

Climate Change Impacts on Biodiversity and Natural Resource Use

Kajal Bharti

Abstract

Climate change is exerting severe pressure on biodiversity and the sustainable use of natural resources worldwide. According to the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES, 2019), nearly 1 million species are at risk of extinction, many within decades, due to climate-related disruptions. Rising global temperatures—approximately 1.1°C above pre-industrial levels (IPCC, 2021)—have led to altered ecosystems, shifts in species distributions, and changes in phenological events like flowering, breeding, and migration. Biodiversity hotspots, such as the Western Ghats, the Amazon rainforest, and coral reef systems, are already witnessing widespread habitat degradation. For instance, India lost over 90,000 sq. km of forest cover between 2001 and 2020 (Global Forest Watch), much of it linked to climate and anthropogenic factors. Coral reefs have experienced mass bleaching events, with the Great Barrier Reef losing over 50% of its coral cover since 1995, primarily due to heat stress. These ecological losses directly affect natural resources—such as freshwater, soil fertility, fisheries, and forest products—upon which more than 3 billion people rely globally. The paper further highlights how rural and indigenous communities in countries like India and Sub-Saharan Africa, where over 60% of livelihoods depend on climate-sensitive sectors like agriculture, forestry, and fishing, are disproportionately affected. It reviews scientific studies, remote sensing data, and community-based reports to understand spatial and temporal changes in biodiversity and resource availability. To address these challenges, the study advocates for nature-based solutions (NbS), climate-resilient conservation strategies, and integration of biodiversity policies with climate action plans. Strengthening local governance, traditional ecological knowledge, and adaptive land-use planning are emphasized as essential steps. Ultimately, without immediate mitigation of greenhouse gas emissions and systemic resource governance, both biodiversity and the vital ecosystem services it supports will face irreversible damage—posing significant risks to food security, water availability, and human well-being.

Key words: Climate Change, Biodiversity Loss, Natural Resources, Ecosystem Services, Nature-based Solutions

Introduction

Climate change has emerged as one of the most formidable challenges of the 21st century, fundamentally altering the relationship between human societies and the natural environment. The phenomenon is no longer a distant threat but a lived reality, manifesting through rising global temperatures, erratic precipitation patterns, increasing frequency of extreme weather events, and shifts in ecological systems. According to the Intergovernmental Panel on Climate Change (IPCC, 2021), the Earth's surface temperature has already risen by approximately 1.1°C above pre-industrial levels, and without immediate mitigation, this could surpass 1.5°C by 2030. Such rapid warming has cascading effects on the biosphere, accelerating species extinctions, degrading ecosystems, and disrupting the delicate balance of natural resource cycles.

Biodiversity—the variety of life on Earth encompassing genes, species, and ecosystems—is an essential foundation for ecological stability and human well-being. Ecosystems provide a wide array of services, including food, freshwater, pollination, soil fertility, carbon sequestration, and climate regulation. Yet, these life-support systems are under unprecedented threat. The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES, 2019) estimates that nearly one million species face extinction within decades, largely due to anthropogenic pressures intensified by climate change. For instance, global coral reefs, often described as the “rainforests of the sea,” have already lost significant cover due to repeated bleaching events, while tropical forests face degradation from both rising temperatures and land-use changes.

India, as a megadiverse country hosting four global biodiversity hotspots—the Himalaya, Indo-Burma, Sundalands (Nicobar Islands), and Western Ghats—represents both the richness and vulnerability of biodiversity in the Global South. Recent assessments indicate that India lost nearly 90,000 sq. km of forest cover between 2001 and 2020 (Global Forest Watch), threatening species habitats and reducing carbon sinks. This biodiversity decline has direct implications for the livelihoods of millions, particularly rural and indigenous communities who rely heavily on agriculture, forestry, and fisheries. With more than 60% of

India's population depending on climate-sensitive sectors, the nexus between biodiversity conservation and sustainable natural resource use is central to development planning (World Bank, 2018).

