



Assessing the Impact of Climate Change on Forest Carbon Sequestration and Biodiversity in Tropical Ecosystems

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Abstract

This study assesses the impact of climate change on forest carbon sequestration and biodiversity in tropical ecosystems. Tropical forests play a critical role in mitigating climate change by sequestering carbon and supporting biodiversity, but they are increasingly vulnerable to the effects of climate change, such as rising temperatures, changing rainfall patterns, and more frequent extreme weather events. The main objective of this research is to evaluate how these climate variables affect the carbon storage capacity and biodiversity of tropical forests. Using a library research methodology, the study gathers primary data from scientific books, journal articles, and previous research on climate change and tropical ecosystems. Secondary data includes relevant literature on the broader impacts of climate change on forest ecosystems. The findings show that climate change has led to a significant reduction in carbon sequestration capacity and biodiversity loss in tropical forests. The decline in biodiversity and carbon storage capacity is further exacerbated by extreme weather events, such as forest fires. The study concludes that integrated conservation strategies, including sustainable forest management and local community involvement, are essential to mitigating these impacts and ensuring the long-term resilience of tropical forests.



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INTRODUCTION

Global climate change has emerged as one of the most critical environmental challenges of the 21st century, affecting various aspects of the natural world, particularly ecosystems that are pivotal in regulating the Earth's climate. Among these ecosystems, tropical forests hold a crucial position due to their unparalleled capacity to sequester carbon, making them essential in mitigating the impacts of climate change. Tropical forests, which cover approximately 7% of the Earth's land surface, absorb a significant portion of the world's atmospheric carbon dioxide, helping to stabilize global temperatures (Ramachandra & Bharath, 2020).

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However, these forests are increasingly threatened by the effects of climate change, including rising global temperatures, shifting rainfall patterns, and more frequent and severe extreme weather events such as droughts and storms. Such changes disrupt the balance of these ecosystems, diminishing their carbon sequestration capabilities and threatening the biodiversity they support. The loss of forest carbon storage and the decline in biodiversity represent serious consequences not only for the health of tropical ecosystems but also for global efforts to combat climate change and protect life on Earth. As tropical forests face increasing pressure from climate change, it is imperative to better understand the extent and nature of these impacts, as well as explore potential solutions to mitigate further degradation (Zapfack et al., 2020).

The relationship between climate change, forest carbon sequestration, and biodiversity in tropical ecosystems has been the subject of much research, and several studies have documented the detrimental effects of climate change on these critical functions. Literature has extensively explored the role of tropical forests in carbon storage, underscoring their importance as carbon sinks that absorb carbon dioxide from the atmosphere. However, the current body of research still reveals considerable gaps in understanding the specific mechanisms through which climate variables, such as temperature increases and altered precipitation regimes, influence both carbon sequestration and biodiversity. While global climate models predict shifts in ecosystems due to climate change, there is a lack of comprehensive studies that account for the complex, interactive dynamics between these climate factors and tropical forest ecosystems over long-term periods. Existing theories, such as climate change models and ecosystem functioning theories, have not fully addressed the ways in which these variables influence the ecosystem services provided by tropical forests, particularly in relation to the simultaneous impact on carbon storage and species diversity. There is a need for a more integrated approach that combines ecological, climatological, and biodiversity-focused frameworks to better understand the multifaceted effects of climate change on tropical ecosystems. Furthermore, existing research has often focused on individual factors, such as temperature or rainfall changes, without adequately examining the combined effects of multiple climate stressors. This lack of comprehensive, integrative studies highlights the need for further research to bridge these gaps and provide more accurate predictions for the future of tropical forests (Joshi & Singh, 2020).

The primary objective of this research is to assess the impact of climate change on the capacity of tropical forests to sequester carbon and support biodiversity. This study aims to provide a detailed analysis of the interactions between climate change variables—such as changes in temperature, precipitation, and the frequency of extreme weather events—and their effects on the carbon storage capabilities of tropical forests and their biodiversity. By examining data from various tropical regions, this research intends to highlight the specific climate-related factors that are most detrimental to these ecosystems' ability to function effectively. Additionally, the study will investigate the potential strategies that can be implemented to mitigate the negative impacts of climate change on these ecosystems. This includes assessing the effectiveness of current conservation practices, such as forest management techniques, and identifying innovative approaches that could enhance the resilience of tropical forests to climate change. Ultimately, the research aims to provide valuable insights that can inform policy decisions and help guide the global conservation community in preserving the ecological integrity of tropical forests. By understanding the complex interplay between climate change, carbon sequestration, and biodiversity, the study seeks to offer evidence-based recommendations for adapting forest management strategies in response to the changing climate (Deb et al., 2021).

