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Climate Change: A Threat to Biodiversity

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Abstract: By the end of the century, climate change is probably going to overtake all other direct drivers of biodiversity loss. Climate change projections, altered land use, and the introduction of exotic or alien species are anticipated to restrict some species' ability to migrate, which will hasten the extinction of existing species. The significant effects of climate change on biodiversity and the ecosystems that sustain life on Earth are a hot debated topic globally. Ecosystem resilience and stability depend heavily on biodiversity, which includes a wide variety of species and genetic diversity. But these ecosystems are disturbed by climate change, which increases the danger of extinction, changes the distribution of species and results in habitat loss. Thus, this review explores the numerous ways that biodiversity is threatened by climate change and provides information on possible mitigation and adaptation measures.

Keywords: Climate change, Global warming, Biodiversity, Ecosystem resilience, Greenhouse gases

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Introduction

Biodiversity encompasses a wide variety of life on Earth, ranging in size from microscopic organisms to massive mammals, as well as the complex network of ecological relationships that keeps our world alive. In addition to serving as a symbol of the wonder and beauty of the natural world, biodiversity is essential to the resilience and stability of ecosystems as well as to human well-being (Vasiliev, 2022). Climate change, however, poses a serious and growing threat to this complex web of life. The overabundance of greenhouse gases in the Earth's atmosphere results in trapping of heat by these gases, global temperature rise, bringing about a host of negative biological and environmental effects (Darkwah *et al.,* 2018). Wide-ranging effects of climate change include altered sea levels, weather patterns, and the frequency and severity of extreme weather events like hurricanes and droughts. Ecosystems are being upset as a result, which increases the danger of extinction, causes changes in the distribution of species, and results in habitat loss (IPCC, 2022). Human cultures that depend on ecosystems for their survival and well-being are also affected by these changes, in addition to the natural world. It is essential to comprehend the

complex relationship between biodiversity and climate change in order to properly address both issues. In order to preserve biodiversity and guarantee a sustainable future, this review will examine the complex effects of climate change on biodiversity, examine the mechanisms causing these changes, evaluate the implications for different ecosystems, and suggest mitigation and adaptation measures.

Impacts of Climate Change on Biodiversity:

Numerous obstacles to biodiversity are demoed by climate change, which has varying effects on ecosystems and species (Prakash and Srivastava, 2019). The effects are wide-ranging and frequently connected, making the threats to several organisms worse. A primary aftereffect of climate change is the modification of habitats, resulting in their depletion and fragmentation. The distribution of plant and animal species may be impacted by forced changes in vegetation zones brought about by warming temperatures and shifting patterns of precipitation (Muluneh, 2021). Climate change imposed habitat loss results in species' inability to migrate or adapt, as well as their restricted range of movement. Furthermore, it isolates populations, reducing genetic diversity and making animals more susceptible to environmental stresses (Travis, 2003; Coristine and Kerr, 2011).

Consequently, many species are compelled to migrate to higher latitudes or altitudes in pursuit of favorable habitats as a result of rising global temperatures (Seebacher and Post, 2015). Mismatches between species and their preferred environments may result from this movement. Certain species might flourish in unfamiliar environments, maybe spreading and out-competing local species. However, species that cannot change fast enough can see a decrease in their population or possibly go extinct. Ecological relationships between plants and pollinators or predators and prey might be upset by shifts in distribution patterns. Ecosystems may become even more unstable when seasonal activities like migration and flowering no longer coincide (White *et al.*, 2021).

Thomas *et al.* (2004) elaborated the increased risk of extinction for many species due to the most concerning effect of climate change. The rate of extinction of species is likely to increase as temperatures rise further. In particular, species with limited geographic ranges or niches in the environment are at greater risk. Extreme weather events, habitat loss, and changes in food availability are just a few of the direct and indirect repercussions of climate change that might force certain species to adapt beyond their limits. Some may be able to change their ranges or adapt, while others may not be able to withstand the combined effects of these challenges. Table 1 summarizes the region specific impacts of climate change.