The introduction of this study situates climate change not merely as an environmental issue but as a multidimensional crisis encompassing ecological, social, and economic dimensions. It highlights how biodiversity loss undermines the availability of vital natural resources such as food, water, timber, and medicinal plants, thereby threatening human security. The urgency lies in recognizing that climate change accelerates existing pressures—deforestation, overfishing, soil degradation, and urban expansion—resulting in compounded risks. At the same time, opportunities exist in adopting adaptive strategies such as nature-based solutions (NbS), climate-resilient conservation approaches, and integration of traditional ecological knowledge into policy frameworks.

This paper therefore seeks to critically examine the impacts of climate change on biodiversity and natural resource use, with an emphasis on spatial and temporal variations across ecosystems. It aims to review scientific evidence, draw from regional case studies, and highlight community-based observations to establish a comprehensive understanding of the problem. By addressing the ecological and socio-economic implications, the study underscores the need for coordinated action at global, national, and local levels to safeguard biodiversity and ensure sustainable resource governance.

Objectives

1. To analyse the impacts of climate change on biodiversity and ecosystem stability.
2. To assess how biodiversity loss affects natural resource use and human livelihoods.
3. To explore adaptive strategies for sustainable biodiversity and resource management.

Data Source and Methodology

The present study is based on a combination of secondary data sources and analytical review. Global assessments such as the *IPCC Assessment Reports (2021)* and the *IPBES Global Biodiversity Report (2019)* were used to understand climate change trends and biodiversity risks. National-level datasets were obtained from Global Forest Watch, the Forest Survey of India (FSI, 2019), and the India State of Forest Report, which provide reliable estimates of forest cover change and ecosystem health. Data on agriculture, fisheries, and livelihoods were

drawn from reports of the Food and Agriculture Organization (FAO, 2021) and the World Bank (2018). Scientific journals, case studies, and community-based reports were reviewed to supplement statistical data with field-based evidence.

The methodology involves a descriptive and analytical approach, combining spatial and temporal assessments of biodiversity loss with its implications for natural resource use. Graphs and maps were prepared to visualize long-term trends in species decline, forest cover loss, and biodiversity hotspots under climate stress. A comparative framework was applied to link global patterns with regional and India-specific case studies. By integrating remote sensing-based datasets, published literature, and institutional reports, the study provides a holistic understanding of how climate change is reshaping ecosystems and influencing human dependence on natural resources.

Climate Change and Biodiversity Loss

Climate change has emerged as a primary driver of biodiversity decline, working in conjunction with direct human pressures such as deforestation, pollution, overexploitation, and land-use change. Rising global temperatures, erratic precipitation, and an increasing frequency of extreme events—such as floods, cyclones, and droughts—are accelerating habitat degradation and species loss. According to IPBES (2019), climate change is already the third most significant driver of biodiversity decline globally, and its influence is intensifying with every decade of continued warming.

- **Habitat Degradation and Fragmentation**

One of the most profound effects of climate change on biodiversity is the alteration and fragmentation of natural habitats. Shifts in rainfall patterns and rising sea levels are degrading wetlands, mangroves, and estuaries, which are critical breeding and feeding grounds for countless species. Coastal ecosystems like the Sundarbans mangrove forest in India and Bangladesh are losing ground to sea-level rise and cyclonic activity, threatening iconic species such as the Royal Bengal Tiger and estuarine dolphins. Similarly, alpine meadows in the Himalayas are shrinking due to glacial retreat and warming temperatures, pushing endemic plant species toward extinction.

- **Coral Reef Bleaching and Marine Ecosystem Collapse**

Marine biodiversity is particularly vulnerable to climate change. The global rise in sea surface temperatures has triggered mass coral bleaching events. The Great Barrier Reef in Australia has lost over 50% of its coral cover since 1995 (Hughes et al., 2017). In the Indian Ocean, repeated bleaching events in the Lakshadweep and Andaman-Nicobar Islands have reduced coral resilience, undermining fish populations and the livelihoods of coastal fishing communities. Ocean acidification, caused by increased CO₂ absorption, further threatens mollusks, shellfish, and reef-building organisms, destabilizing marine food chains.

