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INNOVATIVE APPROACHES FOR CLIMATE CHANGE MITIGATION

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Abstract

Climate system is a complex, interactive system consisting of atmosphere, land surface, snow and ice, oceans, other water bodies and living things. The global temperature is maintained by a balance between heat from the sun and cooling from reflecting some of the heat by the Earth's surface and atmosphere back to the space. But owing to an ever increasing green house gas emissions, from pollution right from the beginning of the industrial revolution has resulted in increasing temperature, rising sea level, droughts, floods, melting polar ice caps, etc all the phenomenon relating to what is termed as global warming and climate change. Climate change refers to a statistically significant change in either the mean state of the climate or in its variability (in terms of temperature, atmospheric pressure, precipitation status etc.) persisting for an extending period (typically decades or longer). Climate Change has lead to habitat fragmentation, migration of habitat, changes in the life cycle pattern of a species, spreading of certain invasive species, changes in the growth and development patterns, increased number of forest fires, insect pest attacks, human diseases etc. This paper basically discusses various problems resulting due to climate change and various innovative methods like geo-engineering and carbon sequestration techniques which can be best practiced for lowering greenhouse gases and hence can act as effective climate change mitigation strategies.

Keywords: Climate change, Plants, Carbon sequestration, Climate change mitigation

Introduction

Climate system is a complex, interactive system consisting of atmosphere, land surface, snow and ice, oceans and other water bodies and living things. Climate change refers to a statistically significant change in either the mean state of the climate or in its variability (in terms of temperature, atmospheric pressure, precipitation status etc.) persisting for an extending period (typically decades or longer) (Lovejoy and Hannah, 2006).

Climate change is one of the most important global environmental challenges facing humanity with implications for food production, natural ecosystems, freshwater supply, health, etc. According to the latest scientific assessment, the earth's climate system has demonstrably changed on both global and regional scales since the pre-industrial era. Further evidence shows that most of the warming (0.1°C per decade) observed over the last 50 years, is attributable to human activities (Sathaye *et al.*, 2006) (Figure-1). This paper basically discusses various problems resulting due to climate change and various innovative methods like geo-engineering and carbon sequestration techniques which can be best practiced for lowering greenhouse gases and hence can act as effective climate change mitigation strategies.

Impacts of global warming and climate change

The GHG emissions have increased by [illegible] from 1970 to 2005. According to the IPCC [illegible] report due to the anthropogenic [illegible] emissions the global mean temperature [illegible]

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expected to rise from 2-4.5°C and of India from 2.7-4.3°C by the end of this century. Rainfall over India is predicted to increase (Hougton, 2003). The ENSO (El Nino Southern Oscillation) has direct impact on the Indian monsoon. The rise in temperature is causing the glaciers and ice caps to melt and also thermal expansion of water which has resulted in a sea level rise of 1.8mm/year from 1961-2003, but from 1993-2003 this pace has almost doubled. The sea level in India is predicted to rise by about 88 cm by 2100 (Lovejoy and Hannah, 2006). This is resulting into salinity ingress and also the submergence of the low lying areas and islands.

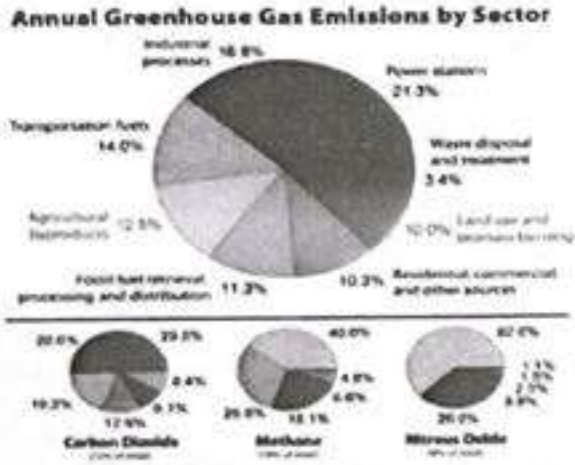

Figure-1: Sectoral GHG emission (McKeon and Gardner, 2009)

The satellite data shows a 2.7% decline in the Arctic ice content by each decade since 1978 and 2 million square km of the permafrost declined till 2000. The IPCC report also confirm of an increase in the number of the droughts since 1970s. An increase in the incidence of heat waves has also been reported all over the world. The winters have become less severe. The thunderstorms, cyclones, hurricanes etc have all increased in number (Anonymous, 2003). The scientists believe that global warming resulting in a rise in the temperature, will lead to cooling of the stratosphere along with the ozone leading to a slow pace of ozone hole repairing (Anonymous, 2004).