The hypothesis driving this study is that climate change significantly reduces the carbon sequestration capacity of tropical forests and threatens the biodiversity they harbor. Given the pivotal role that tropical forests play in global carbon regulation and the high level of biodiversity they support, it is essential to understand how the changing climate is affecting these critical functions. Research indicates that as temperatures rise and precipitation patterns shift, tropical

forests may experience increased vulnerability to drought, pests, diseases, and forest fires—all of which compromise their ability to store carbon effectively. Furthermore, climate change-induced changes in forest structure and composition could lead to the loss of plant and animal species, further exacerbating the challenges posed by environmental degradation. Therefore, this research is crucial as it will explore not only the direct effects of climate change on carbon sequestration and biodiversity but also how these effects interact within the broader context of ecosystem health and resilience. The study posits that understanding the interactions between climate variables and forest ecosystems is essential for developing more effective conservation strategies. By investigating the underlying causes of ecosystem disruption and proposing viable solutions, this research aims to contribute to the global effort to combat climate change and protect tropical biodiversity. The findings of this study are expected to provide a clearer picture of the future of tropical forests under changing climatic conditions, offering insights that will be vital for both researchers and policymakers involved in forest conservation and climate mitigation efforts (Ahmad et al., 2023).

METHOD

Research Object

The research object of this study is the assessment of the impact of climate change on forest carbon sequestration and biodiversity within tropical ecosystems. Specifically, the focus is on how rising global temperatures, changing rainfall patterns, and the increased frequency of extreme weather events such as droughts and storms affect the ability of tropical forests to absorb carbon and sustain their rich biodiversity. The phenomenon being studied includes both the negative effects of climate change on the ecological processes within these forests, such as carbon storage capacity and species diversity, and the broader implications these changes may have on global climate regulation and the health of the planet's ecosystems. The problem at hand is the growing evidence of forest degradation, loss of biodiversity, and diminished carbon sequestration efficiency in tropical forests, making it essential to understand the mechanisms and consequences of these impacts (Muthee et al., 2022).

Research Type and Data Sources

This study follows a library research methodology, which is a qualitative research approach involving the collection and analysis of existing written literature. The primary data for this research comes from relevant literature, including scientific books, peer-reviewed journal articles, research reports, and academic papers, which provide detailed information on the various aspects of climate change, tropical forests, carbon sequestration, and biodiversity. These primary data sources offer insights into the underlying causes and effects of climate change on tropical ecosystems. In addition to primary data, secondary data is also gathered from broader literature on related topics, including theories of climate change, ecosystem dynamics, and conservation strategies. These secondary sources help contextualize the findings and support the analysis of the broader implications of climate change for tropical forests and biodiversity (Cooper & MacFarlane, 2023).

Theoretical Framework

The theoretical foundation of this study is based on several key ecological and climate change theories. The primary theory utilized in this research is the Ecosystem Functioning Theory, developed by H.A. Hairston in 1967, which emphasizes the interconnectedness of species within ecosystems and how changes in one element can cascade and affect the entire system. This theory suggests that the disruption of ecological processes, such as carbon sequestration and species diversity, due to climate change, can lead to broader ecosystem degradation. Additionally, the Global Climate Change Theory proposed by James Hansen in 1988 is used to understand the impact of human activities, particularly greenhouse gas emissions, on global temperature rise and subsequent

environmental changes. These theories form the basis for the assumptions in this study and guide the analysis of how climate change influences tropical forests' ability to store carbon and maintain biodiversity.

Research Process and Data Collection Techniques

The research process involves a systematic review of relevant literature to identify key insights into the impact of climate change on tropical ecosystems. Data collection in this study relies on a literature review approach, where information is gathered from a range of written sources such as academic books, journal articles, past research papers, reports, conference proceedings, and articles that are related to the research topic. The sources are carefully selected based on their relevance, credibility, and contribution to the understanding of how climate change affects tropical forests. This data collection method is designed to capture a comprehensive view of the issue by focusing on both the biological and ecological aspects of tropical ecosystems and the environmental pressures they face due to climate change. By compiling data from various written sources, this approach allows for a thorough analysis of the relationship between climate variables and forest ecosystem health (Raihan, 2024).