- **Shifts in Species Distribution and Phenological Changes**

As global temperatures rise, species are forced to adapt by shifting their geographical ranges. Research indicates that many terrestrial species are moving poleward by approximately 17 km per decade, and marine species by 72 km per decade (Parmesan & Yohe, 2003). In India, montane species such as the Himalayan Monal (Lophophorus impejanus) are being observed at higher altitudes than previously recorded. Similarly, migratory birds like the Bar-headed Goose are altering their wintering patterns in response to climate variability.

Phenological events—such as flowering, fruiting, breeding, and migration—are also shifting. For instance, several tree species in central India now flower weeks earlier than their historical cycles, disrupting plant-pollinator relationships and food web stability. Such mismatches can lead to cascading ecosystem imbalances, ultimately threatening agricultural productivity and ecosystem services.

- **Decline of Forest and Freshwater Ecosystems**

Forests act as both reservoirs of biodiversity and carbon sinks. However, between 2001 and 2020, India lost nearly 90,000 sq. km of forest cover (Global Forest Watch). Much of this is attributed to deforestation, mining, infrastructure expansion, and climate-induced forest fires. The Western Ghats, a UNESCO World Heritage Site and one of the world's top biodiversity hotspots, is increasingly vulnerable to erratic monsoons and rising temperatures, which reduce regeneration capacity and affect endemic species.

Freshwater ecosystems—rivers, lakes, and wetlands—are also under pressure. The Ganga and Brahmaputra river basins, home to endangered species like the Ganga river dolphin, are impacted by erratic flows due to glacial melt and altered monsoon regimes. Declining wetlands

such as Chilika Lake (Odisha) threaten migratory bird species and reduce fish productivity, directly impacting local livelihoods.

- **Increased Risk of Extinction**

The cumulative impacts of climate-induced habitat loss, species range shifts, and phenological disruptions are pushing many species toward extinction. Globally, nearly 25% of assessed species are threatened with extinction (IPBES, 2019). India's red-listed species include the Great Indian Bustard, Snow Leopard, and several freshwater fishes, all of which face climate-driven threats in addition to anthropogenic pressures. Extinction risk not only represents the loss of individual species but also the erosion of ecosystem resilience and the services that sustain human well-being.

Table 1: Climate Change and Biodiversity Indicators

Indicator	Value	Implications
Global species at risk (IPBES, 2019)	≈ 1 million species	Accelerated extinction risk
Global temperature rise (since pre-industrial, IPCC 2021)	≈ 1.1 °C	Habitat shifts, extreme events
Forest loss in India (2001-2020, Global Forest Watch)	≈ 90,000 sq. km	Loss of biodiversity, reduced carbon sinks
Coral reef decline (Great Barrier Reef, 1995-2020)	Over 50% loss	Marine ecosystem collapse
Global crop yield decline (FAO, 2021)	4-10% decline	Threats to food security
Livelihoods dependent on climate-sensitive sectors (World Bank, 2018)	60%+	High vulnerability of rural & indigenous populations

Impacts on Natural Resource Use

Biodiversity loss under climate change does not occur in isolation—it directly affects the natural resources that underpin human survival and economic development. Ecosystem services such as food, water, timber, fisheries, and soil fertility are intimately tied to

biodiversity. As climate change accelerates habitat degradation and species decline, the availability and sustainability of these resources are increasingly threatened. This section examines the impacts across key resource categories.

- **Water Resources and Hydrological Systems**

Freshwater availability is one of the most pressing natural resource challenges under climate change. Rising global temperatures accelerate glacial retreat, affecting water supply in Asia's "Third Pole" (the Himalayas and Tibetan Plateau), which provides freshwater to over 1.5 billion people (Immerzeel et al., 2010). The Ganges-Brahmaputra-Meghna basin, heavily reliant on glacial melt and monsoon rainfall, is experiencing reduced base flows and increased seasonal variability, affecting irrigation and drinking water supply.

