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Review Article

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Impact of Climate Change on Biodiversity: An Overview

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Abstract: Biodiversity is the 'Full variety of Life on Earth'. It includes diversity within species, between species and of ecosystem. Biodiversity plays an important 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. But due to anthropogenic activities the global climate has changed since last few decades.This climate change adversely affected the biological resources of the country. This review basically discuss the importance of biodiversity, the consequences faced by the plants, animals, humans and ecosystem owing to the climate change and also control measures or strategies should be taken for the conservation of biodiversity which can protect the earth from the consequenceof climate change.

Keywords: Biodiversity, Climate change, Conservation, Ecosystem, Human health, livelihood, Species.

INTRODUCTION

Biodiversity is the 'Full variety of Life on Earth'. It includes diversity within species, between species and of ecosystem. The term biodiversity is generally used for natural environment and its conservation. According to UNCED (United Nations Conference on the Environmental and Development), 'Biodiversity means the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems.' In the simplest sense, biodiversity may be defined as the sum total of species richness, *i.e*. the number of species of plants, animals and microorganisms occurring in a given region, country, continent of the entire globe. Broadly speaking, the term biodiversity includes genetic diversity (Diversity of genes within a species), species diversity (Diversity among species), ecosystem diversity (Diversity at the level of community/ecosystem) and habitat diversity. The genetic diversity acts as a buffer for biodiversity (Verma, 2017a).

Biodiversity is the very basis of human survival and economic development. It helps in maintaining the ecological balance. There is a necessity of ecological balance for widespread biodiversity (Verma 2017b). It plays an important role in the function of an ecosystem by providing many services like nutrients and water cycling, soil formation and retention, resistance against invasive species, pollination of plants, regulation of climate, as well as pest and pollution. Biodiversity is also the source of non-material benefits like spiritual and aesthetic values, knowledge system, cultural diversity and spiritual inspiration. Each and every one should understand the levels and values of biodiversity (Verma 2016), for the larger interest of the world. It is source of inspiration to musicians, painters, writers and other artists (Sharma and Mishra, 2011).

India is one of the 12 mega biodiversity countries in the world and divided into 10 biogeographic regions. Our country accounts for two hotspots out of the 35 global biodiversity hotspots: the Indo-Malayam which includes the Eastern

Himalayas, North-east India and Andaman Islands, and the Western Ghats. Biogeographically, India is situated at the tri-junction of three realms: Afro-tropical, Indo-Malayan and Paleo-Arctic realms, and therefore, has characteristic elements from each of them. This assemblage of three distinct realms makes the country rich and unique in biological diversity. It has a great wealth of biological diversity in its forests, wetlands and in its marine areas. It is estimated that over 46,000 species of plants and 81,000 species of animals are found in India. The flowering plants comprise 15,000 species of which about 7000 species are endemic. Among the animal species diversity more than 50,000 species of insects, 4,000 molluscs, 6,500 other vertebrates, 2,546 fishes, 197 amphibians, 408 reptiles, 1224 birds and 350 species of mammals are found in different habitats (Myers *et al*., 2000).

India is equally rich in traditional and indigenous knowledge, both coded and informal on the use and importance of the biodiversity in the country. For generations, thousands of human communities have lived in the midst of this rich biodiversity and evolved sustainable lifestyles, of a symbiotic nature with the natural bounty around them. In the last two centuries, these equations have been radically challenged and threatened by various factors. Among them are a social and political mandate that favours maximum extraction of natural resources to achieve a certain paradigm of 'development' and a top-down model of conservation that ignores and threatens the very existence of the first allies of conservation–local people whose lives are deeply entwined with that of their surrounding for their physical, social, emotional and moral sustenance, in fact their very livelihood (Roy and Roy, 2015).

With the current trend of globalization and Intellectual Property Rights (IPR) regimes there is an urgent need for proper and scientific quantification and documentation of our biodiversity and associated traditional and indigenous knowledge especially in the developing country. This traditional knowledge is critical to science and society for maintaining the nation's natural resources, for growing its agricultural economy, for sustaining and improving the human health and its life style.

