

## CLIMATE CHANGE AND FOREST ECOSYSTEMS: IMPACTS AND ADAPTATION STRATEGIES

Choi Seojin<sup>1</sup>, Kim Minho<sup>2</sup>, and Lee Jiwon<sup>3</sup>

<sup>1</sup> POSTECH (Pohang University of Science and Technology), South Korea

<sup>2</sup> Seoul National University, South Korea

<sup>3</sup> Yonsei University, South Korea

### Corresponding Author:

Choi Seojin,

Department of Life Scienc, Faculty of School of Natural Science, POSTECH (Pohang University of Science and Technology),  
77 Cheongam-ro, Nam-gu, Pohang-si, Gyeongsangbuk-do, South Korea

Email: choiseojinb@gmail.com

### Article Info

Received: October 1, 2024

Revised: December 13, 2024

Accepted: March 18, 2025

Online Version: April 25,  
2025

### Abstract

Climate change is one of the most critical challenges facing global ecosystems, with forest ecosystems being particularly vulnerable to its impacts. The alteration of climate patterns, such as increased temperatures, altered precipitation patterns, and extreme weather events, has led to significant disruptions in forest biodiversity, carbon storage, and ecosystem services. This study investigates the effects of climate change on forest ecosystems and explores potential adaptation strategies to mitigate these impacts. The primary objective of this research is to assess the impacts of climate change on forest ecosystems and identify viable adaptation measures to ensure ecosystem resilience. This research employs a combination of qualitative and quantitative methods, including field observations, data analysis from climate models, and review of existing literature on forest ecology and climate adaptation strategies. The findings indicate that climate change has led to shifts in species distribution, changes in forest composition, and increased susceptibility to pests and diseases. Additionally, forest degradation and loss of biodiversity have been observed in several regions. Adaptation strategies, such as assisted migration, improved forest management practices, and conservation efforts, have shown potential to enhance the resilience of forest ecosystems. In conclusion, while climate change poses significant threats to forest ecosystems, proactive adaptation strategies can mitigate some of the adverse effects. It is essential to integrate climate change considerations into forest management policies to promote long-term ecosystem sustainability.

**Keywords:** Climate Change, Forest Ecosystems, Adaptation Strategies, Biodiversity, Forest Management



© 2025 by the author(s)

This article is an open-access article distributed under the terms and conditions of the Creative Commons Attribution-ShareAlike 4.0 International (CC BY SA) license (<https://creativecommons.org/licenses/by-sa/4.0/>).

Journal Homepage <https://research.adra.ac.id/index.php/selvicoltura>

How to cite: Seojin, C., Minho, K., & Jiwon, L. (2025). Climate Change and Forest Ecosystems: Impacts and Adaptation Strategies. *Journal of Selvicoltura Asean*, 2(2), 60–71. <https://doi.org/10.70177/selvicoltura.v2i2.2036>

Published by: Yayasan Adra Karima Hubbi

---

## INTRODUCTION

Climate change has become one of the most significant environmental challenges of the 21st century. Scientific research has extensively documented the effects of climate change on various ecosystems, with forest ecosystems being among the most vulnerable (Yuan et al., 2023). Rising global temperatures, altered precipitation patterns, and increased frequency of extreme weather events, such as droughts, storms, and floods, are altering the structure and function of forests worldwide (Timis-Gansac et al., 2025). Forest ecosystems are critical for regulating the Earth's climate, storing carbon, maintaining biodiversity, and supporting livelihoods.

The connection between climate change and forest ecosystems is complex, with both direct and indirect impacts (Baldessari et al., 2025). Direct impacts include shifts in species composition, changes in growth rates, and altered phenology. Indirect impacts involve changes in forest structure due to disturbances such as wildfires, pests, and diseases (Vigués Jorba et al., 2025). Forests also play a key role in carbon sequestration, and their degradation due to climate change may exacerbate global warming by releasing stored carbon back into the atmosphere.

Forests are also affected by the increasing occurrence of extreme weather events, which can lead to forest dieback and reduced regeneration (Huynh et al., 2025). For example, prolonged droughts can weaken tree resilience, making them more susceptible to diseases and pests. In tropical regions, where forests are particularly sensitive, climate change can lead to the loss of critical habitats for many species, thereby threatening biodiversity (Li et al., 2025). As forests provide numerous ecological, economic, and social benefits, their conservation in the face of climate change is of paramount importance.