In India, the Sundarbans delta faces salinity intrusion due to rising sea levels, reducing freshwater fish species and agricultural productivity. Simultaneously, declining wetland areas such as Keoladeo National Park (Rajasthan) and Chilika Lake (Odisha) threaten migratory birds and local fisheries, indicating how biodiversity loss translates into water scarcity and ecosystem degradation.

- **Agriculture, Food Security, and Soil Fertility**

Agricultural systems, highly dependent on climate-sensitive factors like rainfall, temperature, and pollinators, are deeply impacted by biodiversity loss. Globally, crop yields of staples such as wheat, rice, and maize have declined by 4–10% over the past three decades due to climate change (FAO, 2021). In India, the Indo-Gangetic Plains—considered the "breadbasket" of the nation—are highly vulnerable to heat waves and irregular monsoons, which reduce wheat and rice productivity.

Biodiversity plays a critical role in agriculture through pollination, pest control, and soil fertility. However, the decline in pollinator populations—such as bees and butterflies—has already reduced crop output in many regions. Soil erosion, nutrient depletion, and loss of beneficial microorganisms due to warming and erratic rainfall further undermine long-term agricultural sustainability. For example, in Bihar and Uttar Pradesh, soil fertility decline has become a serious barrier to achieving stable yields.

- **Forest Resources and Non-Timber Forest Products (NTFPs)**

Forests are a vital source of timber, fodder, medicinal plants, and fuelwood, especially for rural and tribal communities. Climate change is altering forest composition, productivity, and regeneration capacity. In India, the Western Ghats and Northeast states—home to rich biodiversity and tribal livelihoods—are witnessing shifts in vegetation zones and declining availability of NTFPs such as honey, lac, and medicinal herbs. Forest fires, increasingly linked to prolonged dry spells, are reducing biodiversity resilience while also emitting massive amounts of carbon, worsening the climate crisis.

Loss of forest biodiversity also undermines carbon sequestration capacity, making it harder to achieve climate mitigation goals. Indigenous communities in states like Jharkhand and Chhattisgarh, where more than 50% of households depend on forest-based products, are experiencing reduced income and resource insecurity due to biodiversity decline.

- **Fisheries, Coastal Resources, and Marine Livelihoods**

Climate change is reshaping marine ecosystems by raising sea temperatures, altering currents, and increasing ocean acidification. Fish populations are migrating toward cooler waters—marine species shift poleward by an average of 72 km per decade (Parmesan & Yohe, 2003). In the Indian Ocean, commercially important species such as sardines and mackerels are shifting distributions, affecting small-scale fishing communities in Kerala, Tamil Nadu, and Odisha.

Globally, around 3 billion people depend on fisheries for protein intake (FAO, 2020). Coral reef degradation in the Andaman, Nicobar, and Lakshadweep Islands has led to declining fish productivity, affecting both biodiversity and human nutrition. Coastal ecosystems such as mangroves, seagrass beds, and estuaries, which serve as fish nurseries, are also under threat from sea-level rise and cyclones, leading to long-term impacts on marine resource sustainability.

- **Energy and Other Ecosystem Services**

Biodiversity loss also affects energy and supporting services. Hydropower potential is reduced by changing glacial melt patterns and altered river regimes. Deforestation reduces fuelwood availability in rural India, where nearly 40% of households still rely on biomass as their primary cooking fuel. At the same time, ecosystem services like carbon storage, nutrient

cycling, and flood regulation—critical for long-term resource security—are eroding under biodiversity decline.

Climate change-induced biodiversity loss is disrupting natural resource availability across water, agriculture, forests, and fisheries. These disruptions directly threaten food security, rural livelihoods, and human well-being. For countries like India, with a large share of the population dependent on natural resources, the stakes are especially high.