The agricultural yield will decline due to droughts and floods. The forest area will show a high net primary productivity (NPP) due to the high level of CO_2 they will become mature fast and would become carbon sources rather than sinks. The desertification will increase (Anonymous, 2003). Human health is also going to suffer due to an increase in the tropical diseases like vector-borne diseases (malaria, dengue, chikangunia), rodent borne diseases and water borne diseases (cholera, diarrhoea, dysentery).

Mitigation strategies to combat climate change

Mitigation deals with the causes of climate change, while adaptation tackles its effects. Mitigation has been defined by the Intergovernmental Panel on Climate Change (IPCC) as "an anthropogenic activity to reduce the sources or enhance the sinks of greenhouse gases" and adaptation as "adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities." (Davis, 1981).

Global warming mitigation involves reducing the intensity of radiative forcings so as to reduce the effect of global warming and it can be made possible by two aspects; Geo-engineering and Carbon sequestration.

Geoengineering is the deliberate large-scale intervention in the Earth's natural systems to counteract climate change usually by removing CO_2 from the air or limiting the amount of sunlight reaching the planet's surface. Geo-engineering are the proposals from which many are still at the concept stage to manipulate the earth's climate so as to decrease the impact of global warming from the greenhouse gas emission (Figure 2). There is wide range of proposed geoengineering techniques. Generally, these can be grouped into two categories

Solar Radiation Management (SRM) or Solar Geoengineering

SRM techniques aim to reflect a small proportion of the Sun's energy back into space, counteracting the temperature rise caused by increased levels of greenhouse gases in the atmosphere which absorb energy and raise temperatures. Schemes designed to reduce the amount of sunlight reaching Earth include:

1. **Albedo enhancement** Includes increasing the reflectiveness of clouds or the land surface so that more of the Sun's heat is reflected back into space.
2. **Space reflectors.** Blocking a small proportion of sunlight before it reaches the Earth which can be done by floating thousands of tiny mirrors in space between Earth and the sun to increase reflectivity also growing high albedo crops.
3. **Stratospheric aerosols.** Introducing small, reflective particles into the upper atmosphere to reflect some sunlight before it reaches the surface of the Earth. The proposals include spraying sulphate aerosols into the stratosphere and cloud seeding ships which form clouds with albedo more than the normal clouds hence increasing reflectivity (Anonymous (2016).

Carbon Dioxide Removal (CDR) or Carbon Geoengineering

CDR techniques aim to remove carbon dioxide from the atmosphere, directly countering the increased greenhouse effect and ocean acidification. These techniques would have to be implemented on a global scale to have a significant impact on carbon dioxide levels in the atmosphere. Some proposed techniques include:

1. **Afforestation/reforestation:** Reforestation is an important technique for climate change mitigation (Sulistyawati *et al.*, 2007). It is suggested that the global climate problem could be solved by planting a total of 500 million hectares of plantations even without parallel efforts to minimize carbon emissions from fossil fuel combustion (Baral and Guha, 2004). Biochar 'Charring' biomass and burying it so that its carbon is locked up in the soil.
2. **Bio-energy with carbon capture and sequestration.** Growing biomass, burning it to create energy and capturing and sequestering the carbon dioxide created in the process. Another technology comprises of the various methods of carbon sequestration called Carbon Capture and Storage (CCS). According to a 2005 IPCC report major point sources of carbon dioxide include coal-fired power stations, natural gas, fossil fuel-based hydrogen, and synthetic fuel. CO_2 emissions from such sources can be captured and stored in underground geologic formations. CCS technologies are already being widely used in industries producing fertilizers, hydrogen and natural gas processing (Kenneth and Ronald, 2006). However these innovations are very much in development and the full implications on the wider atmospheric, marine and terrestrial ecosystems have yet to be determined.
3. **Bio-energy crops:** Bioenergy crops can be defined as any plant used to produce bioenergy (i.e., renewable energy from biological sources). Today, sugarcane, oil crops, and cereals, particularly maize and wheat, make the largest contribution to bioenergy. Such systems could provide a net ecosystem C sequestration of 4.4 million grams (Mg; 4.4 × 10-9 GT) per ha per year (Jansson *et al.*, 2010). Algae is also a very capable biofuel, according to one estimate, 1,000 tonnes of CO_2 can be sequestered by algae/acre / year. And

can produce 500-20000 gallons of oil per acre per year which is far more than any bioenergy crop (Khan and Rashmi, 2008) (Table1).

