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International Journal on Environmental Sciences

International Journal on Environmental Sciences 13(1), January-June 2022, pp. 43-48
https://doi.org/10.53390/
ISSN No.: 0976-4534

EFFECTS OF CLIMATE CHANGE ON ECOSYSTEM AND BIODIVERSITY: A REVIEW

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Review Article

Received: **18.05.2022** Accepted: **28.05.2022** Published: **07.06.2022**

ABSTRACT

Anthropogenic activities have changed the global climate since last few decades. This climate change adversely affected the biological resources of the country. This review basically discuss on the climate change, biodiversity and ecosystems well as consequences faced by the plants, animals, humans and ecosystem owing to the climate change. Climate change affects entire ecosystems, as well as all living organisms inside them. All living animals have had to adapt, shift, or die out as the environment has changed over Earth's history. Ecosystems and species can evolve together when these changes occur gradually. A gradual transition also allows organisms to adapt to changing conditions. When these changes happen swiftly, the species tries to adapt as soon as possible in a suitable site. Invasive species will be able to expand on new land in new ways as a result of climate change.

Keywords: Anthropogenic activities, Ecosystem, Biodiversity, Environment, Natural disaster.

INTRODUCTION

Climate change is one of the most important global environmental challenges of the present century (Prakash, 2021). The changing climate can affect the basic elements required for maintaining good health: clean air, potable water, adequate food, coastal settlement and shelter. It also increases the incidence of vector-borne diseases, decrease in crop production, more frequent extreme weather events which could be attributed to changing environment. Addressing climate change will need promoting mitigation and adaptation strategies without hampering economic development, good scientific evidence and coordinated action by multiple stakeholders. This article shows that linkages between climate change and human health are complex and multi-layered and predications of the future health impacts of climate change are still uncertain. 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.

Biodiversity is continually transferred by a changing climate. Conditions change across the face of the planet, sometimes slowly, sometimes in larger increments leading to rearrangements of biological associations. Now, a new type of climate brought about by human activities is being added to this natural variability, threatening to accelerate the loss of biodiversity already underway due to other human stressors. The response of biodiversity to climate change has become an extremely active field of research. Predictions play an important role in alerting scientists and decision makers to potential future risks, provide a means to bolster attribution of biological changes to climate change and can support the development of proactive strategies to reduce climate change impacts on

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biodiversity. Maintaining and restoring healthy ecosystems plays a key role in adapting to and mitigating climate change through biodiversity conservation, sustainable use and sustainable land management and yields multiple environmental, economic and social benefits.

Anthropogenic activities and Climate change: 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.

Climate change results due to both; natural and anthropogenic driver (Prakash and Verma, 2022). 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 (Kunzig, 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 Jasral, 2013).

The different possible effects of climate change that can operate at individual, population, species, community, ecosystem and biome scales, notably showing that species can respond to climate change challenges by shifting their climatic niche along three non-exclusive axes: time (e.g. phenology), space (e.g. range) and self (e.g. physiology). Climate change has led to phonological shifts in flowering plants and insect pollinators, causing mismatches between plant and pollinator populations that lead to the extensions of both the plant and the pollinator with expected consequences on the structure of plant-pollinator networks (Kiers *et al.*, 2010). Climate change is able to decrease genetic diversity of populations due to directional selection and rapid migration, which could in turn affect ecosystem functioning and resilience (Botkin *et al.*, 2007).

Climate and agriculture are interrelated processes, both take place on a global scale. Global warming is projected to have significant impact on conditions of affecting agriculture, including temperature, precipitation and glacial run-off. Rising carbon dioxide levels would also have effects both detrimental and beneficial, on crop yields. The overall effect of climate change on agriculture will depend on the balance of these effects.

As the planet warms, rainfall patterns shift and extreme events such as droughts, floods and forest fires become more frequent. The densely populated coastal areas and island nations will lose their millions of homes as the sea level rises. As per World Development Report of the World Bank (2010), the poor people in Africa, Asia and elsewhere face prospects of tragic crop failures; reduced agricultural productivity; and increased hunger, malnutrition and diseases. 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 by 30% for the summer have been projected **(**Kumar and Chopra, 2009**).**

Climate change and Biodiversity

The term Biodiversity is used by Rio de Janerio Convention to refer to all aspects of variability evident within the living world, including diversity within and between individuals, populations, species, communities, and 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, species diversity, ecosystem diversity and habitat diversity.

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) and a number of other studies predict that a changing global climate change to be the principal threatens to the biological diversity and ecosystem (Anonymous, 2007; Prakash and Srivastava, 2019; Verma, 2021). The distribution of species (biogeography) is largely determined by climate, as is the distribution of ecosystems and plant vegetation zones (biomes). Climate change may simply shift these distributions but, for a number of reasons, plants and animals may not be able to adjust resulting some species and ecosystems are likely to be eliminated by climate change. When a species becomes extinct, the species associated with it in an obligatory way also become extinct.

Beyond this, the various effects on populations are likely to modify the web of interactions at the community level. In essence, the response of some species to climate change may constitute an indirect impact on the species that depend on them. A study of 9650 interspecific systems,

including pollinators and parasites, suggested that around 6300 species could disappear following the extinction of their associated species (Koh *et al.*, 2004). A resent analysis of potential future biome distributions in tropical South America suggests that large portions of Amazonian rainforest could be replaced by tropical savannahs (Lepetz *et al*., 2009).