Table 2: India-specific Climate-Biodiversity Impacts

Region/Ecosystem	Climate Change Impact	Implications for Resources
Himalayas	Glacial retreat, shrinking alpine meadows, species migration	Reduced freshwater flows, loss of endemic plants
Western Ghats	Erratic monsoons, vegetation shifts, forest fires	Declining forest productivity, NTFP loss
Sundarbans (Mangroves)	Sea-level rise, salinity intrusion, cyclone damage	Loss of fish stocks, reduced farming productivity
Indo-Gangetic Plains	Heat stress, irregular rainfall, declining wheat & rice yields	Threats to food security in breadbasket regions
Chilika Lake (Wetland)	Declining fish productivity, migratory bird loss	Livelihood insecurity for fishing communities
Andaman & Nicobar Islands (Coral Reefs)	Mass bleaching events, loss of marine biodiversity	Collapse of marine-based livelihoods

Vulnerability of Rural and Indigenous Communities

The impacts of climate change on biodiversity and natural resource use are not experienced equally across societies. Rural and indigenous communities—particularly in developing countries—are disproportionately vulnerable due to their heavy reliance on climate-sensitive sectors like agriculture, forestry, and fisheries, coupled with limited adaptive capacities. The degradation of biodiversity and ecosystem services intensifies poverty, food insecurity, and livelihood vulnerability, creating cycles of socio-economic marginalization.

- **Dependence on Natural Resources**

Globally, more than 60% of livelihoods in rural areas depend on biodiversity-based resources (World Bank, 2018). For indigenous peoples, forests, rivers, and farmlands are not only sources of subsistence but also integral to cultural identity and traditional knowledge systems. In Sub-Saharan Africa and South Asia, smallholder farmers and fishing communities face severe climate-related shocks, as declining biodiversity reduces the availability of crops, wild foods, timber, and fish.

In India, nearly 275 million people directly depend on forests for subsistence, many of whom belong to tribal communities (FSI, 2019). With declining availability of non-timber forest products (NTFPs) such as mahua, tendu leaves, lac, and medicinal plants, household incomes are shrinking. Similarly, farmers in rainfed regions of Bihar, Jharkhand, and Odisha, where agriculture depends on biodiversity-driven ecosystem services like soil fertility and pollination, are experiencing reduced yields under climate variability.

- **Exposure to Climate Risks**

Geographic exposure further compounds vulnerability. Indigenous communities in coastal and delta regions face sea-level rise, salinity intrusion, and cyclonic storms. The Sundarbans provide a striking case, where mangrove loss due to climate change undermines natural protection against cyclones like Amphan (2020), leaving fishing and farming households highly exposed to disaster risks.

In the Himalayan region, glacial retreat and erratic snowfall threaten pastoral livelihoods and traditional cropping systems. Communities dependent on yak herding, medicinal plant collection, and mountain agriculture face growing uncertainty. Similarly, shifting monsoon patterns in Northeast India disrupt jhum (shifting cultivation) cycles, reducing food security and increasing dependency on external markets.

- **Limited Adaptive Capacity**

While industrialized regions have access to financial, technological, and institutional buffers, rural and indigenous populations often lack such resilience. Poverty, poor infrastructure, weak institutional support, and limited access to markets constrain their adaptive capacity. For example, small-scale farmers in Bihar's flood-prone districts struggle to adopt climate-resilient seeds or irrigation systems due to lack of credit and extension services.

Similarly, fishing households in Kerala and Tamil Nadu cannot easily shift to alternative livelihoods when fish stocks decline.

Social marginalization also limits women and marginalized caste groups within rural communities from accessing adaptation resources. This intersectional vulnerability heightens the socio-economic consequences of biodiversity decline, making adaptation both a gendered and class-sensitive issue.

- **Erosion of Traditional Ecological Knowledge (TEK)**

Indigenous knowledge systems—developed over centuries—play a critical role in sustainable resource use. Practices such as sacred groves in Jharkhand, rainwater harvesting in Rajasthan, and mixed cropping in Northeast India have historically maintained biodiversity resilience. However, climate change-induced ecological shifts are eroding the efficacy of these practices. Younger generations, increasingly disconnected from traditional knowledge, are unable to fully harness such adaptive strategies, further weakening community resilience.

