Biodiversity in a Changing Climate: Assessing Impacts, Challenges, and Pathways to Ecosystem Resilience

Lead Paper Presentation

Godfrey Okoye University (GOUNI) Interdisciplinary Conference on Climate Change

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Introduction

 Climate change is reshaping the natural world, making survival harder for everyone on the planet, from organisms to the biome levels.

 Continued climate change is having predominantly adverse and often irreversible impacts on many ecosystems and their services, with significant negative social, cultural, and economic consequences.





 As our environment changes, the delicate balance of ecosystems shifts, potentially disrupting biodiversity and threatening ecological stability.

Biodiversity encompasses the genetic, species, and ecosystem diversity that sustains ecological balance and human well-being.

Biodiversity underpins critical ecosystem services, including pollination, water purification, and carbon sequestration.





- All three levels of biodiversity work together to keep nature balanced and healthy, which in turn supports human life by providing food, medicine, clean air, and water.
- If biodiversity is lost, ecosystems weaken, making it harder for nature and humans to thrive.

- For instance, declining pollinator populations threaten global food security
- altered water cycles and increased evaporation contribute to water shortages.
- invasive species gain opportunities to establish themselves in new areas, often outcompeting native species.



 Warmer temperatures and altered rainfall patterns enable pests and pathogens previously confined to tropical regions to expand into temperate zones.





This presentation explores the intricate relationship between climate change and biodiversity, assessing the extent of ecological disruptions, the major challenges in conservation, and potential pathways to building ecosystem resilience.



Credit: International Institute for Applied Systems Analysis

- Understanding these impacts is crucial for developing strategies to enhance ecosystem resilience and ensure sustainable coexistence with nature.
- The rapid decline of animal and plant species in recent decades has led some experts to declare that another mass extinction is underway.

- The Report finds that around 1 million animal and plant species are now threatened with extinction, many within decades, more than ever in human history.
- The average abundance of native species in most major land-based habitats has fallen by at least 20%, mostly since 1900.



Population and species-range responses to environmental changes since the last glacial maximum, documented for selected North American conifer trees and Eurasian cervids Credit: Grantham Institute Briefing paper No 13



Habitat Loss and Fragmentation

- Rising temperatures and shifting precipitation patterns alter vegetation zones, leading to habitat reduction.
- Deforestation reduces precipitation, leading to more droughts, wildfires, and shifts in weather patterns



Habitat Loss and Fragmentation



When large ecosystems become fragmented, species with large ranges may not have enough area to survive.

 Arctic ice melting threatens polar species, while coral reef bleaching affects marine biodiversity.

Meltwater flow into seas causing freshening, stratification, and near-shore sedimentation with a negative influence on biodiversity by clogging and burying the plankton eaters living on the seabed.

Such processes will make polar regions more susceptible to invasive (non-indigenous) species.



Coral reef bleaching

 Scientists attribute the latest widespread bleaching event stretching from Panama to Australia to rapidly rising ocean temperatures, largely fueled by climate change.



• The crisis continues to intensify, threatening marine ecosystems worldwide

- Corals are among the most vulnerable ecosystems on the planet to climate change.
- Supports 25 per cent of marine life, and could virtually disappear by the end of this century.
- "The loss of corals would be a true tragedy from a biodiversity and economic perspective," says Leticia Carvalho, the Head of the Marine and Freshwater Branch of the United Nations Environment Programme (UNEP).

2. **Species Distribution and Migration**

- Many species are shifting their ranges to cooler regions or higher altitudes.
- Migration plays a crucial role in species distribution, population dynamics, and ecosystem functioning
- Conversely, species in the recipient community encounter unfamiliar neighbors, which can disrupt ecological balance, leading to increased competition, displacement, or even local extinctions.

GEOGRAPHICAL DISTRIBUTION OF ANIMALS



Mismatches in predator-prey relationships and pollination networks disrupt ecosystem functions.

- Any modification in seasonal activity in one species can have consequences on interacting species, within and among trophic levels.
- Changes in abiotic conditions are affecting the life histories of all living organisms across all trophic levels, ultimately altering biotic interactions, community stability and ecosystem functioning.

3. Increased Extinction Risks

 Species unable to adapt or migrate face heightened extinction risks.

 Amphibians, insects, and small mammals are particularly vulnerable.

