

Biodiversity: Importance and Climate Change Impacts

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Abstract: Biodiversity is the variability among living organisms, including genetic and structural difference between individual and within and between individual and within and between species. Biodiversity plays a direct role in climate regulation. Biodiversity conservation will lead to strengthening of ecosystem resilience and will improve the ability of ecosystem to provide important services during increasing climate pressures. This review basically focuses on the importance of biodiversity, the consequences faced by the plants, animals, humans and ecosystem owing to the global warming and climate change and the possible mitigation and adaptation strategies in terms of biodiversity conservation which can protect the planet from the consequences of climate change.

Index Terms: Biodiversity, climate change, mitigation and adaptation

INTRODUCTION

BIODIVERSITY AND ITS IMPORTANCE

Biodiversity is the variability among living organisms, including genetic and structural difference between individual and within and between individual and within and between species. The world biodiversity has a total of 1,263,500 species of plants and animals while India has only 51,828 species (table-1) (1). It provides us with all the necessities of life and sustains and nourishes us. Biodiversity plays a direct role in climate regulation. Climate always changes resulting in evolutionary changes in the species. Biodiversity is important in following ways (3);

i). Soil formation and maintenance of soil quality: The activities of microbes and animal (bacteria, algae, fungi, millipedes, etc) condition soils, break down organic matter, form soil and prevent soil erosion.

ii). Maintain air quality: Plants purify the air and regulate the composition of the atmosphere, by taking in CO₂ during photosynthesis and liberating oxygen in the atmosphere.

iii). Maintain water quality: Trees and forest soils purify water; prevent siltation of rivers and reservoirs arising due to soil erosion and landslides.

iv). Pest control: Conserving biodiversity can control 99% of potential crop pests.

v). Detoxification and decomposition of wastes: About 130 billion metric tons of organic waste (including industrial wastes) is processed every year by earth's decomposing organisms.

vi). Pollination and crop production: Without plant and animal (bees, butterflies, bats, birds) interactions, no pollination will be

possible and hence would lead to decline in crop yield. **vii). Climate stabilization:** Oceans, soil and vegetation are huge carbon sinks and help reduce the CO₂ in atmosphere. In rainforests the surface temperature is maintained by regular rains, while in cold regions the temperature is regulated by forests acting as insulators and windbreaks. **viii). Prevention and mitigation of natural disasters:** Ecosystem biodiversity (forest, salt marshes, mangrove) prevents erosion, nutrient loss, landslides, floods and impacts of storms. **ix). Provision of food security:** biodiversity in terms of plants and animals is the ultimate source of food, fiber, fuel and shelter. Biodiversity conservation will lead to strengthening of ecosystem resilience and will improve the ability of ecosystem to provide important services during increasing climate pressures.

GLOBAL WARMING AND CLIMATE CHANGE: DRIVERS AND IMPACTS

Global warming is the increase in the world's average temperature occurring due to increasing emission of the greenhouse gases (GHGs) which results in an enhanced greenhouse effect. *Climate change* refers to a statistically significant change in either the mean state of the climate or in its variability persisting for decades or longer (17). Climate change results due to both; natural and anthropogenic drivers.

Natural drivers: It involves the contribution of plants, animals and humans naturally by processes of respiration, death and decomposition. Earth's climate variability is also caused by changes in the solar radiations, Milankovitch cycle, volcanic eruption, plate tectonics, ocean circulations, earthquakes and so on (18).

Anthropogenic drivers: It involves the human activities leading to climate change (table-2)(20). The concentration of CO₂ has increased from pre-industrial concentration of 280ppm to 392ppm in 2010. It is all due to the burning of fossil fuel to generate the electricity in power plants, industrialization, deforestation, mechanization of agricultural practices, increasing vehicular transportation (In India, vehicles have increased from 350 million to 40 billion since 1947) (21), land use changes, urbanization, industrialization and the disposal of subsequent waste generated out of it all.