Large scale development and construction have posed significant threat to biodiversity. It has lead to destruction of various fragile ecosystems. Human activities significantly contribute towards destruction of natural habitats. The construction of road, dams, mining activities and other development projects have led to destruction of biodiversity of that region. All these factors related to large scale development are one of the major contributors of threat to biodiversity.

In the recent times India's biodiversity is severely threatened. The important causes of threats to biodiversity are the habitat destruction, invasive species, pollution, population and overexploitation of natural resources. Other prominent factor for the depletion of biodiversity is the rampant poaching. Though stringent laws have been enacted by the government regarding poaching and Wildlife Protection Act (1972) has been passed, which ensures the protection of wildlife and effectively deal with poaching related issues and also many arrests have been made regarding that in recent few years, it is still prevalent and is a cause of concern for the biodiversity and despite the government spending cores on the conservation of animals, the effective implementation of poaching related laws is yet a cause of concern. Similarly overharvesting of forest also depletes the biodiversity of the region.

Another important factor is the conversion of land under forest and grasslands into residential lands and using them for other developmental activities which lead to depletion of biodiversity. Deforestation has a huge impact on the biodiversity and clearing of forests for developmental activities lead to reduced forest cover and also contributes to climate changes affecting ecosystems around the globe.

The biodiversity loss has ecological impact (Kumar Ajay *et al*., 2017) and its main cause is the changes in the environment. Environmental conditions play a key role in defining the function and distribution of organisms, in combination with other factors. Environmental changes have had enormous impacts on biodiversity patterns in the past and will remain one of the major drivers of biodiversity patterns in the future. Environmental changes are studied under the change in climate or changes due to overpopulation, overexploitation of natural resources and deforestation.

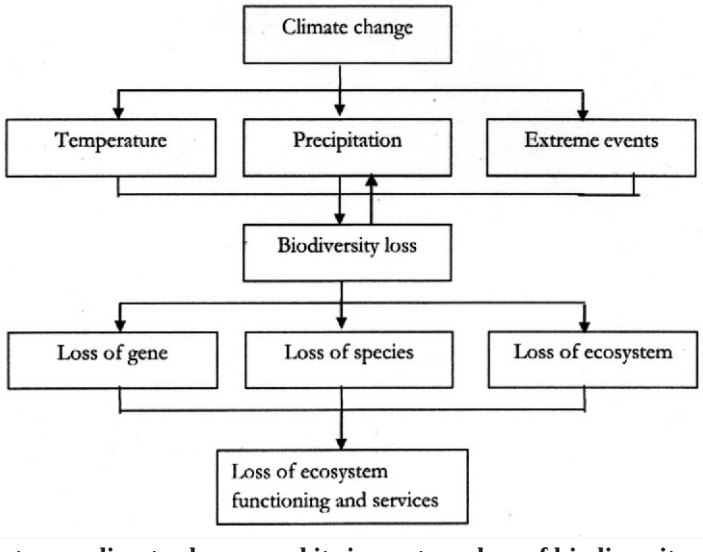

Figure: Link between climate change and its impacts on loss of biodiversity and ecosystem.

Climate Change and its Impact

The word climate refers to the weather variation of any specific area over a period of time. Climate includes the average temperature, amount of precipitation, days of sunlight, and other variables that might be measured at any given site. However, there are also changes within the Earth's environment that can affect the climate. Climate change refers to any change in the environment due to human activities or as a result of natural processes. Climate change refers to significant and long-term changes to a region's climate. These changes can occur over a few decades, or millions of years. Climate change alters entire ecosystems along with all of the plants and animals that live there.

Plants and animals are sensitive to fluctuations in temperature and climate. Evidence of organic evolution clearly indicated that rapid climate changes have been associated with mass extension of plants and animals. Rapid climatic changes could lead to increased diseases, land slide, forest fire which result in destruction of animals and plants. All organisms are adapted to a particular range of climatic conditions. Change in the climatic condition has a danger of extinction of several plants and animals species. Although all species are not directly influenced by changes in environmental conditions but also indirectly influence through their interactions with other species. Indirect impacts are equally important in determining the response of plants to climate change. A species whose distribution changes as a direct result of climate change may 'invade' the range of another species for example, introducing a new competitive relationship. Thus climate change is likely to affect minimum and maximum temperatures and trigger more extreme rainfall events and storms. For the Indian sub-continent, less rainfall in winter and increased precipitation in the summer monsoon are predicted; and in 2050, decreases in winter precipitation by 10-20% and summer by 30% have been projected (Kumar and Chopra, 2009). Climate change results due to both; natural and anthropogenic driver.