Table 1 Comparison of some sources of biofuel (Khan and Rashmi, 2008)

Plants	*Gallons of oil per acre per year*
Algae	500-20000
Oil Palm	635
Coconut	287
Jatropha	207
Rapeseed/Canola	127
Peanut	113
Sunflower	102
Safflower	83
Soybeans	48
Hemp	39
Corn	18

4. **Ambient Air Capture:** Building large machines that can remove carbon dioxide directly from ambient air and store it elsewhere for example an artificial tree has been developed that absorbs CO_2 by filtering it over sodium hydroxide (NaOH) and converts it into crystals of sodium carbonate (Na_2CO_3) which stores 90,000 tonnes of CO_2 in a year.

4.1 **Ocean Fertilization:** Adding nutrients to the ocean in selected locations to increase primary production which draws down carbon dioxide from the atmosphere. Iron fertilization of the oceans, increase such blooms of algae and phytoplanktons, which would then draw down carbon dioxide from the atmosphere and fix it on the seabed.

4.2 **Enhanced Weathering:** Exposing large quantities of minerals that will react with carbon dioxide in the atmosphere and storing the resulting compound in the ocean or soil.

4.3 **Ocean Alkalinity Enhancement:** Grinding up, dispersing, and dissolving rocks such as limestone, silicates, or calcium hydroxide in the ocean to increase its ability to store carbon and directly ameliorate ocean acidification. Limestone fertilization of the oceans so as to enhance the CO_2 absorption capacity of the oceans (Anonymous, 2016).

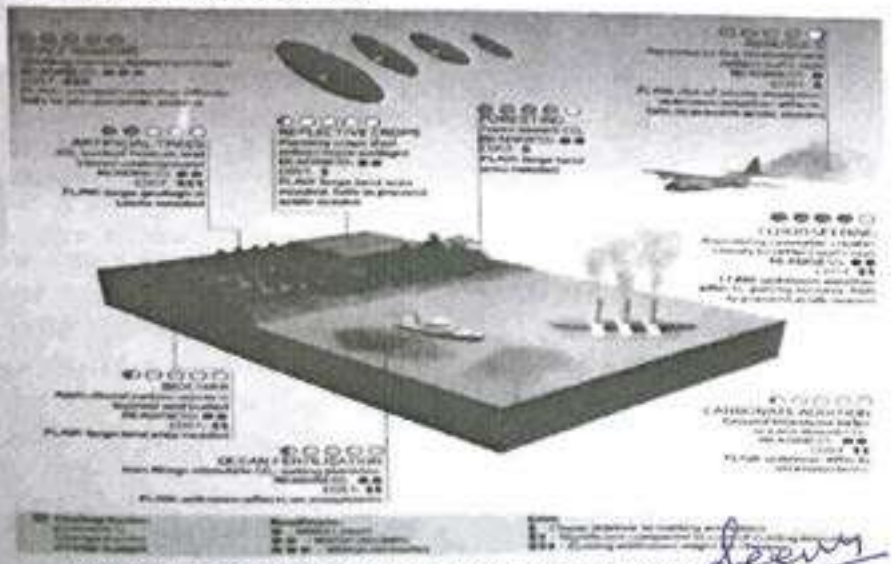

Figure:2 Geoengineering to mitigate climate change (Anonymous, 2016)

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Conclusion

Climate change is affecting the vegetation and leading to their habitat fragmentation, phenological variations, spread of invasive species, increased number of forest fires, pest attacks and extinctions. This review article discussed on the impacts of climate change and various mitigation strategies. Climate engineering would represent a large-scale, intentional effort to modify the climate and offers the hope of temporarily reversing some aspects of global warming and allowing the natural climate to be substantially preserved whilst greenhouse gas emissions are brought under control and removed from the atmosphere by natural or artificial processes (Anonymous, 2011).

As such, climate intervention is no substitute for reductions in carbon dioxide emissions and adaptation efforts are aimed at reducing the negative consequences of climate change. However, as our planet enters a period of changing climate never experienced before in recorded human history, interest is growing in the potential for deliberate intervention in the climate system to counter climate change. Carbon dioxide removal strategies address a key driver of climate change, but research is needed to fully assess if any of these technologies could be appropriate for large-scale deployment.

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