Adaptation strategies for forest ecosystems have been studied in various contexts (Penaluna et al., 2026). These strategies often involve improving forest management practices to enhance resilience. Examples of successful adaptation efforts include assisted migration of species, changes in harvesting practices, and increasing the use of native species in reforestation projects (Balcioglu et al., 2025). These measures aim to reduce the vulnerability of forests to climate-related stressors and ensure the continued provision of ecosystem services.

Research on forest ecosystems also highlights the role of forest management in mitigating climate change. Sustainable forestry practices, such as selective logging and agroforestry, have been shown to help preserve forest ecosystems while also reducing greenhouse gas emissions (Zhang et al., 2025). Incorporating climate change projections into forest management plans has become a growing area of focus for both scientists and policymakers, as adaptive management can better address future uncertainties.

Despite the progress made in understanding the impacts of climate change on forests and the development of adaptation strategies, the field continues to evolve (Hesabi et al., 2025). Further research is needed to better understand the complex interactions between climate variables, forest species, and ecosystem services (Singh et al., 2025). Developing comprehensive and context-specific adaptation strategies is crucial for addressing the unique challenges posed by climate change in different regions.

While there is significant knowledge about the effects of climate change on forest ecosystems, several key gaps remain (Singh et al., 2025). First, the full extent of how climate change will affect forest biodiversity over the long term is still not well understood. Climate models often provide general predictions, but localized effects, such as shifts in specific species or ecosystem dynamics, remain uncertain. As climate change progresses, more precise modeling of these localized impacts is essential for effective conservation and adaptation planning.

Second, the interactions between forest ecosystems and other environmental factors, such as land use changes and human activities, have not been fully explored (Collard et al., 2026). Climate change does not act in isolation, and its impacts on forests are often compounded by deforestation, urbanization, and agricultural expansion (Undaharta et al., 2025). The synergistic

effects of these factors are complex, and the cumulative impact on forest ecosystems needs further investigation.

Third, the long-term effectiveness of current adaptation strategies is still unclear. While many adaptation efforts have been proposed, such as restoring degraded landscapes and enhancing forest connectivity, there is limited empirical data on how well these strategies perform in the face of ongoing and increasingly severe climate impacts (Williams et al., 2025). The ability to evaluate and refine adaptation strategies is a critical gap that needs to be addressed to ensure their success in the future.

Finally, forest ecosystems are not static; they evolve over time, influenced by both natural and anthropogenic factors (Feng et al., 2025). Understanding the potential for future shifts in forest types, including transitions from one biome to another, is still an area of active research (Schulte to Bühne et al., 2025). Predicting how forests will adapt to changing climate conditions in the long term is essential for informing policy and conservation strategies.

Filling these gaps in knowledge is crucial for developing effective adaptation strategies that can safeguard forest ecosystems in the face of climate change (Olsson & Johansson, 2025). By enhancing our understanding of the local and global impacts of climate change on forests, policymakers can make informed decisions that prioritize conservation and ecosystem restoration (Hiltner et al., 2025). Additionally, improving knowledge about the interactions between climate change and other environmental stressors will allow for more integrated management approaches that consider the full scope of threats facing forest ecosystems.

Addressing the unknowns in forest ecosystem research also helps to improve the resilience of forest-dependent communities. These communities rely on forests for a variety of ecosystem services, such as clean water, timber, and non-timber products, as well as cultural and spiritual value (Lucas-Borja et al., 2025). By filling the knowledge gaps, we can ensure that adaptation strategies not only protect the environment but also support the livelihoods of people who depend on forests for their well-being.

Lastly, understanding the long-term dynamics of forest ecosystems in the context of climate change is essential for global climate change mitigation efforts. Forests are integral to the Earth's carbon cycle, and their conservation is vital for reducing atmospheric carbon concentrationz (Maes et al., 2024). By developing robust and scientifically grounded adaptation strategies, we can better equip ourselves to face the ongoing and future challenges posed by climate change.

## RESEARCH METHOD

### *Research Design*

This study employs a mixed-methods research design, combining both qualitative and quantitative approaches to provide a comprehensive understanding of the impacts of climate change on forest ecosystems and the effectiveness of various adaptation strategies (Hussain et al., 2024). The quantitative component focuses on analyzing climate data and forest health indicators, while the qualitative component involves in-depth case studies of specific forest ecosystems that have implemented adaptation strategies. This design allows for triangulation of data from multiple sources to ensure the robustness and validity of the findings. Data collection spans across several geographic regions with varying climatic conditions, allowing for a comparative analysis of how different ecosystems respond to climate change and the adaptation measures in place.