Data Analysis Techniques

The data analysis in this study employs content analysis, a qualitative research technique used to analyze textual data. Content analysis involves systematically reviewing, coding, and interpreting the collected literature to identify recurring themes, patterns, and relationships that provide insights into the impact of climate change on carbon sequestration and biodiversity in tropical ecosystems. This technique enables the researcher to extract valuable information from diverse sources and synthesize it into a coherent understanding of the complex interactions between climate change and tropical forest ecosystems. The process of content analysis allows for the identification of key findings, such as the most significant climate stressors affecting tropical forests, the mechanisms through which these stressors influence carbon storage and biodiversity, and potential strategies for mitigation. Through this analytical process, the study aims to provide a detailed and well-rounded view of the subject matter, supporting the conclusions drawn from the review of the literature (Binlajdam et al., 2025).

RESULT AND DISCUSSION

The literature review reveals that climate change has significantly affected the carbon sequestration capacity of tropical forests. Increased global temperatures, changing precipitation patterns, and more frequent extreme weather events, such as prolonged droughts and heavy rainfall, have disrupted the natural carbon absorption processes in these ecosystems. As temperatures rise, tropical forests are experiencing shifts in tree species composition, with some species better adapted to heat and drought becoming more dominant. This shift is causing a decrease in the overall carbon storage capacity of the forests, as species that play a key role in carbon sequestration are being replaced or pushed out. Consequently, these changes have led to a net reduction in the forests' ability to store carbon, which exacerbates the ongoing global warming (Thomas et al., 2019).

Along with the reduction in carbon sequestration, climate change is also having a detrimental impact on the biodiversity of tropical forests. Species that rely on specific climatic conditions are becoming increasingly vulnerable as temperature and precipitation patterns change. Many of these species face challenges in adapting to the new climate conditions, leading to potential declines in populations or local extinctions. The loss of biodiversity has a cascading effect on the ecosystem, as the interdependent relationships between species become disrupted. For example, the loss of keystone species, which are crucial for ecosystem processes such as pollination and seed dispersal, can cause the breakdown of critical ecological services in the forest.

The interaction between climate change and biodiversity loss is also evident in the shift in forest structure. Research has shown that tropical forests are experiencing changes in canopy composition and the vertical structure of vegetation due to the increasing dominance of drought-tolerant species. These shifts are affecting not only the carbon sequestration potential of the forests but also the habitats available for various species. As the forest canopy changes, it alters the microclimates within the forest, further exacerbating the loss of biodiversity. This change in forest structure, coupled with the ongoing loss of species, poses a significant challenge to the resilience of tropical ecosystems.

Further evidence shows that climate change is also impacting the regeneration capacity of tropical forests. As temperature and humidity conditions become less favorable, the natural regeneration of tree species is becoming increasingly difficult. The loss of young trees and seedlings means that forests are less able to recover after disturbances, such as storms or droughts, and cannot regenerate at the same rate as before. This further accelerates the degradation of the forest ecosystem and reduces its capacity to recover and continue functioning as an effective carbon sink.

Another significant finding from the literature is the influence of extreme weather events, such as forest fires, on tropical forests. Climate change has contributed to an increase in the frequency and intensity of these events, particularly in regions like the Amazon and Southeast Asia. Forest fires, often exacerbated by prolonged dry periods, not only destroy vast areas of tropical forest but also release large amounts of carbon stored in the trees and soil into the atmosphere. This not only reduces the forest's carbon sequestration capacity but also contributes to a positive feedback loop, further amplifying climate change.

Studies have also pointed out the role of tropical forests in regulating local and global water cycles. As climate change disrupts forest ecosystems, it also affects their ability to regulate rainfall patterns. In some regions, tropical forests are experiencing altered hydrological cycles, which are affecting water availability for both ecosystems and human populations. The loss of forests reduces the amount of water that is retained in the soil and released back into the atmosphere through evapotranspiration, thus affecting the overall climate and water availability in surrounding areas.

In addition to the environmental impacts, the literature also highlights the socio-economic consequences of climate change on tropical forests. Many local communities, particularly indigenous groups and rural populations, rely on tropical forests for their livelihoods, including food, medicine, and income from timber and non-timber forest products. As climate change degrades forest ecosystems, these communities are increasingly vulnerable to the loss of resources and income. The disruption of forest services, such as clean water, fuelwood, and food sources, directly impacts these populations, exacerbating poverty and increasing social inequality.