The concentration of Green House Gases (GHGs) in the Earth's atmosphere has increased due to incessant anthropogenic activity and this is the main cause of climate change. The greenhouse effect is the warming caused by gases such as carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and fluorinated gases that trap heat. The natural greenhouse effect is amplified by human-induced increases in greenhouse gases, which raises global temperatures. The delicate equilibrium that many species depend on for survival is upset when this warming has cascading consequences on ecosystems and biodiversity (Xu *et al.*, 2009). In parallel, the absorption of excess atmospheric CO_2 by the world's oceans has led to a phenomenon known as ocean acidification where CO_2 dissolves in seawater, forming carbonic acid, which lowers the pH of the ocean (Doney *et al.*, 2009). The acidification poses a significant threat to marine biodiversity, particularly to organisms with calcium carbonate skeletons or shells, such as corals, molluscs, and some planktonic species.

Because greenhouse gases are building up in the atmosphere, global temperatures have been rising continuously. The effects of this temperature rise on biodiversity are extensive with a direct impact on the distribution, physiology and behaviour of species, which

impacts their capacity to flourish in their native environment. There are certain temperature ranges that many species can only survive and procreate in. Species may experience heat stress, changed reproductive patterns, and changes in food availability when temperatures rise above these thresholds. Changes in species distribution caused by temperature can cause errors in the timing of important ecological processes, such migration or flowering, upsetting the complex web of relationships within ecosystems.

An increase in the frequency and severity of extreme weather events, such as heat waves, droughts, floods, hurricanes, and storms, is another sign of a changing climate. The biodiversity may be directly and significantly impacted by these occurrences. Severe weather conditions have the potential to directly affect species, their habitats, and the ecosystems they live in. For instance, protracted droughts can result in water scarcity and habitat degradation, while hurricanes and storms can destroy coral reefs and coastal habitats. These occurrences can also worsen existing dangers, such habitat loss and fragmentation, which makes it harder for certain species to adapt and survive. Formulating effective measures to reduce climate change's impacts on biodiversity requires an understanding of these mechanisms and factors. Ensuring the long-term health and resilience of ecosystems globally requires addressing the core causes, such as lowering greenhouse gas emissions.

Consequences for Ecosystems:

Malhi *et al.* (2020) amalgamated the impacts of climate change on ecosystem and explored novel perspectives on how ecosystems respond to climate change, how ecosystem resilience can be enhanced and how ecosystems can assist in addressing the challenge of a changing climate. The varied and intricate coral ecosystems are threatened by both ocean acidification and rising sea temperatures. Elevated temperatures have the potential to induce coral bleaching, a condition in which corals shed their symbiotic algae, resulting in a reduction of colour and vibrancy (Baker *et al.*, 2008; Hoegh-Guldberg, 2011). Reef structures may deteriorate as a result of prolonged or severe bleaching events that cause coral death. Coral reefs are faced with additional issues due to ocean acidification.

The impact of climate change on forest ecosystem is substantial since they support a multitude of ecosystem services and are essential for biodiversity. The makeup, organization, and efficiency of forest ecosystems are impacted by temperature increases and shifting patterns of precipitation. Variations in temperature and precipitation can modify the geographical ranges of tree species, resulting in modifications to the distribution and composition of forests. Forest ecosystems are directly threatened by the frequency and intensity of wildfires, which are connected to increasing temperatures and longer droughts (Joyce *et al.*, 2014; Nigatu, 2019).

Climate change is having one of the fastest and most noticeable effects on Polar Regions - the Arctic and Antarctic. In particular, the pace of warming in the Arctic is more than twice that of the rest of the world which has far-reaching effects that go beyond the Polar Regions. Moreover, the warming temperatures and shifting ice conditions in the Antarctic have an effect on animals like krill, which are an important part of the Antarctic food web. Whales, seals, and penguins in the higher trophic levels are also affected by these fulminant shifts (Meredith *et al*., 2019).