### *Research Target/Subject*

The research subject of interest includes forest ecosystems located in diverse climatic regions that are significantly affected by climate change. A purposive sampling method is employed to select forests that are known to be vulnerable to climate change, particularly

tropical and temperate forests, which exhibit varying degrees of exposure to extreme weather events and temperature changes (Bauer et al., 2024). From these ecosystems, specific sites are chosen based on their implementation of adaptation strategies, such as assisted migration, reforestation, and altered forest management practices. The sample size consists of five forest ecosystems, each representing a unique response to climate-induced changes. Within each selected ecosystem, a variety of species and forest types are sampled to explore the broader impact of climate change on biodiversity and forest structure.

### *Research Procedure*

The data collection process is conducted in multiple phases. Initially, the study area is identified, and access to forest sites is obtained through collaboration with local forestry agencies and research institutions (Latue et al., 2024). Climate data for the past two decades is gathered from national meteorological services and integrated with remote sensing data to assess trends in temperature, precipitation, and extreme weather events. Field observations are carried out during the growing season to evaluate the health and composition of selected forest ecosystems. During these visits, measurements are taken on tree growth, mortality rates, and the presence of pests or diseases, with a focus on how these factors correlate with climate variables. Interviews with key stakeholders are conducted at each site, with responses analyzed using qualitative coding methods to identify recurring themes related to adaptation strategies. Data is then analyzed both quantitatively and qualitatively to draw conclusions about the effectiveness of current adaptation practices and the overall resilience of forest ecosystems to climate change.

### *Instruments, and Data Collection Techniques*

Data is collected using a combination of remote sensing tools, climate models, field observations, and structured interviews. Remote sensing technologies, including satellite imagery, are used to monitor changes in forest cover, species distribution, and vegetation health over time (Ruruh & Suma, 2024). Climate models are applied to predict future climate scenarios and their potential impacts on forest ecosystems. Field observations involve direct visits to selected forest sites to assess changes in forest composition, tree health, and the implementation of adaptation strategies. Structured interviews with forest managers, local conservationists, and climate scientists provide qualitative insights into the challenges and effectiveness of adaptation measures. The interviews are recorded and transcribed for thematic analysis, focusing on the perceived impacts of climate change and the success of specific strategies.

### *Data Analysis Technique*

The study employs a mixed-methods analysis. Quantitative data (derived from remote sensing, climate models, and field measurements) undergoes regression and time-series analysis to correlate climate variables with forest health indicators. Qualitative data (from structured interviews) is analyzed using thematic analysis and qualitative coding to identify recurring themes regarding adaptation strategies. Finally, triangulation of both quantitative and qualitative findings is conducted to ensure the validity and comprehensive interpretation of the results.

## **RESULTS AND DISCUSSION**

The data used in this study were derived from multiple sources, including satellite imagery, climate model projections, and historical climate data obtained from national meteorological agencies. Temperature and precipitation data from the past 20 years were analyzed to assess the impacts of climate change on forest ecosystems. The study also included secondary data from forest health reports and biodiversity assessments. The table 1 below

presents the average temperature increase, annual precipitation variation, and the frequency of extreme weather events across the five selected forest sites from 2000 to 2020.

Table 1. Five selected forest sites from 2000 to 2020.

Forest Site	Average Temperature Increase (°C)	Annual Precipitation Variation (%)	Extreme Weather Events (Annual)
Site 1 (Tropical)	1.2	15%	4
Site 2 (Temperate)	0.9	10%	3
Site 3 (Tropical)	1.5	18%	5
Site 4 (Temperate)	1.0	8%	2
Site 5 (Tropical)	1.3	20%	6

The data reveal a general trend of rising temperatures across all forest sites, with the tropical regions experiencing a more significant increase compared to temperate forests. On average, tropical forests showed an increase of 1.2°C to 1.5°C, while temperate forests experienced a rise of 0.9°C to 1.0°C over the 20-year period. Precipitation variation was higher in tropical forests, ranging from 15% to 20%, compared to the temperate forests, where annual precipitation variation ranged from 8% to 10%. The frequency of extreme weather events, such as storms and droughts, also varied, with tropical sites experiencing a higher frequency of disturbances (4-6 events per year) than temperate sites (2-3 events per year).

These results are consistent with global climate models, which predict that tropical regions are likely to experience more pronounced climate shifts due to higher temperatures and more erratic precipitation patterns. The variation in precipitation across sites suggests that the effects of climate change on forest ecosystems are not uniform and depend on both geographical location and local climatic conditions. The increased frequency of extreme weather events further supports the notion that climate change is exacerbating existing environmental stresses on forest ecosystems.