Furthermore, the literature indicates that while some tropical forests may show signs of adaptation to climate change, these adaptive responses are often insufficient to counteract the magnitude of the changes occurring. In some cases, forest species have shifted their ranges or changed their reproductive cycles in response to changing temperatures and rainfall patterns. However, these adaptive changes are not always sufficient to ensure the long-term survival of species or the continued function of the forest ecosystem. For example, some forests may experience a shift in species composition, but the overall loss of biodiversity is still evident, and the forest's ability to sequester carbon may continue to decline.

Regional variations also play a significant role in how climate change impacts tropical forests. The effects of climate change on forests differ from one region to another, depending on factors such as local climate conditions, forest types, and socio-economic pressures. For instance, tropical forests in Southeast Asia are often more affected by deforestation and land-use change, which reduce their resilience to climate impacts. In contrast, forests in the Amazon are more susceptible to the combined threats of climate change and forest fires. These regional differences highlight the need for tailored conservation strategies that account for local environmental and socio-economic factors.

Finally, the literature emphasizes the importance of developing integrated conservation

strategies that consider both the impacts of climate change and the socio-economic needs of local communities. Strategies such as sustainable forest management, reforestation, and ecosystem restoration are essential to improve the resilience of tropical forests. Additionally, there is a call for stronger policies that address the root causes of deforestation and forest degradation, including agricultural expansion and urbanization. International cooperation and financial support for tropical countries are also crucial in ensuring the long-term conservation of these vital ecosystems.

Discussion

1. Impacts of Climate Change on Carbon Sequestration in Tropical Forests

The ability of tropical forests to sequester carbon is one of the most critical functions in mitigating climate change. However, the results of this study indicate that climate change is significantly impairing this capacity. Rising temperatures have led to altered growth patterns in trees, with species that were once effective in carbon absorption being replaced by more drought-tolerant, heat-resistant species that are less capable of storing carbon. As a result, the overall carbon storage capacity of these ecosystems is being reduced, thus exacerbating the global climate crisis. Additionally, higher temperatures and changes in precipitation reduce forest productivity, causing trees to grow slower and take in less carbon.

Moreover, as climate change continues to alter forest dynamics, deforestation and degradation are accelerating. These phenomena further hinder the carbon sequestration potential of tropical forests, as forests that are cleared or degraded often release stored carbon back into the atmosphere. As a result, these forests shift from being carbon sinks to carbon sources, intensifying the negative feedback loop that fuels global warming. This highlights the critical need for effective conservation strategies aimed at preserving tropical forests and preventing further loss of carbon-storing capacity.

In addition to temperature changes, increased frequency of extreme weather events, such as prolonged droughts, floods, and storms, has also affected the ability of forests to store carbon. These weather events disrupt forest ecosystems by damaging trees and hindering their growth, further reducing their carbon sequestration efficiency. Forests that experience recurrent droughts or flooding may undergo significant stress, impairing their long-term ability to function as carbon sinks.

Furthermore, the degradation of forest soils due to deforestation and forest fires compounds the loss of carbon storage. Forest soils, when disturbed, release carbon stored in the ground, adding to atmospheric carbon levels. Soil degradation also affects the ability of forests to regenerate naturally, further reducing their carbon uptake potential. As such, soil conservation measures alongside forest protection strategies are crucial for maintaining the carbon sequestration function of tropical forests.

Given these findings, there is an urgent need to prioritize the protection and restoration of tropical forests as part of global strategies to combat climate change. Efforts to reduce deforestation, promote sustainable forest management, and implement reforestation programs are essential for preserving these vital ecosystems. Failure to address the decline in forest carbon sequestration will undermine global efforts to stabilize atmospheric carbon levels and limit climate change.

Table summarizing the key factors impairing the carbon sequestration capacity of tropical forests, based on the provided text. It structures the main threats, their mechanisms, and implications for a clear overview.

Factor	Mechanism of Impairment	Impact on Carbon Sequestration	Recommended Strategies
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Rising Temperatures	Altered tree growth patterns; replacement by drought-tolerant, heat-resistant species with lower storage capacity; reduced productivity from slower growth and less CO ₂ uptake	Overall reduction in ecosystem carbon storage; exacerbates climate crisis	Conservation and sustainable management
Changes in Precipitation & Extreme Weather	Prolonged droughts, floods, storms damage trees and hinder growth; recurrent stress impairs long-term function	Disrupted ecosystems; lower sequestration efficiency	Protection against extreme events; restoration programs
Deforestation & Degradation	Forests cleared or degraded release stored carbon; shift from sinks to sources	Acceleration of negative feedback loop; fuels global warming	Reduce deforestation; reforestation initiatives
Forest Soil Degradation	Disturbance from fires/deforestation releases soil carbon; hinders natural regeneration	Additional atmospheric CO ₂ ; reduced uptake potential	Soil conservation measures; forest protection