Due to increase in temperature several plant species like *Berberis asiatica, Taraxacum officinale, Jasminum officinale* etchave 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) increase in 3^{0}C 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 and explained that invasive species are a threat to native species being more tolerant to climatic variations. The major invasive alien plant species include *Lantana camara, Eupatorium odoratum, Eupatorium adenophorum, Parthenium hysterophorus, Ageratum conyzoides, Mikania micrantha, Prosopis juliflora* and *Cytisus scoparius.* 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, its main food have shown decline 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 (*Ficedula nigrorufa*) 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. Climate changes could also have positive effects on biodiversity. For example, more increase in temperature and increased carbondioxide are likely to be beneficial to many plants, resulting in an acceleration of biomass production. Milder winters might increase survival of many currently threatened species might in temperate regions. Increased precipitation may also benefit some plant communities and species depending on them. Moreover, several studies reported detrimental effects of climate change on biological invasions (Parmesan, 2006). Although few studies report beneficial effects of global changes on biodiversity, they certainly exist and add to the difficulty of getting a clear overview of the effects of climate changes on the biodiversity of our planet. Biodiversity is affected by excessive use of pesticides too (Vinod et al., 2021). Conservation of biodiversity is big challenge in modern context (Prakash and Verma, 2019; Arya, 2021). However it is necessary for ecological balance, human survival and sustainable development (Ashok, 2017; Verma, 2018, 2019) because biodiversity loss has large impact everywhere (Ashok, 2016; Kumar and Verma, 2017).

Because of climate changes, species may no longer be adapted to the set of environmental conditions in a given region and could therefore fall outside its climatic niche. As other components of the ecological niche of species are not supposed to change directly, we hereafter refer only to climatic niches of species. To persist, individuals, populations or species must produce adaptive responses, which can be of several types, and are provided by two categories of mechanisms.

Besides climate change, invasive species also affect the biodiversity. When you combine these two, the consequences are expected to be far-reaching. Invasive species will be able to expand on new land in new ways as a result of climate change. Natural disasters such as storm surges and high winds, which are becoming more common and severe as the world heats, spread non-native plants and insects to new areas. Cactus moths, for example, were likely brought to Mexico by the winds of the 2005 hurricane season, posing a threat to unique cactus species. Almost all ecosystems in the world, including India, have been invaded by the major taxonomic groups. *Lantana camara, Eupatorium odoratum, Eupatorium adenophorum, Parthenium hysterophorus, Ageratum conyzoides, Mikania micrantha, Prosopis juliflora, and Cytisus scoparius* are among the most common invasive alien plant species.

Climate change and Ecosystem

Millennium Ecosystem Assessment (MEA) assessed the consequences of ecosystem change for human well-being from 2001 to 2005, the MEA involved more than 1360 experts to work worldwide and predicts that only a small change in climate has severe impact on the ecosystems. The Millennium Ecosystem Assessment completed in 2005 found that overall people have made greater changes to ecosystems in the last half of the 20th century than at any time in human history.

Terrestrial ecosystem: Beyond 2050, terrestrial ecosystems, which play an important role as carbon sinks, may reach the upper limit of the absorptive capacity or even, decrease their net carbon uptake. It increases the global average temperature exceed 1.5-2.5^{0}C that adversely affected the food and water supply to species. Thus, major changes in ecosystem structure & function, species' ecological interaction and geographic ranges decrease the 20-30% plant and animal species.

Marine and Coastal ecosystem: 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). The sea level rise recorded over the past 40 years is responsible for the loss of 28 percent of the mangrove ecosystem. Modelling suggests that up to 96 percent of suitable tiger habitat in the Sundarbans could be lost in the next 50–90 years (Loucks *et al*., 2010). Islands are also rich in biodiversity and have 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.

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 vector borne diseases, such as malaria and dengue fever, to areas where cooler temperatures previously protected people from these threats (FAO, 2012).

Inland water ecosystem: It includes fresh water lotic and lentic 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 extension.

CONCLUSION

Anthropogenic activities are directly and indirectly responsible for climate change which has an adverse 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). The timing of species life cycle events is expected to be altered, species distributions will change radically, trophic networks will be affected and ecosystem functioning may be severely impaired, leading in the worst cases to countless species extensions.

Increasing our understanding of the effects of climate change on biodiversity, and developing ways of mitigating such effects, are critical to limit such damage. Over the past decades, some of this understanding has been effectively translated into mathematical models that can be used to forecast climate change impacts on species distributions, abundance and extensions. These models are characterized by their high diversity of understanding structures and assumptions, with predictions differing greatly depending on the models used and species studied. Most of these models indicate alarming consequences for biodiversity with worst-case scenarios leading to extension rates that would qualify as the sixth mass extension in the history of earth (Barnosky *et al.*, 2011).

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). It is also crucial to improve our understanding of the vulnerability of biodiversity to climate change, to develop other predictive approaches and to go beyond prediction. Even so biodiversity is a key resource in climate mitigation and adaptation strategies through the delivery of direct and indirect ecosystem services.

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