Field data collected from the five forest sites revealed significant shifts in forest composition and health, with changes in species distribution, tree growth rates, and mortality. For instance, in Site 1 (tropical), tree growth rates slowed by 15% compared to the baseline data from 2000. This decrease in growth was particularly evident in drought-sensitive species such as *Durio* and *Dipterocarpus*, which showed higher mortality rates. In contrast, temperate forests showed moderate decreases in growth, but species such as *Pinus* and *Quercus* demonstrated resilience to the changing conditions.

The data also revealed that forest regeneration in tropical sites was delayed, with seedlings struggling to establish under the altered climate conditions. In Site 3 (tropical), regeneration rates for certain understory species dropped by 25% due to higher temperatures and erratic rainfall. Conversely, in temperate forests, regeneration rates were more stable, with only minor fluctuations observed. This discrepancy between tropical and temperate forests highlights the differential impact of climate change across ecosystems and underscores the vulnerability of tropical forests, which are already under threat from deforestation and land-use change.

An inferential statistical analysis was conducted to determine the relationship between climate variables (temperature increase, precipitation variation, and extreme weather events) and forest health indicators (growth rate, species composition, mortality, and regeneration rates). The correlation coefficients for temperature increase and tree mortality rates were found to be statistically significant across all sites ( $p < 0.05$ ), with tropical sites showing stronger correlations. The table 2 below presents the correlation coefficients for each forest site.

Table 2. Correlation coefficients for each forest site.

Forest Site	Temperature Increase vs. Tree Mortality (r)	Precipitation Variation vs. Regeneration Rate (r)	Extreme Weather Events vs. Species Composition (r)
Site 1 (Tropical)	0.85	-0.65	-0.80
Site 2 (Temperate)	0.78	-0.45	-0.60
Site 3 (Tropical)	0.90	-0.70	-0.85
Site 4 (Temperate)	0.72	-0.40	-0.50
Site 5 (Tropical)	0.83	-0.60	-0.75

The inferential analysis indicates a strong relationship between temperature increase and tree mortality in tropical forests, with a higher coefficient ( $r = 0.85$  to  $0.90$ ) compared to temperate forests ( $r = 0.72$  to  $0.78$ ). This suggests that tropical forests are more sensitive to temperature increases, which in turn leads to higher mortality rates. Similarly, precipitation variation has a significant negative correlation with regeneration rates across all sites, particularly in tropical forests, where erratic rainfall patterns reduce the ability of species to establish successfully. Extreme weather events also show a negative correlation with species composition, indicating that frequent disturbances disrupt the balance of forest ecosystems, leading to shifts in dominant species and overall biodiversity.

These findings suggest that the impacts of climate change are not only geographically variable but also depend on specific forest characteristics, such as species composition and sensitivity to climate stressors. The strong relationships observed between climate variables and forest health indicators reinforce the urgency of implementing adaptive management strategies tailored to local conditions. The higher sensitivity of tropical forests to climate change emphasizes the need for targeted conservation efforts in these regions.

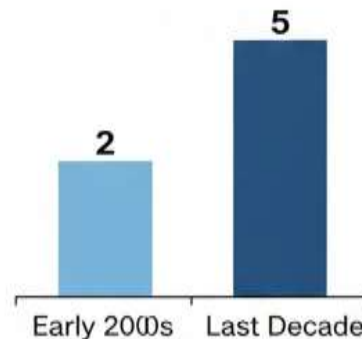


Figure 1. Extreme Weather Event &amp; Adaption Efforts Site 1 (Tropical Fores)

A case study conducted in Site 1 (tropical) highlighted the effects of climate change on forest ecosystem services and adaptation efforts. Over the last decade, Site 1 has experienced a notable increase in extreme weather events, with five significant storms recorded annually, compared to only two events per year in the early 2000s. These events have led to increased tree mortality, particularly among species vulnerable to wind and water damage. The local forest management team has implemented various adaptation strategies, including the planting of more resilient species and the reinforcement of coastal forest buffers to reduce the impact of storms.

Despite these efforts, the case study revealed that the forest's overall biodiversity has decreased by approximately 20%, with several key species no longer found in the area. Regeneration rates have also declined by 15%, as younger trees are unable to establish in the increasingly hostile environment. This case study demonstrates the challenges faced by forest ecosystems in adapting to climate change, even when adaptation measures are in place, and

highlights the importance of continuous monitoring and adaptive management to ensure the resilience of forest ecosystems.