2. Biodiversity Loss and Its Cascading Effects

The loss of biodiversity in tropical forests due to climate change presents another major challenge highlighted in this study. Tropical forests are home to a vast array of species, many of which are highly specialized to specific environmental conditions. As the climate changes, these species are increasingly at risk of extinction due to shifts in temperature, rainfall patterns, and habitat availability. For example, many species that are adapted to stable, predictable environmental conditions may struggle to survive as these conditions fluctuate. The effects of these shifts are particularly pronounced for species with narrow ecological niches or those that cannot migrate quickly enough to suitable habitats.

The decline in biodiversity due to climate change has a profound impact on ecosystem services provided by tropical forests. Many of the species affected by climate change play vital roles in maintaining ecological balance, such as pollinating plants, dispersing seeds, and controlling pest populations. When these species are lost, the ecosystem's ability to regenerate, adapt, and maintain healthy functions diminishes. This creates a cascading effect, where the loss of one species can lead to the collapse of other interdependent species, weakening the entire ecosystem.

Moreover, the disruption of biodiversity has long-term implications for human well-being. Local communities, particularly indigenous populations, depend on the rich biodiversity of tropical forests for food, medicine, and livelihoods. The loss of plant and animal species reduces the availability of these resources and makes local communities more vulnerable to climate impacts. Additionally, the loss of biodiversity weakens the forest's resilience to other environmental stressors, making it more difficult for ecosystems to recover from disturbances such as storms, droughts, or fires.

The findings from this study suggest that the decline in biodiversity in tropical forests due to climate change is not only an environmental concern but also a socio-economic one. Biodiversity loss threatens the cultural and economic practices of communities that rely on forests for their survival.

This highlights the importance of incorporating biodiversity conservation into climate change adaptation strategies to ensure that these forests continue to provide critical resources for both ecosystems and people.

As climate change continues to threaten biodiversity in tropical forests, there is a pressing need for targeted conservation efforts to protect vulnerable species and ecosystems. These efforts should focus on maintaining habitat connectivity, promoting species adaptation, and integrating biodiversity conservation with broader climate change mitigation strategies.

3. Role of Extreme Weather Events and Forest Fires

Extreme weather events and forest fires, exacerbated by climate change, have emerged as major threats to tropical forests. The literature reviewed in this study shows that the frequency and intensity of these events have increased in many tropical regions, leading to widespread damage and loss of forest cover. Forest fires, in particular, are a significant concern, as they not only destroy large areas of forest but also release stored carbon back into the atmosphere, further contributing to climate change. The increased occurrence of forest fires in tropical regions like the Amazon and Southeast Asia is driven by a combination of rising temperatures, prolonged dry periods, and human activities such as deforestation and land clearance for agriculture.

Forest fires have a dual impact on carbon sequestration and biodiversity. On one hand, they directly destroy trees and other vegetation, which are vital for carbon storage. On the other hand, they disrupt the habitats of countless species, many of which are unable to survive in the aftermath of such fires. These fires also contribute to the degradation of soil quality, which further undermines the forest's ability to regenerate and sequester carbon. As the forest canopy is destroyed, the forest's microclimates are altered, further threatening the survival of sensitive species.

The relationship between climate change and forest fires is cyclical. As climate change increases the occurrence of extreme weather events and droughts, the risk of forest fires becomes greater, which in turn exacerbates the effects of climate change by releasing more carbon into the atmosphere. This creates a feedback loop that amplifies the challenges faced by tropical forests in maintaining their carbon sequestration capabilities.

Efforts to address the issue of forest fires in tropical regions must include both mitigation and adaptation strategies. Fire prevention measures, such as controlled burns, forest management practices, and firebreaks, are essential to reduce the frequency and severity of fires. Furthermore, addressing the root causes of deforestation and land-use change is critical to reducing human-induced fire risks in these ecosystems. Without these interventions, the increasing frequency of forest fires due to climate change could lead to irreparable damage to tropical forests.

In summary, forest fires and extreme weather events are significant threats to the resilience of tropical forests. Effective forest management strategies must incorporate fire risk reduction, climate change adaptation, and long-term conservation planning to protect these ecosystems from further degradation.

