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THE IMPACT OF CHANGING CLIMATE ON NATURAL VEGETATION: A COMPREHENSIVE ANALYSIS

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ABSTRACT
This research paper deals with the intricate relationship between changing climate patterns and their profound effects on natural vegetation. With climate change emerging as a critical global concern, it is imperative to understand the repercussions on ecosystems and biodiversity. Changing climate patterns results in change in temperature fluctuations, altered precipitation patterns and drought stress, changes in extreme weather events, snow packs, wind events, Ice storms, sea level rise, tropical cyclones etc. According to the "Assessment of climatic change over the Indian region - A report of the Ministry of Earth Sciences Government of India''_ in the period of 30 years (1986 to 2015) temperature of the warmest day and the coldest night of the year have risen by 0. 63 degrees centigrade and 0. 4 degree centigrade respectively. Such changes cause risk of soil erosion, nutrient deposition, spreading of contaminants and pathogens, flooding etc. All these have intense effect on biodiversity and ecosystem services, phonological changes in natural vegetation (forest flora) e. g. in leaf phenology (bud break, leaf maturation, leaf senescence etc), species diversity, patterns of invasive species, forest productivity and biomass production, forest health etc. This leads to an overall impact on the forest and its ecosystem. Repercussion is that plants face an uncertain future. This paper aims to contribute to a better understanding of the intricate dynamics between climate change and the world's natural vegetation.

KEY WORDS: *Natural Vegetation, precipitation patterns, Phenology, Extreme weather.*

INTRODUCTION

The Earth's climate is undergoing unprecedented changes due to human activities, primarily the emission of greenhouse gases. The report *Assessment of Climate Change over the Indian Region* prepared by the Union Ministry of Earth Sciences (MoES) warned that the India's average temperature has already increased by around 0.7 degree Celsius during the 1901–2018 period due to greenhouse gas emissions and by the end of 2100 it is expected to rise by approximately 4.4 degree Celsius (relative to 1976–2005 average, in the worst-case scenario), These changes have far-reaching consequences on ecosystems, with natural vegetation being particularly vulnerable. Globally Climate is one of the most important determining factors of vegetation patterns and has significant influence on the distribution, structure and ecology of forests (Kirschbaum et al, 1996) .

The global climate change is greatly associated with land use/land cover changes (LULCC) (Bonan, 2008; Halder et al., 2016).Climate-vegetation studies by several researchers have shown that climatic regimes determine specific plant communities or functional types in any region (Walter ,1985)**.**The purpose of this research paper is to systematically explore and document the multifaceted impact of changing climate on natural vegetation.

MATERIALS AND METHODS

The Study is based on collection of data by searching research papers of the authors, working in the same area of interest and analysing it for the purpose of study. Climate change is a very vast subject, so only some of the parameters are taken into consideration for the study.

RESEARCH FINDINGS

After the study, the points of interest are listed here. All the reviewed literature indicates an alarming situation and needs immediate attention to be taken to revive and come to a "less harmful situation " .

CLIMATE CHANGE AND TEMPERATURE FLUCTUATIONS

One of the most prominent manifestations of climate change is the rise in global temperatures. Temperature fluctuations have direct and indirect effects on natural vegetation. Elevated temperatures can lead to increased evaporation, affecting soil moisture content and nutrient availability. Additionally, temperature changes can disrupt the delicate balance between plant and animal species, leading to shifts in ecological communities.

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Research indicates that certain plant species are more sensitive to temperature changes than others. Some species may thrive in warmer conditions, while others may face decline or extinction. The alteration in temperature regimes can also influence the timing of flowering, seed production, and overall plant phenology.A modelling study for India by Sharma Jagmohan et.al(2017) indicated that 30.6% and 45% of the forest areas are likely to experience shift in forest types due to the projected climate change under A1B scenario in the mid (2030s) and long (2080s) term, respectively. For the people who depend on forest resources for their livelihoods, impacts of climate change on forests have severe implications.

ALTERED PRECIPITATION PATTERNS AND DROUGHT STRESS

Climate change is associated with shifts in precipitation patterns, leading to more frequent and intense droughts in some regions.The report *Assessment of Climate Change over the Indian Region* prepared by the Union Ministry of Earth Sciences (MoES) said “Both, the frequency and spatial extent of droughts, have increased significantly during 1951–2016. In particular, areas over central India, southwest coast, southern peninsula and north-eastern India have experienced more than two droughts per decade, on an average, during this period. The area affected by drought has also increased by 1.3 percent per decade over the same period. Climate model projections indicate a high likelihood of an increase in the frequency (more than two events per decade), intensity and area under drought conditions in India by the end of the twenty-first century,”.