Freshwater ecosystems, such as lakes, marshes, and rivers, are also impacted by climate change, which has significant effects on biodiversity. The distribution and availability of freshwater resources can be impacted by changes in runoff, temperature rises, and altered precipitation patterns. River flows and the availability of water downstream may be impacted by variations in the timing and amount of snowmelt and glacier melt brought on by rising temperatures. The aquatic environments and the organisms that rely on them are affected by this. Furthermore, extreme weather conditions like

Table 1: Region-specific Climate Change Impacts (IPCC, 2016)

Australia	Changes in water resources Threats to coastal ecosystems Increased vulnerability of biodiversity	Europe	Reductions in alpine plant habitat Threats to mangroves, sea grass beds, coral reefs and salt marshes Introduction and expansion of invasive alien species
North America	Increased vulnerability of ecosystems Particular vulnerability to climate extremes	Central/South America	Increased rates of species extinction Threats to mangroves and coral reefs Increased vulnerability of fish stocks
Asia	Changes to plant distribution, growth and timing of seasonal activities Threats to mangroves, sea grass beds, coral reefs and salt marches	Africa	Range shifts in southern extinction Changes in species composition especially in arid and semi-arid forests Changes in water resources

droughts and floods can upset freshwater ecosystems, resulting in habitat loss, modified nutrient cycles and alterations in water quality. The consequences of climate change are amplified across several domains due to the interdependence of freshwater ecosystems with terrestrial and marine ecosystems (Doll and Zhang, 2010).

Conservation Challenges:

Conservation efforts must give priority to initiatives that address the underlying causes of climate change while simultaneously strengthening the resilience of ecosystems and species, since climate change continues to pose a serious danger to biodiversity. In order to reduce greenhouse gas emissions, significant and quick action is required. This means reducing the impact of human activity on the environment through legislation, converting to renewable energy sources, and improving energy efficiency. It is crucial to locate and maintain critical habitats that provide safe havens for endangered species, but without affecting normal life and livelihood of local population. It should be noted that the declaration of more and more protected areas has resulted in the creation of conservation refugees and their population is increasing in countries like India (Kurian and Vinodan, 2018). Protected area creation and upkeep can give wildlife safe havens from the effects of climate change. In order for species to survive in the face of a changing climate, it is imperative that they are able to migrate across landscapes. This could entail lowering obstacles to movement, regulating connectivity between habitats, and establishing wildlife corridors, excluding agricultural lands and residential areas.

Policy and International Efforts:

The global aspect of climate change necessitates international cooperation for reducing greenhouse gas emissions and stops the rise in global temperatures, a number of agreements and regulations have been put in place. Among these is the United Nations Framework Convention on Climate Change (UNFCCC)'s 2015 adoption of the Paris Agreement (Levina, 2007 and Dechezlepr^etre *et al.,* 2022). As part of the Paris Agreement, participating nations pledge to cut greenhouse gas emissions through nationally determined contributions (NDCs). These contributions are updated and assessed on a regular basis to take changing climate goals into account. With attempts to keep the increase to 1.5 °C, the pact seeks to keep increases in global

temperature well below 2 °C above pre-industrial levels. This acknowledges that higher temperature thresholds are linked to increased hazards to biodiversity and ecosystems. The agreement acknowledges that adaptation efforts are necessary to mitigate the effects of climate change, especially in areas that are vulnerable. Numerous international accords that are explicitly focused on biodiversity conservation are in addition to the global climate agreements. The connections between biodiversity loss and climate change are emphasized by these accords. Notable examples include, Convention on Biological Diversity (CBD) (an international treaty addressing biodiversity conservation and sustainable use); Intergovern-mental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) (an independent intergovernmental body that assesses the state of biodiversity and ecosystem services globally).