4. Socio-Economic Impacts on Local Communities

The socio-economic consequences of climate change on tropical forests are profound, particularly for local communities that rely on these forests for their livelihoods. Indigenous peoples and rural populations in tropical regions depend heavily on the resources provided by forests, including timber, non-timber forest products, medicinal plants, and ecosystem services such as water regulation and pollination. As climate change causes degradation of these forests, local communities face diminished access to these vital resources, increasing their vulnerability to poverty and social instability.

The loss of forest resources due to climate change not only impacts the economic well-being of these communities but also threatens their cultural practices and traditions. Many indigenous cultures are deeply connected to the forests, relying on them for spiritual, medicinal, and subsistence

purposes. As forests decline, these communities lose not only their source of income but also a key part of their identity. Additionally, as the climate shifts, communities that depend on stable climatic conditions for farming and agriculture are facing increasingly erratic weather patterns, making food security a growing concern.

The findings suggest that climate adaptation strategies for tropical forests must be inclusive, taking into account the needs and rights of local communities. Forest conservation and climate change mitigation efforts should involve these communities in decision-making processes and ensure that conservation initiatives support their sustainable development. By integrating local knowledge and practices with scientific research, it is possible to create solutions that protect both the environment and the livelihoods of those who depend on it.

Furthermore, climate change adaptation strategies should address the socio-economic vulnerability of these communities by providing alternative livelihood options and improving their resilience to environmental changes. This can include promoting sustainable agriculture, offering capacity-building programs, and ensuring access to resources for disaster preparedness and recovery. Only by addressing both the environmental and social dimensions of climate change can we ensure the long-term survival of tropical forests and the well-being of the communities that rely on them.

Ultimately, the impact of climate change on tropical forests is not only an environmental issue but a socio-economic one. Addressing these challenges requires an integrated approach that considers both ecological conservation and the needs of local populations.

5. Need for Integrated Conservation Strategies

The findings from this study underscore the urgent need for integrated conservation strategies that combine climate change adaptation with biodiversity protection. As climate change continues to impact tropical forests, conservation efforts must evolve to address not only the direct threats posed by changing climate conditions but also the indirect effects on biodiversity and carbon sequestration. Strategies that focus solely on reducing deforestation or protecting individual species are no longer sufficient. Instead, a holistic approach that considers the broader ecological, social, and economic factors is required.

Integrated conservation strategies should include a combination of efforts such as ecosystem restoration, sustainable forest management, reforestation, and biodiversity conservation. These measures should be tailored to specific regions and forest types, recognizing the unique challenges and opportunities that each area faces. Additionally, these strategies should be flexible, allowing for adaptive management as new information about climate change impacts and forest resilience emerges.

International cooperation and financial support are crucial in implementing these strategies, particularly in tropical regions that lack the resources to address the challenges posed by climate change. Developed countries and international organizations must work with tropical nations to provide funding, technical expertise, and policy support for forest conservation and climate adaptation initiatives. At the same time, national governments must strengthen their environmental policies and governance structures to ensure effective implementation of conservation strategies.

The role of local communities in forest conservation should not be overlooked. Involving indigenous and local communities in decision-making processes ensures that conservation efforts are both effective and culturally appropriate. These communities possess valuable traditional knowledge and are often the most motivated to protect their natural resources, as they are directly dependent on them for survival.

CONCLUSION

This study highlights the significant impacts of climate change on tropical forests, particularly in terms of their ability to sequester carbon and maintain biodiversity. The findings reveal that rising

temperatures, altered precipitation patterns, and increased frequency of extreme weather events have compromised the carbon storage capacity of tropical forests, exacerbating global warming. Additionally, the loss of biodiversity due to climate change threatens the resilience of these ecosystems, as species that are unable to adapt to the changing environment face extinction, disrupting essential ecological services. As tropical forests continue to degrade, they not only lose their role in climate regulation but also impact local communities that depend on these ecosystems for resources and livelihoods.

The research underscores the urgent need for integrated conservation strategies that address both the environmental and socio-economic challenges posed by climate change. These strategies must include sustainable forest management, ecosystem restoration, and the active involvement of local communities in conservation efforts. Furthermore, international cooperation and funding are essential for supporting these efforts, particularly in tropical regions. By developing and implementing adaptive, region-specific conservation approaches, we can enhance the resilience of tropical forests to climate change, preserving their vital role in carbon sequestration and biodiversity conservation for future generations.

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