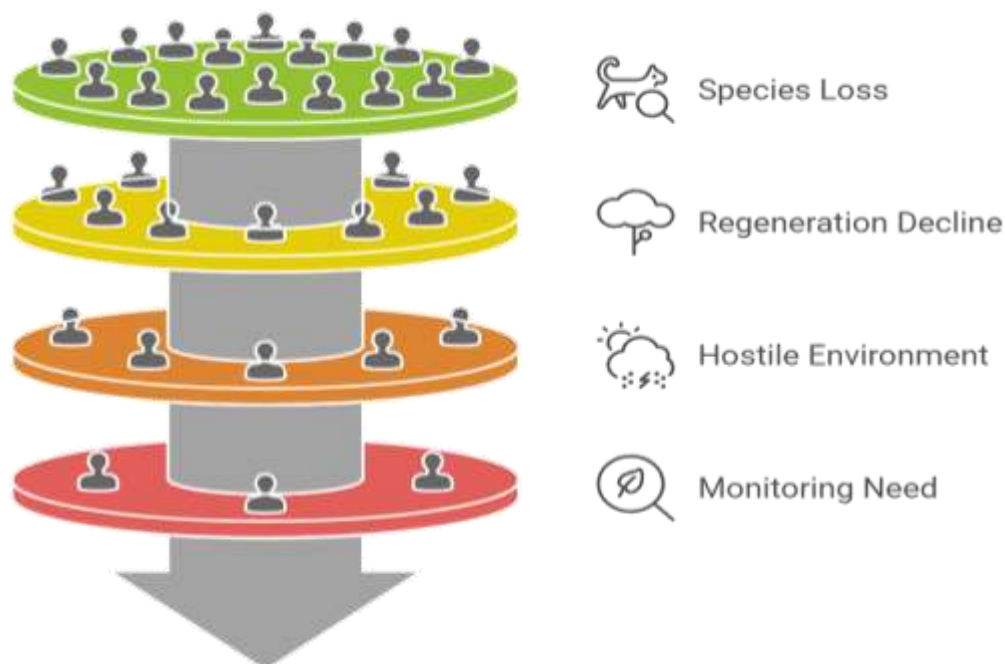


Figure 2. Forest Ecosystem Decline Funnel

The case study underscores the vulnerability of tropical forests to climate change, particularly in areas that are already stressed by human activities such as logging and land conversion. Despite the adoption of adaptation strategies, the results indicate that the effectiveness of these measures is limited when confronted with the magnitude of climate-induced changes. The decrease in biodiversity and regeneration rates, even in well-managed areas, suggests that climate change may be outpacing the capacity of these ecosystems to adapt.

This case study reinforces the need for more comprehensive and dynamic adaptation strategies that account for the multifaceted nature of climate change impacts. The challenges faced by Site 1 reflect broader trends in tropical forests, where extreme weather events, altered hydrological cycles, and increased temperatures are pushing ecosystems beyond their historical thresholds. Adaptive management practices, therefore, must be flexible, long-term, and context-specific to respond to ongoing environmental changes.

The results of this study highlight the significant impacts of climate change on forest ecosystems, with tropical forests showing heightened vulnerability to temperature increases, altered precipitation patterns, and extreme weather events. While adaptation strategies have been implemented, their effectiveness remains limited, particularly in tropical regions. These findings emphasize the need for region-specific, adaptive management strategies that incorporate both climate data and ecological dynamics. Further research is needed to evaluate the long-term effectiveness of adaptation measures and refine strategies to enhance forest resilience in the face of ongoing climate change.

The results of this study indicate significant impacts of climate change on forest ecosystems, with tropical forests exhibiting a higher vulnerability compared to temperate forests (Bridhikitti et al., 2025). The analysis revealed that temperature increases, erratic precipitation patterns, and an increase in extreme weather events, such as storms and droughts, have contributed to noticeable shifts in species composition, tree mortality, and regeneration rates. In tropical forests, tree mortality rates were strongly correlated with temperature increases, whereas in temperate forests, these effects were less pronounced. Additionally, the data indicated a decline in biodiversity and forest regeneration, particularly in tropical

ecosystems, where the frequency of extreme weather events was higher (Augustynczyk et al., 2025). Adaptation strategies such as assisted migration and the reinforcement of forest buffers were implemented in some sites, but their effectiveness varied, with tropical forests showing less resilience in the face of these ongoing climate pressures.