Synergies and Conflicts:

There are opportunities and challenges when international climate agreements and biodiversity conservation initiatives collide. Developing cohesive and successful tactics requires an understanding of these dynamics. Certain climate change mitigation strategies, like reforestation and sustainable land management, can also help conserve biodiversity. Important habitats can be preserved and carbon sinks can be achieved by protected areas. On the other side, efforts to conserve biodiversity may be at odds with climate mitigation strategies like the generation of bioenergy or extensive afforestation. It is crucial to carefully consider any trade-offs and implement plans that strike a balance between the goals of biodiversity and climate change. As a result, integrated approaches that take into account both the objectives of climate change and biodiversity are becoming more popular. These approaches entail coordinating policies related to both issues to make sure that efforts to address one do not worsen the other. Achieving lasting results requires navigating the complexities of these international accords and identifying oppor-tunities for cooperation between the aims of biodiversity conservation and climate change mitigation. Thus, coordinated efforts at the international level are critical in handling these interconnected challenges successfully.

Future Outlook:

Although our understanding of how climate change affects biodiversity has advanced significantly, there are still a number of unknowns and research gaps. Filling in these gaps is essential to improving tactics and arriving at wise choices. Important regions of ambiguity consist of:

- *Predicting Species Responses*: It is still difficult to correctly forecast how different species will react to changing climate circumstances. This intricacy is a result of a number of factors, including interactions with other species, species-specific adaptive capacities, and the significance of local environmental conditions.
- *Ecosystem-Level Responses*: It is difficult to predict how entire ecosystems will react to climate change. The complicated interactions between species in ecosystem dynamics make it difficult to forecast how changes in the environment will cascade into one another.
- *Long-Term Effects*: There are many unanswered questions on how climate change will affect biodiversity in the long run. To effectively predict future events, research on the cumulative effects over extended periods of time is necessary, especially when taking interactions with other stresses into account.
- *Feedback Mechanisms*: Research is still being done to identify and understand the feedback mechanisms that connect biodiversity to climate change. Ecosystem stability is greatly impacted by feedback loops, in which changes in one element increase or decrease changes in another.
- *Social-Ecological Systems*: The subject of studying climate change integration of social and ecological aspects is developing. Developing comprehensive conservation and adaptation strategies requires an

understanding of the relationships between human activities, social reactions, and the implications on biodiversity.

- *Conservation versus livelihood*: Majority of the conservation initiatives across third world countries, especially in India are totally against livelihood options which contributes to social discontent and anarchy which indirectly supports anti-conservation mentality among public. Thus alternative proposals are the need of the hour for tackling such complexities effectively.

Sustaining interdisciplinary research, working together and incorporating new knowledge into conservation and climate policy frameworks are necessary to address these concerns. Public education and awareness campaigns are essential parts of a holistic plan to combat biodiversity loss and climate change. Communities that are knowledgeable and empowered are crucial allies in the joint endeavour to create a future that is more resilient and sustainable.

Conclusion

Ecosystem stability, resilience and the provision of vital services all depend on biodiversity which includes a vast variety of species, each of which contributes differently to preserving the equilibrium of natural systems. However, because of changing species ranges, increasing risks of extinction, and habitat degradation, climate change poses serious concerns to biodiversity. These problems are made worse by the factors of climate change, such as rising temperatures and greenhouse gas emissions. Frameworks from international agreements like the Convention on Biological Diversity and the Paris Agreement are crucial for tackling climate change and protecting biodiversity. On the other hand, these agreements' conflicts and synergies need to be carefully considered. As a result, numerous species are in danger of going extinct due to the effects of climate change, which include abrupt temperature increases, extreme weather and habitat modification. The interdependent network of life on Earth is seriously threatened by the combined effects of climate change and other stresses. Global action that is swift and coordinated is required to reduce greenhouse gas emissions, save important habitats and strengthen ecosystem resilience. Postponing these initiatives puts the health of current and future generations at danger as well as the basic basis of biodiversity. In conclusion, creating a sustainable and resilient future for our planet requires an all-encompassing and cooperative strategy that tackles the social, political and scientific aspects of climate change and biodiversity loss.

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