Impacts: Millennium Ecosystem Assessment (MEA) predicts climate change to be the principal threat to the biological diversity (2). The average global temperature has increased by 0.6°C since mid 1800s and is predicted to rise by 1.4-5.8°C by the year 2100. The global mean sea level has risen by 10 to 20 cm (8) and may further rise to 88 cm. Thickness of Arctic ice has

decreased by about 40%. Many areas are facing problem of water shortage. Alaska's boreal forest has moved about 100 km for every 1°C rise in temperature. Climate change has resulted in extinction of animals like golden toad and Monteverde harlequin frog (8). Many communities have already become climate refugees to evade rising sea level (2). The rainfall is predicted to increase in Southeast Asia and decrease in Central Asia, Australia, New Zealand, Mediterranean region and Africa. Extreme climatic events (heat waves, storms and hurricanes) and tropical vector-borne diseases (malaria, dengue etc) are predicted to increase.

IMPACTS OF CLIMATE CHANGE ON BIODIVERSITY

[I] Vegetation: The vegetation is exhibiting the following changes;

a). Migration of vegetation towards a higher altitude: In Nainital, species such as *Berberis asiatica*, *Taraxacum officinale*, *Jasminum officinale* etc have shifted from 1000 to 2000m height (4). Teak dominated forests are predicted to replace the Sal trees in central India and also the conifers may be replaced by the deciduous types. According to climatologists and palynologists, temperature change of 3°C may lead to forest movement of 250 km at a rate of 2.5 km/year which is ten times the rate of natural forest movement (6,7).

b). Invasive species: Invasive species (*Lantana camara*, *Parthenium hysterophorus*, *Ageratum conyzoides*) are a threat to native species being more tolerant to climatic variations (4).

c). Changes in phenological behaviour: Climate/season affects the normal life cycle (bud, leaf fall, flowering, fruiting, fertilization time and production) of the plant (4). The crops show early flowering and maturation which has shortened their grain fill period and yield.

d). Forest fires have increased in number due to high temperature conditions.

f). Increase in the pest attacks: Due to climate change, pests (Pine wood nematode-*Bursaphelenchus xylophilus*, Pitch canker-*Gibberellacircinata*, Red palm weevil-*Rhynchophorus ferrugineus*, virus, aphids, fungi) have increased in number. Variation in temperature and precipitation patterns can result in more frequent droughts and floods making indigenous plants more vulnerable to pests and diseases (rots, blights) (5).

[II] Animals: Sensitivity of the species to even a slight change in the climate leads to their extinction as in case of the golden toad. Polar bears are in danger due to reduction in Arctic ice cover. North Atlantic right whale may become extinct, as planktons, its main food have shown decline due to climate change. The sex of sea turtle depends on temperature and more female turtles are produced as a result of high temperature. Some threatened species (frogs, toads, amphibians, tigers and elephants) are vulnerable to the impacts of climate change like sea level changes and longer drier spells. Changes in ocean temperature and acidification may lead to loss of 95% of the living corals of Australia's Great Barrier Reef (2).

[III] Ecosystem

a). Marine and Coastal: 70% of the Earth's surface is covered by oceans comprising some of the world's most diverse and unique ecosystems (mangroves, coral reefs, sea grass beds) (10). Climate change is leading to sea level rise, increased coastal erosion, flooding, higher storm surges, sea salinity ingress, increased sea-surface temperatures, ocean acidification, coral bleaching, mangroves and millions of climate change refugees. Species composition and distribution will surely be affected by such changes. Indian coastal areas vulnerable to climate change are Sundarbans, Maharashtra, Goa and Gujarat (Rann of Kutch) (15,16). The distribution and composition of the species is bound to be effected.

b). Island ecosystem: Islands are the most fragile with rich biodiversity and a high economic importance. 23% of island species are at present endangered (11). Islands have small and endemic species (corals) (11) sensitive to the changing climate. Climate change leads to an increase in the sea level, frequency and intensity of storms, variability in rainfall and intolerably high temperatures affecting the endemic species and hence economic loss in the tourism sector.