- **Case Studies of Disproportionate Impacts**

- **Sundarbans (West Bengal):** Cyclone-induced loss of mangroves and declining fish populations have reduced income for over 4.5 million people, forcing climate-induced migration.
- **Western Ghats (Kerala and Karnataka):** Erratic rainfall has diminished spice production (pepper, cardamom), impacting small farmers dependent on biodiversity-rich agroecosystems.
- **Tribal Belts of Central India:** Dependence on forest produce has declined as rising temperatures and deforestation reduce yields of lac, honey, and mahua flowers.
- **Himalayas (Uttarakhand, Himachal Pradesh, Sikkim):** Apple-growing zones are shifting upwards, reducing productivity for mid-altitude farmers while creating livelihood uncertainty.

Rural and indigenous communities are at the frontline of climate change impacts on biodiversity and natural resource use. Their high dependence on ecosystems, coupled with limited adaptive capacity and socio-economic marginalization, make them especially vulnerable. Addressing these vulnerabilities requires integrating traditional knowledge with

modern adaptation strategies, strengthening local governance, and ensuring equitable access to climate resilience resources.

Adaptation and Mitigation Strategies

The growing threats of climate change to biodiversity and natural resource use require urgent interventions that combine adaptation (coping with current and future impacts) and mitigation (reducing greenhouse gas emissions and enhancing sinks). Effective strategies must integrate ecological restoration, technological innovation, local governance, and traditional knowledge. This section outlines major pathways for building resilience and sustaining biodiversity under climate change.

- **Nature-based Solutions (NbS)**

Nature-based solutions (NbS) involve using ecosystems themselves to address societal challenges, including climate change, biodiversity loss, and disaster risks. These approaches not only reduce vulnerability but also generate co-benefits for biodiversity and communities.

- **Mangrove Restoration:** Mangroves act as natural barriers against cyclones, storm surges, and coastal erosion. For instance, restoration projects in Odisha's Kendrapara district reduced the impact of Cyclone Fani (2019) on coastal villages, while also enhancing fish nursery grounds.
- **Wetland Conservation:** Wetlands like Chilika Lake (Odisha) provide flood buffering, fisheries, and biodiversity conservation. Protecting them ensures both ecological resilience and livelihood security.
- **Afforestation and Agroforestry:** Agroforestry systems, such as integrating fruit trees and nitrogen-fixing species in farms, improve soil fertility, carbon sequestration, and farmer incomes. In Jharkhand and Chhattisgarh, agroforestry is being promoted as a climate-resilient livelihood strategy.

- **Climate-Resilient Conservation Strategies**

Conservation approaches must be restructured to account for dynamic climate risks. Traditional static conservation boundaries may not be sufficient, as species distributions shift due to temperature and rainfall changes.

- **Biodiversity Corridors:** Establishing ecological corridors allows species to migrate and adapt to shifting habitats. In India, the Elephant Corridors Project demonstrates

how connectivity enhances resilience for large mammals under habitat fragmentation and climate change.

- **Adaptive Protected Area Management:** Protected areas such as Kaziranga National Park (facing frequent floods) and Jim Corbett Tiger Reserve (increasing forest fires) require adaptive management strategies, including water regulation, fire monitoring, and buffer zone management.
- **Community-based Conservation:** Involving local communities in conservation (e.g., Joint Forest Management in India) enhances both biodiversity outcomes and livelihood benefits, ensuring long-term sustainability.

- **Strengthening Local Governance and Institutional Capacity**

Decentralized governance plays a key role in resource management under climate stress. Panchayati Raj Institutions (PRIs), tribal councils, and local cooperatives can effectively monitor biodiversity use and implement conservation programs when empowered with knowledge and resources.

- **Participatory Resource Mapping:** Using GIS and remote sensing tools alongside community knowledge enables accurate monitoring of land-use changes and biodiversity decline.
- **Policy Integration:** Linking National Biodiversity Action Plans (NBAP) with National Action Plan on Climate Change (NAPCC) ensures that biodiversity protection is mainstreamed into climate policies.
- **Financing Mechanisms:** Access to international climate funds (e.g., Green Climate Fund) can support biodiversity-linked adaptation projects in vulnerable regions.