Natural drivers involves earth's climate variability caused by changes in the solar radiations, Milankovitch cycle, volcanic eruption, plate tectonics, ocean circulations, earthquakes and so on (Kunzing, 2008). Anthropogenic drivers involves the contribution of human activities to increasing the emission of green house gases like carbon dioxide, methane and nitrous oxide into the atmosphere at an alarming rate in different sectors such as in energy supply (25.9%), industrial sector (19.4%), deforestation (17.4%), agricultural (13.5%), transportation (13.1%), urbanization (7.9%) and waste (2.8%) (Rathore and Jasrai, 2013).

IMPACT OF CLIMATE CHANGE ON ENVIRONMENT

Global warming: The impact of the greenhouse gases is the warming near surface global temperature through the green house effect. 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 warming affects plants, animals and microorganisms both by changing their habitats and by directly affecting their physiological processes. The means sea level has risen by 10 to 20 cm and may further rise to 88 cm (Rathore and Jasrai, 2013). 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 and ringed seal).

Coral bleaching: Another important phenomenon associated with temperature rise is coral bleaching. When corals become affected by the rising temperature and other climatic issues they lose their beautiful colours turning white. The rising temperature results into increase in sea temperatures which negatively impacts the corals resulting in vanishing of the reefs which are considered to be one of the most bio-diverse ecosystems.

Water resources: Climate change affects the water resources thought increased evaporation rate. Increased evaporation rates are expected to reduce water supplies in many regions. The greatest deficits are expected to occur in the summer leading to be decreased soil moisture levels and more frequent and severe agriculture drought. More frequency and severe droughts arising from climate change will have serious and management implication for water resource users. Such droughts also impose costs in terms of wildfires both in control costs and lost timber and related resources.

IMPACT OF CLIMATE CHANGE ON BIODIVERSITY

Only a small change in pattern of climate has severe impact on the biodiversity, altering the habitats of the species and presenting a threat for their survival, making them vulnerable to extinction. Millennium Ecosystem Assessment (MEA) predicts climate change to be the principal threat to the biological diversity (Anonymous, 2007).

Due to increase in temperature several plant species like *Berberisa siatica, Taraxacum officinale, Jasminum officinale* etc. have shifted towards higher altitude in Nainital. 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 Gates (1990) 3°Cincrease in temperature may leads to the forest movement of 2.50 km/ year which is ten times the rate of natural forest movement.

Anonymous (2009) reported that changes in climate affects the normal life cycle of plant. He also reported that invasive species (*Lantana, Parthenium* and *Ageratum conyzoides*) are a threat to native species being more tolerant to climatic variations. Variation in temperature and precipitation patterns can result in more frequent droughts and droughts and floods making indigenous plants more vulnerable to pests and diseases (Tibbetts, 2007).

Slight change in climatic condition leads to the extinction of animal species. For example climate change has resulted in extinction of animals like golden toad and Monteverde

harlequin frog (McCarthy *et al*., 2001). Polar bears are in danger due to reduction in Arctic ice cover; North Atlantic whale may become extinct, as planktons which are its main food have shown declination due to climate change. Though the exact impact of climate change on India's natural resources is yet to be studied in detail, pioneering studies show that endemic mammals like the Nilgiri tahr face an increased risk of extinction (Sukumar *et al*., 1995). Further, there are indicative reports of certain species e.g., Black-and rufous flycatcher (Mikania micrantha) shifting their lower limits of distribution to higher reaches, and sporadic dying of patches of Shola forests with the rise in ambient surface temperatures.

The sex ratio of sea turtle disturb because as a result of high temperature more female turtles are produced. 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 (Anonymous, 2007).