A Quarter Of All Species Are Threatened With Extinction

Share of plant/animal species at risk of extinction worldwide



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Based on the assessment of 138,374 species Source: IUCN Global Species Programme Red List Unit

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3. Changes in Phenology and Ecosystem Services

- In the context of climate change and biodiversity, phenological shifts can disrupt ecological interactions and alter species' survival strategies.
- Altered migration and breeding patterns impact food chains and ecosystem interactions.
- The decline of pollinators like bees and butterflies, essential for biodiversity and crop production, jeopardizes global food security by reducing agricultural yields and threatening ecosystem stability.



5. Ocean Acidification and Marine Biodiversity Loss

- Increased CO₂ absorption reduces calcium carbonate availability, affecting shellfish and coral reefs.
- Declining fish populations impact marine food webs and fisheries.



 Decline in Migratory Fish Populations: Between 1970 and 2020, migratory freshwater fish populations experienced an average decline of 81%, with Latin America and the Caribbean witnessing a catastrophic 91% decrease.

• As of December 2023, 25% of freshwater fish species are at risk of extinction, with climate change affecting 17% of these threatened species.

Conservation of biodiversity is essential as insurance to maintain resilient ecosystems and ensure a sustainable flow of ecosystem goods and services to society.

Challenges in Biodiversity Conservation Amid Climate Change

1. Lack of Predictive Models

- Uncertainty in climate projections complicates conservation planning.
- The Institute and Faculty of Actuaries (IFoA) IFoA has called for climate risk assessments to consider "risk of ruin"

2. Limited Protected Areas and Connectivity

• Many reserves are geographically static and do not account for species migration needs.

• Bengtsson et al. (2003) noted that existing reserves and national parks are unlikely to incorporate ecosystems' long-term and large-scale dynamics.

• Present static reserves should be complemented with dynamic reserves, such as ecological fallows and dynamic successional.

 These include allowing some land to rest and recover naturally (ecological fallows) and managing areas where plants and animals can go through natural cycles of growth and change (dynamic successional reserves).

• This approach helps maintain a healthy environment by imitating how nature naturally changes over time, such as through forest regrowth after a fire or flood.

3. Human Activities and Land Use Change

• Urbanization, deforestation, and industrial expansion exacerbate habitat destruction.

 Large-scale human activities, particularly land-use changes, have significantly altered vital ecosystems, threatening biodiversity, disrupting carbon and water cycles, and contributing to climate change.





4. Policy and Governance Gaps

- Weak enforcement of environmental regulations hinders conservation efforts.
- Example, Frequent oil spills and gas flaring devastate marine and terrestrial ecosystems, in the Niger Delta region due to lack of power or willingness by Regulatory bodies to impose penalties, as well as weak government oversight.
- Despite conservation laws, illegal poaching continues, driven by demand for ivory, rhino horns, and exotic pets.
- Illegal logging and land conversion for agriculture, such as cattle ranching and soybean farming, continue without regulation in the Amazon.

5. Limited Public Awareness and Funding

- Conservation efforts often face financial constraints and lack of political support.
- Despite growing scientific evidence on climate change and biodiversity loss, many communities, policymakers, and industries lack sufficient knowledge about the importance of conservation.
- Many school curricula do not adequately address biodiversity and climate change, while most scientific research often remains confined to academic circles, limiting public engagement.
- Climate and conservation issues receive less coverage compared to political or economic matters.
- Some traditional practices, such as wildlife hunting and deforestation, persist due to ignorance of their long-term consequences.

Pathways to Ecosystem Resilience

1. Climate-Smart Conservation Strategies

- Establishing dynamic and flexible protected areas to account for shifting habitats.
- Promoting assisted migration and genetic adaptation programs.

2. Ecosystem-Based Adaptation (EbA) Approaches

- Restoring wetlands, forests, and mangroves to enhance natural carbon sequestration.
- Integrating biodiversity considerations into urban planning.

3. Strengthening Policy Frameworks and International Collaboration

- Implementing global agreements such as the Convention on Biological Diversity (CBD).
- Encouraging cross-border conservation initiatives.

4. Harnessing Technological Innovations

- Using remote sensing and AI for biodiversity monitoring.
- Advancing genetic conservation techniques such as seed banks and biobanking.

5. Community Engagement and Indigenous Knowledge Integration

- Empowering local communities to participate in conservation efforts.
- Recognizing traditional ecological knowledge as a valuable resource.

Conclusion

- Biodiversity conservation in a changing climate demands proactive and interdisciplinary approaches.
- By integrating scientific research, policy interventions, and community-driven efforts, we can enhance ecosystem resilience and safeguard biodiversity for future generations.
- The urgency of addressing these challenges cannot be overstated, as the fate of countless species and ecosystems depends on our collective actions today.



Thank you for listening