- **Role of Traditional Ecological Knowledge (TEK)**

Indigenous and local communities have centuries-old knowledge of sustainable biodiversity use, which can be harnessed to build resilience.

- **Sacred Groves:** Found widely in Northeast India and Western Ghats, sacred groves preserve rare plant and animal species, functioning as community-protected biodiversity hotspots.
- **Water Harvesting:** Traditional water systems like Ahar-Pyne in Bihar and Johads in Rajasthan enhance water security while supporting agro-biodiversity.

➤ **Crop Diversity:** Indigenous practices of mixed cropping and seed preservation maintain genetic diversity and reduce vulnerability to climate-induced crop failures.

- **Technological and Policy Innovations**

Beyond traditional approaches, technology and policy innovations are critical in addressing biodiversity loss under climate stress.

➤ **Early Warning Systems:** Satellite-based monitoring of floods, droughts, and forest fires helps protect ecosystems and communities.

➤ **Climate-smart Agriculture:** Adoption of drought-resistant seeds, drip irrigation, and integrated pest management improves food security while reducing biodiversity pressures.

➤ **Legal and Policy Support:** Strengthening frameworks such as the Biological Diversity Act (2002) in India, alongside stricter enforcement of environmental laws, ensures that biodiversity conservation is not sidelined in development projects.

- **Synergizing Adaptation and Mitigation**

While adaptation focuses on reducing vulnerabilities, mitigation addresses root causes of climate change. Integrated approaches—such as REDD+ (Reducing Emissions from Deforestation and Forest Degradation)—offer dual benefits by curbing emissions and enhancing biodiversity. Similarly, ecosystem-based adaptation (EbA) ensures resilience by protecting ecosystem functions while contributing to carbon sequestration.

Adaptation and mitigation strategies must operate at multiple scales—from local indigenous practices to global policy frameworks. Nature-based solutions, climate-resilient conservation, participatory governance, and integration of traditional knowledge provide pathways for safeguarding biodiversity. Without such strategies, climate change will continue to erode ecosystem services, deepening resource insecurity and social inequality.

Conclusion and Findings

Climate change is no longer a distant ecological challenge but an immediate crisis with profound implications for biodiversity and natural resource use. This study highlights that biodiversity—across forests, wetlands, agricultural ecosystems, and marine habitats—is under severe stress due to rising temperatures, altered rainfall, glacial retreat, and extreme weather

events. The ecological losses are directly linked to declining natural resources, threatening the survival and well-being of millions, particularly in developing nations like India.

Key Findings

1. **Accelerated Biodiversity Loss:** Nearly one million species are at risk of extinction globally (IPBES, 2019). In India, biodiversity-rich ecosystems such as the Western Ghats, Himalayas, Indo-Burma, and Nicobar **Islands** are experiencing unprecedented habitat degradation.
2. **Forest and Habitat Decline:** India lost approximately 90,000 sq. km of forest cover between 2001 and 2020 (Global Forest Watch). This decline not only reduces species habitats but also diminishes carbon sequestration, making climate mitigation harder.
3. **Marine and Freshwater Stress:** Coral reefs in the Indian Ocean and the Great Barrier Reef have undergone mass bleaching, with the latter losing over 50% of coral cover since 1995. Freshwater systems such as the Ganga-Brahmaputra basin face glacial retreat and altered flows, affecting both biodiversity and water availability.
4. **Impacts on Agriculture and Food Security:** Climate variability has reduced global crop yields of staples like wheat and rice by 4–10% in the past three decades (FAO, 2021). In India, erratic monsoons and heat stress particularly threaten the Indo-Gangetic Plains, while soil fertility decline is worsening agricultural productivity.
5. **Livelihood Vulnerability:** Over 60% of livelihoods in India and Sub-Saharan Africa depend on climate-sensitive sectors. Rural and indigenous communities are disproportionately impacted due to high dependence on forests, agriculture, and fisheries, compounded by poverty and weak adaptive capacity.
6. **Erosion of Traditional Ecological Knowledge (TEK):** Climate change is disrupting indigenous practices such as sacred grove protection, shifting cultivation, and water harvesting. The loss of TEK reduces adaptive capacity and threatens cultural heritage.
7. **Emerging Adaptation Strategies:** Promising approaches such as Nature-based Solutions (NbS), climate-resilient conservation, community-based governance, and ecosystem-based adaptation (EbA) are gaining ground. However, implementation gaps and lack of integration with policy frameworks remain major challenges.