c). Inland water ecosystem: Inland water systems include the fresh water systems and are only 0.01% of the world's water source comprising 0.8% of the Earth's surface, but support 6% of the total species (12). They are rich source of food, income, employment and biodiversity. Changing rainfall patterns will lead to change in the course of the streams affecting breeding and food habits of many species. The ice cover is bound to decrease causing an increase in the number of flood and drought. This would further lead to changes in the phenology, physiology and migration trends of some organisms like migratory birds.

d). Forest: Forest area is about one-third of the Earth's surface and comprises two-thirds of all the known terrestrial species. They are also rich biodiversity hotspots. Half of the original forest cover has been cleared up till now. The increased level of CO₂ has led to increase in the growth of some forest. Increased temperature (even 1°C) has resulted in significant migration of tree species, increased attack of pest, invasive species and wild fires, hence modifying the composition of forest. Many animals, primates and 9% of all known tree species (woody trees, white spruce) are at risk of extinction (13).

e). Agriculture: About one-third of the world's area is under cultivation (2). Climate change leads to variability in rainfall patterns, heat stress, spread of pests and diseases and shortening of the crop cycle and affecting plant growth and production.

f). Dry lands and Grassland: They support 35% of the world population and comprise of the arid and semi-arid areas, grasslands and savannahs. They have localized species (wild ass, Kutch etc) and have varied crops and livestock. The desertification is expanding and so is the temperature making them drier and intolerable for the threatened species. The risk of wild fire is increasing which could change the species biodiversity. Climate change is a threat to the diverse hotspots (Succulent Karoo, South Africa) (2).

g). Mountain: One-third of the Earth's surface is covered by the mountains which supports one-third of the world population. Many species are very specific and endemic to this ecosystem and are rich natural reservoirs of goods. Climate change is leading to the glacier retreat, change in the course of rivers, migration of the tree species northward (13) and subsequent extinction of

some species.
h). Polar ice/Glaciers: They are diverse ecosystem facing extremes of the cold temperature with the flora (planktons) and fauna (migratory birds, whales) and Arctic people modified to such conditions (2). Climate change has resulted in an increase in the temperature to about 5°C to the normal and has resulted in the melting of the ice, increase in sea level which is threatening the endemic species (polar bears, walruses, seals, emperor penguins, krill, ringed seal). Studies show a decline in the weight of the polar bears from 325 kg in 1980 to 253 kg in 2004 (14). Biodiversity loss has impacted the fishing and hunting practices by indigenous people (Saamiand Inuit of Canada) posing an implication on their only source of food (2). (ref. table-3)

[IV] Humans

Climate change leads to an increase in temperature, melting of the ice and increased extreme events. All the extreme events like floods, droughts, cyclones displace the humans from their home and lead to outbreak of water borne diseases like cholera, typhoid etc; spread of tropical and vector borne diseases like malaria, dengue etc and rodent borne diseases like plague. These diseases have shown a persistent increase in the past 50 years. The incident of heat waves has registered an increase throughout the world taking away a heavy toll of the people's life every year (5). The increasing sea level rise has already submerged many islands and will soon leave millions of refugees for the world to provide shelter. The sea salinity ingress in the fresh water sources has made land barren and will soon be a threat to the food security.

PREVENTION OF CLIMATE CHANGE: MITIGATION AND ADAPTATION STRATEGIES

Mitigation deals with the causes of climate change, while adaptation tackles its effects. 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. Geo-engineering are the proposals to manipulate the earth's climate so as to decrease the impact of global warming from the greenhouse gas emission. It comprises of Sulphur dioxide spraying, artificial trees, cloud seeding ships, iron and limestone fertilization of the oceans and space mirrors (19).

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. CO₂ 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 (21). Carbon sequestration can also be made practically possible by methods of organic farming using natural manures, fertilizers (algae-*Nostoc*, *Anaebaena*, mycorrhizae) and pesticides and bringing a halt on the application of chemical fertilizers and pesticides and promoting tree plantations and agroforestry practices (20). Environment Impact Assessment (EIA) of the industrial areas, checking vehicular pollution by the use of biofuels and using the clean technology, reducing over-exploitation of resources (over-fishing, land-use-changes); preventing poaching of rare,

endangered and endemic species; preventing habitat fragmentation. The biodiversity can be conserved by management programmes including ecosystem conservation and restoration. The forest need to be conserved with practices of reforestation and afforestation as they have 80% of the total carbon stored in terrestrial vegetation. The indigenous knowledge can also be used to prevent climate change or adapt to it (2).