Changes in precipitation have direct implications for natural vegetation, particularly in arid and semi-arid ecosystems. Drought stress can lead to reduced plant growth, increased susceptibility to diseases, and even mortality in extreme cases. The effects of drought on forests depend on many factors, including the duration and severity of the drought and site-level characteristics of the forest. Forests with dense tree cover are more susceptible to moisture stress because the trees must compete for water (D’Amato et al. 2011).

The impact of altered precipitation patterns is not limited to water availability alone. It also affects nutrient cycling in soils, further influencing the health and vitality of natural vegetation. The long-term consequences of drought stress can result in changes to the composition and structure of plant communities.

CHANGES IN EXTREME WEATHER EVENTS

Climate change is contributing to an increase in the frequency and intensity of extreme weather events, such as hurricanes, cyclones, floods, and wildfires. These events can have immediate and severe impacts on natural vegetation. Floods can disrupt ecosystems by altering soil structure and nutrient availability, while wildfires can lead to the destruction of entire plant communities.

There is recent evidence of climate change-attributed variability in precipitation patterns and temperature trends in India, primarily due to anthropogenic influences (Kumar G. et al., 2020; Raghavan et al., 2020). This has led to increasing incidences of various climatic extremes and meteorological disasters in the Indian region, viz., flood (Lal et al., 2020b, 2020c; Ahmad et al., 2021), tropical cyclones (Kumar S. et al., 2020; Kumar et al., 2021 A.), heat waves (Chakraborty et al., 2019; Dubey et al., 2021), drought (Lu et al., 2019), and cloud bursting (Dimri et al., 2017). Changes in wind events and snow packs have been reported to affect forests in many ways(IPCC,2007)

The increased occurrence of extreme weather events poses challenges for the resilience of natural vegetation. Certain plant species may be better adapted to withstand specific climatic conditions, but the rapid and extreme nature of climate-related events can surpass their adaptive capacities, leading to irreversible damage.

IMPACT ON BIODIVERSITY AND ECOSYSTEM SERVICES

Natural vegetation plays a crucial role in supporting biodiversity and providing essential ecosystem services. As climate change disrupts the habitats of numerous plant and animal species, the risk of extinction rises. The report *Assessment of Climate Change over the Indian Region* prepared by the Union Ministry of Earth Sciences (MoES) said that several regions in India are global biodiversity hotspots with numerous endemic species of plants and animals and with the “climate changing more rapidly than the usual pace of evolutionary adaptability of many species, they may face increasing threats on account of these changes.” Changes in vegetation patterns can result in the displacement of native species, altered migration patterns, and disrupted ecological interactions.

The loss of biodiversity has cascading effects on ecosystem services such as pollination, water purification, and carbon sequestration. Understanding these interconnected relationships is vital for devising effective conservation strategies in the face of a changing climate.

Work of Pandey and Ghimire(2012), Parida, Pandey and Patel(2020) depicted that vegetation over Northeast India and Himalayas had a browning trend over the period 2000–2015 because of declined precipitation/moisture and solar radiation trends with increased warming trend, a phenomenon known as temperature-induced moisture stress or temperature-induced drought stress.

These findings are also consistent with negative trends suggested by other studies [Wang, 2017, Mishra, N.B.; Mainali, K.P.,2017] which were attributed to deforestation, shifting cultivation and human-induced land use conversion for urban expansion. In the Uttarakhand Himalayas, browning of vegetation was also reported by Mishra and Chaudhari [2015] associated with temperature-induced moisture stress which arose due to increased temperature with declines or no changes in precipitation. This phenomenon has an adverse impact on vegetation productivity [D'Arrigo et.al., 2004, Krishnaswamy, et.al. 2014]

Whilst the ecosystem services are generally defined as "the life-support and life-enhancing services of natural ecosystems," human activities are already significantly reducing the flow of these ecosystem services from the forests on a large scale, and if current trends continue with climate change posing as an added stressor, forests provide a wide range of ecosystem services such as protecting water quality and quantity (including stream flow, drinking water supplies, and groundwater) by slowing down runoff, preserving biodiversity, sequestering carbon, and providing wood and other non-timber forest products (NTFPs) and an aesthetic element in the landscape with significant economic and spiritual values (Heal 2000).Changes in soil organic carbon reported by Gopalkrishnan et al (2011).

Initial studies on 'biome shifts' characterised climate primarily in terms of average temperature, average rainfall, and CO_2 concentrations. Using the differential manner of carbon isotope absorption in plants with different photosynthetic pathways, a study in the Nilgiri sholas of the southern Western Ghats (Sukumar, Suresh, and Ramesh 1995) suggested that under higher CO_2 and moisture conditions, an expansion of montane forest and a shift in the composition of grassland species can be expected. Subsequent studies grappled with conflicting predictions about the direction of climatic shifts, giving rise to different conclusions about whether forest productivity would increase and forests' vegetation would shift to moister types or whether drier types of forest would expand and tree mortality might increase because of decreasing rainfall and soil moisture (Ravindranath and Sukumar 1998).