Climate change also alters the disease behavior in animals. The devastating amphibian disease chytrid fungus, likely exacerbated by warmer temperatures, has left many amphibian populations dwindling or extinct.

IMPACT OF CLIMATE CHANGE ON ECOSYSTEM

Millennium Ecosystem Assessment (MEA) predicts that only a small change in climate has severe impact on the ecosystems (Anonymous, 2007).

Marine and Coastal ecosystem: 70% of earth's surface is covered by oceans comprising unique ecosystems like mangroves, coral reefs, sea grass beds. Climate change is leading to sea level rise, increased coastal erosion, flooding, higher storm surges, sea salinity ingress, increased sea-surface temperatures, ocean acidification and coral bleaching. Rising sea level presents extreme threat to marine ecosystems which can lead to disturbance in habitat and patterns of survival of marine species. Wetlands and coastal ecosystems are at a huge risk due to increasing sea levels. Many communities have already become climate refugees to evade rising sea level (Anonymous, 2007). Indian coastal areas vulnerable to climate change are Sunderbans, Maharashtra, Goa and Gujarat (Rann of Kutch). Species composition and distribution will surely be affected by such changes (Rathore and Jasrai, 2013). The Sundarbans is the largest natural low-lying mangrove ecosystem in the world, distributed over 10,000 square kilometers. The sea level rise recorded over the past 40 years is responsible for the loss of 28% of the mangrove ecosystem. Modelling suggests that up to 96% of suitable tiger habitat in the Sundarbans could be lost in the next 50–90 years (Loucks *et al*., 2010).

Himalayan ecosystem: Temperatures in the Himalayan ecosystem are increasing at a rate of 0.9°C annually, which is considerably higher than the global average of 0.7°C per decade. Due to this changes mosquito are seeing first time in Lhasa and Tibet cities, located 3490 meters above sea level. There are similar reports of flies at Mount Everest base camp in Nepal. The presence of these insects suggests the possible spread of vectorborne diseases, such as malaria and dengue fever, to areas where cooler temperatures previously protected people from these threats (FAO, 2012).

Island ecosystem: Islands are rich in biodiversity and has high economic importance. But at present due to climate change more than 23% island species are becoming endangered and hence economic loss in the tourism sector.

Inland water ecosystem: It includes lotic and lentic fresh water ecosystem and comprising 0.8% of the earth's surface, but support 6% of the total species. They are rich source of food, income, employment and biodiversity. Changing climatic conditions like rainfall and temperature lead to changes in the phenology, physiology and migration trends of some organisms like migratory fishes and birds.

Forest ecosystem: One third of earth's surface is covered by forest and it is the home place of two third of all terrestrial species. They are also rich biodiversity hotspots. But half of the original forest has been cleared up till now. Green house effect has led to increase in growth of some forest, migration of tree species towards high altitude, increased attack of pest, invasive species and wild fires, hence modifying the composition of forest. According to FAO (2000), due to these changes many animals, primates and 9% of all known plant species are at verge of extinction.

Agriculture: 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. It affects both sustainable and unsustainable agriculture. The unsustainable agriculture has multiple effects (Verma 2017c) and disturbs the ecological balance (Verma 2018a) and biodiversity structure. Biodiversity loss has impacted the fishing and hunting practices by indigenous people posing an implication on their only source of food. By the middle of the century, crop yields could decreases by 30% in Central and South Asia, while by 20% in East and Southeast Asia.

Dry lands and grassland: They have localized species (Wild ass, Kutch etc.) and have varied crops and livestock. The risk of wild fire is increasing which could change the species biodiversity.

IMPACT OF CLIMATE CHANGE ON HUMANS

Climate change leads toan increase in temperature, melting of the ice, increased natural events like floods, droughts, and cyclones displace the humans from their home.Hot climate makes insect pests in general and vectors and pathogens in particular to spread over a wider range and enhances their

survival rate. An increase of 1°C in surface temperature is estimated to correspond 10% increase in incidence of insects as pests and insurgence of many diseases like cholera, typhoid etc.; spread of tropical and vector borne diseases like malaria, dengue etc. androdent borne diseases like plague. These diseases have shown a persistent increase in the past 50 years.

