high yielding varieties (HYVs). This agricultural paradigm required the adoption of a number of factors namely irrigation, chemical pesticides, fertilizers and hybrid seeds bred for disease resistence and high yield. By the 1970s, Green Revolution –style farming had replaced the traditional farming practices of millions of developing country farmers. As time passed that is roughly in 1990s, almost 75% of Asian rice areas were sown with these new varieties. Green revolution later ensued a shift from diversity to monocultures, which caused many traditional varieties to disappear and many local varieties erupted. Maintaining agricultural biodiversity is vital to long term food security as it is vital insurance against crop and livestock disease outbreaks and improves the long term resilience of rural livelihoods to adverse trends or shocks (Pimbert, 1999). Other costs of Green revolution were the financial costs of building huge dams for irrigation, the financial costs required for construction and operation of the projects, heath costs incurred due to chemical contamination of food, costs involved in soil losses from increasingly degraded soils, genetic erosion and draining of groundwater aquifers (Alvares, 1996). Green Revolution farming systems also required substantial irrigation, putting further strain on world's limited water resources.

Productivity declines: Rice as a case study

Recently, the productivity of rice and other cereals in green revolution area has declined. The data is best obtained from long term trials conducted by the International Rice Research Institute (IRRI). The objective is to monitor maximum yields obtained over time, holding knowledge best available cultivars and scientific management, rice yields, holding input levels constant, decline over long term (Pingali *et al*., 1997).

Sustainable agriculture as an option

Agriculture needs to undergo for a radical overhaul to address these issues in the era of climate change. This is not just because it is important to take care of the environment, but also because sustainability is absolutely necessary for the continuation of the productivity of the agro-ecosystem. Threats to environmental sustainability of agriculture have threatened agriculture itself. A greater emphasis is needed for safeguarding natural resources and agroecological practices, as well as on tapping the wide range of traditional knowledge held by local communities and farmers, which can work in partnership with formal science and technology. It stresses that sustainable agriculture that is biodiversity-based, including agro-ecology and organic farming, is resilient, productive, beneficial to poor farmers, and will allow adaptation to climate change.

Sustainable agricultural approaches can be in many forms, such as agro-ecology, organic agriculture, ecological agriculture, biological agriculture, etc. Despite adequate global food production, many still go hungry because

increased food supply does not automatically mean increased food security. It is important to assess the food produces and the technology and knowledge to produce and the purchasing power to acquire it. Sustainable agriculture approaches thus allow farmers to improve local food production with low cost, readily available technologies and inputs without causing environmental damage.

Sustainable agriculture is productive

One criticism of sustainable agriculture, especially organic agriculture, is that it cannot meet the world's food demands, primarily because of low yields and insufficient organic fertilizer. In general, organic yields can be broadly comparable to conventional yields in developing countries, organic practices can greatly increase productivity, particularly if the existing system has low-input

Organic farming is the form of agriculture that relies on techniques such as crop rotation, green manure, compost and biological pest control to maintain soil productivity and control pests on a farm. Organic farming excludes or strictly limits the use of manufactured fertilizers, pesticides (which include herbicides, insecticides and fungicides), plant growth regulators such as hormones, livestock antibiotics, food additives, and genetically modified organisms (DGARD).

Organic agricultural methods are internationally regulated and legally enforced by many nations, based in large part on the standards set by the International Federation of Organic Agriculture Movements (IFOAM), an international umbrella organization for organic farming organizations established in 1972 (Paull, 2010). IFOAM defines the overarching goal of organic farming as:

"Organic agriculture is a production system that sustains the health of soils, ecosystems and people. It relies on ecological processes, biodiversity and cycles adapted to local conditions, rather than the use of inputs with adverse effects. Organic agriculture combines tradition, innovation and science to benefit the shared environment and promote fair relationships and a good quality of life for all involved." (Lasalle and Hepperly 2008).

International Federation of Organic Agriculture Movements (IFAOM)

Since 1990, the market for organic products has grown from nothing, reaching $55 billion in 2009 according to Organic Monitor. This demand has driven a similar increase in organically managed farmland. Approximately 37,000,000 hectares (91,000,000 acres) worldwide are now farmed organically, representing approximately 0.9 percent of total world farmland (2009) (Table 2).

Climate change

A recent study has found that organic methods could produce enough food on a global per capita basis to sustain the current human population, and potentially an ever larger population, without putting more farmland into production. The researchers examined a global dataset of 293 examples, and found that on an average, in developed countries, organic system produces 92% of the yield produced by conventional agriculture. In developing countries, however organic systems produce 80% more than conventional farms. Organic agriculture emphasizes closed nutrient cycles, biodiversity, and effective soil management providing the capacity to mitigate and even reverse the effects of climate change. Organic agriculture can decrease fossil fuel emissions and, like any well managed agricultural system, sequesters carbon in the soil. The elimination of synthetic nitrogen in organic systems decreases fossil fuel consumption by 33 percent and carbon sequestration takes CO_2 out of the atmosphere by putting it in the soil in the form of organic matter which is often lost in conventionally managed soils. Carbon

sequestration occurs at especially high levels in organic no-till managed soil.

Agriculture has been undervalued and underestimated as a means to combat global climate change. Soil carbon data show that regenerative organic agricultural practices are among the most effective strategies for mitigating CO_2 emissions.

For a number of years, there have been concerns that climate change negotiations will essentially ignore a key principle of climate change negotiation frameworks: the common but differentiated responsibilities.

This notion of climate justice is typically ignored by many rich nations and their mainstream media, making it easy to blame China, India and other developing countries for failures in climate change mitigation negotiations.

Development expert, Martin Khor, calculated that taking historical emissions into account, the rich countries owe a carbon debt because they have already used more than their fair quota of emissions.

Yet, by 2050 when certain emission reductions are needed by, their reduced emissions will still add up to be go over their fair share. However, rather than continue down the path of unequal development, industrialized nations can help pay off their carbon debt by truly helping emerging countries develop along a cleaner path, such as through the promised-but-barely-delivered technology transfer, finance, and capacity building.

So far however, rich nations have done very little within the Kyoto protocol to reduce emissions by any meaningful amount, while they are all for negotiating a follow on treaty that brings more pressure to developing countries to agree to emissions targets.

In effect, the more there will be delay the more the poor nations will have to save the Earth with their sacrifices (and if it works, as history shows, the rich and powerful will find a way to rewrite history to claim they were the ones that saved the planet).The climate is changing and the earth is warming up, and there is now overwhelming scientific consensus that it is happening, and human-induced. With global warming on the increase and species and their habitats on the decrease, chances for ecosystems to adapt naturally are diminishing. Many have agreed that climate change may be one of the greatest threats facing the planet. Recent years show increasing temperatures in various regions, and/or increasing extremities in weather patterns. So we have to cut down on our way of living.

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