More recent research employing more complex regional climate models and process-based vegetation models suggests that, in the event of increased CO2 levels and future climate, over 70% of India's forests would transition to moist forest types (Chaturvedi et al. 2011; Ravindranath, Sukumar, and Saxena 2006). This biome will continue to decline due to the wetting tendency that most climate models indicate (Rasquinha and Sankaran 2016). Prosopis's existence does, however, also serve as a sign that human activity may both mitigate and lessen the effects of climate change depending on the location. For example, in the Western Ghats, current changes owing to fire and fragmentation (Kodandapani, Cochrane, and Sukumar 2004) and the presence of another invasive plant (Lantana) may limit the expected shift from dry deciduous to moist deciduous forest (Hiremath and Sundaram 2005).

PHENOLOGICAL CHANGES IN NATURAL VEGETATION

Climate change influences the timing of key events in the life cycle of plants, known as phenological changes. These events include flowering, leaf emergence, and seed maturation. Alterations in phenological patterns can have profound implications for plant-pollinator interactions, herbivore dynamics, and overall ecosystem functioning. Phenological changes in leaves (bud break, leaf maturation, and leaf senescence), have also been observed (Wharton et al,2004). Research suggests that rising temperatures are causing earlier flowering and shifting phenological patterns in many plant species. These changes can disrupt the synchronisation between plants and their pollinators, potentially leading to declines in reproductive success and overall plant fitness.

ADAPTATION STRATEGIES FOR NATURAL VEGETATION

From the study conducted it is observed that ,as the impacts of changing climate on natural vegetation become more evident, there is a growing need for adaptive strategies to mitigate potential losses, and promote resilience. Conservation efforts must focus on identifying and protecting climate-resilient plant species, preserving critical habitats, and establishing corridors to facilitate species migration.

Additionally, there is a need for interdisciplinary research to develop innovative approaches for managing ecosystems under changing climate conditions. This includes exploring the potential role of assisted migration, genetic modification, and sustainable land management practices to enhance the adaptability of natural vegetation.

In order to lessen vulnerability to climate change, native species regeneration is encouraged (not exotic species) in degraded natural forest lands through protection and natural regeneration. Also multi-species plantation forestry should be encouraged, in place of monoculture plantations.Use of short-rotation species in commercial or industrial forestry will help it adapt to any negative effects of climate change. Using silvicultural techniques like sanitation harvesting and enhanced thinning will help it become less likely that pests and diseases will arise. Conserving water and soil is a crucial adaptation strategy for lowering vulnerability. This will lessen the negative effects of drought on forest growth. It also lowers soil carbon loss and improves soil carbon density by speeding up the biomass growth of grasslands, plantations, and forests. Increasing the amount of organic matter in the soil by adding manure will improve soil fertility and moisture retention, lessen the soil's susceptibility to drought and moisture stress, and boost the rates at which grasses and trees sequester carbon.

Implementation of fire safety protocols to lessen the susceptibility of forests to fire dangers brought on by global warming and droughts.

Implementing measures to conserve forests and biodiversity, such as stopping deforestation, growing protected areas, and implementing sustainable harvesting methods. This is an essential adaptation tactic to lessen the ecosystems of forests' susceptibility. Above all, it is crucial that the region's forest conservation initiatives be planned to minimise the deterioration and fragmentation of the region's current forests. Plant species

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relocation to promote natural migration and anticipatory planting are more options.

CONCLUSION

This research paper has provided a comprehensive examination of the impact of changing climate on natural vegetation. The evidence presented underscores the urgent need for global action to mitigate climate change and protect the Earth's diverse ecosystems. While challenges lie ahead, proactive conservation measures, sustainable land management practices, and international cooperation can help safeguard the invaluable natural vegetation that sustains life on our planet. As we move forward, it is essential to prioritise scientific research, policy initiatives, and public awareness to address the multifaceted challenges posed by climate change and ensure a sustainable future for natural ecosystems.

It appears from a number of studies on how plants are adapting to climate change that most plants will be under more stress and produce less in the future. However, there remain many unanswered questions regarding how plant life in general will be impacted by the intricate relationships between plant physiology and behaviour, resource availability and use, changing plant communities, and other aspects in the face of climate change.

Implementing measures to conserve forests and biodiversity, such as stopping deforestation, growing protected areas, and implementing sustainable harvesting methods. This is an essential adaptation tactic to lessen the ecosystems of forests' susceptibility. Above all, it is crucial that the region's forest conservation initiatives be planned to minimise the deterioration and fragmentation of the region's current forests. Plant species relocation to promote natural migration and anticipatory planting are more options.

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