- **Policy-Oriented Conclusions**

- **Integrate Climate and Biodiversity Policies:** Climate change action plans and biodiversity conservation strategies must be aligned to prevent siloed interventions.
- **Strengthen Local Governance:** Empowering Panchayati Raj institutions, tribal councils, and local cooperatives ensures bottom-up decision-making in biodiversity management.
- **Scale up Nature-based Solutions:** Mangrove restoration, agroforestry, and wetland protection should be prioritized as low-cost, high-impact adaptation measures.
- **Invest in Research and Monitoring:** Remote sensing, GIS-based biodiversity tracking, and community-led monitoring are essential for adaptive management.
- **Mainstream Traditional Knowledge:** Indigenous ecological practices should be formally recognized and integrated into climate adaptation policies.
- **Equity and Justice in Adaptation:** Special attention must be given to marginalized groups—women, small farmers, tribal populations—who face disproportionate risks.

The findings of this study reinforce the urgent need for a transformative approach to biodiversity and natural resource governance under climate change. Biodiversity loss is not merely an ecological issue—it is a direct threat to human survival, food security, and socio-economic development. Unless greenhouse gas emissions are drastically reduced and adaptive strategies are scaled up, both biodiversity and the ecosystem services it supports may reach irreversible tipping points.

For countries like India, the path forward lies in integrating science, policy, and community action. Strengthening resilience through nature-based solutions, empowering vulnerable communities, and bridging traditional knowledge with modern conservation practices will be essential. Ultimately, the health of biodiversity and ecosystems determines the sustainability of natural resources and the well-being of future generations.

References

- Allison, E. H., Perry, A. L., Badjeck, M. C., Adger, W. N., Brown, K., Conway, D., ... Dulvy, N. K. (2009). Vulnerability of national economies to the impacts of climate change on fisheries. *Fish and Fisheries*, 10(2), 173–196. <https://doi.org/10.1111/j.1467-2979.2008.00310.x>
- FAO. (2020). *The State of World Fisheries and Aquaculture 2020: Sustainability in Action*. Rome: Food and Agriculture Organization of the United Nations.
- FAO. (2021). *The State of Food Security and Nutrition in the World 2021*. Rome: Food and Agriculture Organization of the United Nations.
- Forest Survey of India (FSI). (2019). *India State of Forest Report 2019*. New Delhi: Ministry of Environment, Forest and Climate Change, Government of India.
- Global Forest Watch. (2021). *Tree Cover Loss Data 2001–2020*. Washington, D.C.: World Resources Institute. Available at: <https://www.globalforestwatch.org>
- Hughes, T. P., Kerry, J. T., & Simpson, T. (2017). Coral reefs in the Anthropocene. *Nature*, 546, 82–90. <https://doi.org/10.1038/nature22901>
- Immerzeel, W. W., van Beek, L. P. H., & Bierkens, M. F. P. (2010). Climate change will affect the Asian water towers. *Science*, 328(5984), 1382–1385. <https://doi.org/10.1126/science.1183188>
- IPBES. (2019). *Global Assessment Report on Biodiversity and Ecosystem Services*. Bonn: Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services.
- IPCC. (2021). *Climate Change 2021: The Physical Science Basis*. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge: Cambridge University Press.
- Parmesan, C., & Yohe, G. (2003). A globally coherent fingerprint of climate change impacts across natural systems. *Nature*, 421, 37–42. <https://doi.org/10.1038/nature01286>
- World Bank. (2018). *Adaptation and Resilience in Climate Change: Building Stronger Communities and Economies*. Washington, D.C.: The World Bank Group.