Thus global climate changes have major implications on human health. It is obvious that effect on ecosystem will change the distribution and burden of vector borne infectious diseases including bacterial diseases. Changes in epidemiology may already be underway, complex biological changes are associated with change in ecosystem. Water and food borne pathogens create havoc in developing countries that too when conditions are conducive for spread of pathogens and compromise with the hygiene conditions. Green house gases play their role by increasing the carbon emission, due to which the disease curve is increasing faster. Carbon emission is increasing to a dangerous level, making animal lives vulnerable to pathogens and diseases. 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.

IMPACT OF HABITAT LOSS, OVERPOPULATION AND OVEREXPLOITATION

Besides climatic change, other human activities are also largely responsible for biodiversity loss. It is estimated that about 27000 species become extinct every year. If this will continues, 30% of world's species may be extinct by the year 2050. The current extinction rate is 100 to 1000 times to that of natural rate of extinction. Other human activities are: habitat destruction, invasive species, pollution, population and overexploitation of natural resources (Kannan and James, 2009).

Climate change will provide new ways for invasive species to encroach on new territory. Natural disasters like storm surges and high winds, which increase in number and severity as the earth warms, spread non-native plants and insects to new territories. Virtually all ecosystems worldwide have suffered invasion by the main taxonomic groups including India. The major invasive alien plant species include *Lantana camara, Eupatorium odoratum, Eupatorium adenophorum, Parthenium hysterophorus, Ageratum conyzoides, Mikania micrantha, Prosopis juliflora* and *Cytisus scoparius*.

Rapidly increasing population has forced down the men to cut down the forests to fulfill the requirements of food and shelter. Deforestation has led to the destruction of the habitats of plants and animals. Loss of habitats is the most important cause of extinction of species. Habitat extinction compels the species to move where they find it difficult to adapt and this may ultimately lead to their extinction. Physically larger species and those living at lower latitude or in the forests or oceans are more sensitive to reduction in habitat area (Drakare *et al*., 2006).

Human activities like deforestation, pollution, overpopulation are ultimately responsible for habitat destruction. Introduction of exotic species is also responsible for the loss of biological diversity. The endemic and other local species may not be able to compete with the exotic species and are unable to survive. Overexploitation, in the form of hunting of animals and plants for their commercial value is one of the major reasons for loss in biodiversity. Illegal wildlife trade is the single largest threat to biodiversity loss. Overpopulation of human and over consumption of natural resources is the root cause of all biodiversity loss (Sharma and Mishra, 2011).

CONCLUSION

It is evident that the loss in biodiversity is due the change in climate. All these changes in environment, adversely affecting the biodiversity, are mainly due to the human activities.The increase in the greenhouse gases is leading to global warming at a faster rate and impacts on biodiversity, ecological balance and humans. The ecological balance is an indispensable need for human survival (Verma 2018b). Every change in the ecosystem process or in ecological balance 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 phonological behaviour like breeding period, migration time etc., increase in the forest fires and pest attacks (Rathore and Jasrai, 2013). 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 aforestation, reforestation and agro-forestry practices. Biodiversity-based adaption and mitigation strategies willenhance the resilience of ecosystems and prevent damage to human and natural ecosystems.

Increasing our understanding of the affects of climate change on biodiversity, developing ways of mitigating such effects and reduced anthropogenic activities are critical to limit such damage. Without conserving the biodiversity and minimizing the anthropogenic activities, it is almost impossible to get the inclusive and sustainable development (Verma, 2019). Thus, there is a growing realization among decision-makers that biodiversity is not an optional bonus in human affairs, but the very foundation of our existence. Moreover, biodiversity conservation tailored to changing climatic conditions is not only necessary to help species and habitats to adapt to change, but such action is also likely to mitigate climate change (FAO, 2012). In terms of agriculture, there is a need for climate resilient farming systems. Climate literacy should be spread and a cadre of Community Climate Risk Managers should be formed in villages. The calamity of climate change should be converted into an opportunity for developing and spreading climate resilient farming techniques and systems (Swaminathan and Keshvan, 2012).

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