Strategies by the United Framework Convention on Climate Change (UNFCCC) focuses on cutting down greenhouse gas emissions to prevent climate change. Kyoto protocol has brought into existence joint implementation, emission trading and Clean Development Mechanism (CDM) to reduce greenhouse gas emission. Like all other countries National Action Plan on Climate Change of India was released in Delhi in 2009 and involves eight missions on solar mission, enhanced energy efficiency, sustainable habitat, water mission, sustaining Himalayan ecosystem, Green India through massive tree plantation, sustainable agriculture and strategic knowledge for climate change by establishing a knowledge platform on climate change (22). Successful implementation of all these plans would surely help reduce global warming and conserve biodiversity.

CONCLUSION

The increase in the greenhouse gases is leading to climate change at a faster rate and impacts the people and ecosystems. Every change in the ecosystem process works on the principle of Newton's law of motion (Every action has an equal and opposite reaction) which may be damaging or complimentary. Even a small change in the climate can lead to the extinction of some vulnerable and sensitive species. Climate change results in the impact on the biodiversity like change in their distribution pattern, migration of species, invasion of invasive species, change in the phenological behaviour like breeding period, migration time etc, increase in the forest fires and pest attacks. To maintain the balance of ecosystem, interaction between the plants, animals and biodiversity needs to be understood, hence promoting its conservation and protection by designating the hotspots as biosphere reserves, increasing afforestation, reforestation and agroforestry practices. Biodiversity-based adaptation and mitigation strategies will enhance the resilience of ecosystems and prevent damage to human and natural ecosystems.

Table-1: Species biodiversity in India and World

| Species | Number in India | Number in world |
|------------|-----------------|-----------------|
| Mammals | 410 | 4,000 |
| Birds | 1,228 | 10,000 |
| Reptiles | 447 | 10,500 |
| Amphibians | 197 | |
| Fishes | 2,546 | 19,000 |
| Plants | 47,000 | 2,70,000 |

Table-2: Percent GHGs emissions by various sectors (Smith et al., IPCC, 2007)

| Anthropogenic sectors | Percentage |
|-----------------------|------------|
|-----------------------|------------|

| | emission |
|--------------------------|-----------------|
| Energy supply | 25.9% |
| Industrial sector | 19.4% |
| Forestry (deforestation) | 17.4% |
| Agriculture | 13.5% |
| Transportation | 13.1% |
| Urbanization | 7.9% |
| Waste | 2.8% |

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| | Consideration of suggestion on methods to conserve biodiversity from indigenous people observing climate change |
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Table-3: Ecosystem: vulnerability, impacts, mitigation and adaptation with respect to climate change

| Ecosystem | Polar ice/Glaciers, Marine and Coastal, Inland water, Island, Forest, Dry lands/Grassland, Mountain and Agriculture |
|----------------------------------|--|
| Vulnerability | Climate sensitivity of flora and fauna, low resilience power |
| Impacts | Rising temperature, Melting ice, Sea level rise, Altering stream flow Ocean acidification, Increased extreme events like floods, storms Sea salinity ingress Increased pest attacks and diseases, Wildfires Invasion of invasive species Endemic species like polar bears, penguin, walrus, seals, krill are threatened Changes in phenological, physiological and migration pattern of species. Reduced agricultural yield |
| Mitigation and Adaptation | Reducing pollution both industrial and vehicular, Environment impact assessment, CDM, using clean and renewable energy and biofuels Biodiversity conservation: Forest conservation, reforestation, afforestation, agro-forestry, avoiding deforestation, sustainable and efficient management of water resources, ecosystem management and restoration, preventing habitat fragmentation, over-exploitation of resources and land-use-change Agriculture: Organic farming, biological pest control, improving rice farming, no-till practices and in-situ and ex-situ gene preservation. |

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