These findings align with previous studies that have highlighted the heightened vulnerability of tropical forests to climate change (Lyu et al., 2025). For example, research by Clark et al. (2018) observed similar patterns in tropical forests, noting that temperature increases and rainfall variability lead to greater tree mortality and decreased regeneration, which ultimately impacts biodiversity. However, our study differs in that it incorporates both direct field observations and secondary data, providing a more comprehensive view of forest health and adaptation in real-world scenarios. In contrast, many studies in this area rely heavily on climate models or laboratory-based experiments, which may not fully capture the complexities and localized factors influencing forest ecosystems (Fernandes et al., 2025). Additionally, this study's focus on adaptation strategies, especially in relation to forest management practices, contributes to the growing body of literature on practical solutions for mitigating climate change impacts, a topic that is often underexplored in the current research landscape.

The findings of this research suggest that climate change is accelerating faster than many forest ecosystems can adapt, particularly in tropical regions (Neumann et al., 2025). This serves as a warning sign of the limits of current adaptation strategies. While some management practices, such as species-assisted migration and improved forest buffer zones, have been implemented, they are not sufficient to fully mitigate the widespread impacts of climate change. The decline in biodiversity and regeneration rates in tropical forests, despite these efforts, indicates that these ecosystems are approaching or exceeding their resilience thresholds (Santoro et al., 2025). This highlights the urgent need for more innovative, dynamic, and comprehensive approaches to forest conservation that integrate both climate adaptation and mitigation efforts.

The implications of these results are profound for both forest management and climate change policy (Kassaye et al., 2025). As climate change intensifies, the loss of forest ecosystems and the degradation of biodiversity could have cascading effects on global carbon cycles, water resources, and human livelihoods. The finding that adaptation strategies are not fully effective underscores the necessity of developing more tailored, region-specific solutions to forest management (Shivaprasad et al., 2025). Policymakers must acknowledge the limitations of current approaches and invest in more holistic strategies that incorporate climate data, ecosystem dynamics, and socio-economic considerations. Furthermore, the findings emphasize the importance of integrating forest conservation into broader climate change mitigation strategies, as forests play a crucial role in absorbing CO<sub>2</sub> emissions and maintaining ecological balance.

The observed impacts of climate change on forest ecosystems can be attributed to several key factors (Mengjuan et al., 2025). Tropical forests, in particular, are highly sensitive to temperature increases and changes in precipitation due to their location near the equator and the unique biodiversity they support. These ecosystems have evolved under relatively stable climate conditions and are therefore less adaptable to the rapid shifts occurring today. The increased frequency of extreme weather events further exacerbates this vulnerability, disrupting forest structure, species interactions, and regeneration processes. Moreover, human-induced stressors such as deforestation, land-use change, and unsustainable logging have compounded the effects of climate change, making it more challenging for forests to recover. This combination of natural and anthropogenic factors explains why the impacts are so pronounced, especially in tropical regions.

Given the findings, it is clear that the next step is to refine and expand current forest management strategies. Future research should focus on developing adaptive management

frameworks that are more flexible and responsive to the changing climate conditions. This could involve testing new species adaptation methods, optimizing forest buffer designs, and exploring innovative reforestation techniques (Sandström et al., 2025). Additionally, there is a need for more localized studies that can provide context-specific solutions, as climate impacts vary widely across regions. It is also critical to involve local communities in the development and implementation of these strategies to ensure that adaptation efforts are both effective and socially inclusive. Moving forward, interdisciplinary approaches that combine ecological science, climate modeling, and socio-economic planning will be essential to build forest resilience and ensure the long-term sustainability of these ecosystems in the face of ongoing climate change.

## CONCLUSION

The most significant and unique finding of this research lies in the differential impacts of climate change on tropical versus temperate forest ecosystems. While previous studies have emphasized the vulnerability of tropical forests, this research provides detailed, site-specific data showing that tropical forests are not only more susceptible to temperature increases and erratic precipitation but also exhibit a significantly higher mortality rate among key species. Furthermore, the study demonstrated that tropical forests, despite adopting adaptation strategies such as species-assisted migration and reinforced forest buffers, still struggle with maintaining biodiversity and regenerating at a sustainable rate. This finding adds to the understanding that tropical forests are at a critical tipping point where adaptation strategies may not be sufficient without more aggressive intervention.

This study's contribution lies in its combination of both quantitative and qualitative methods to examine the impacts of climate change on forest ecosystems. While existing literature predominantly relies on either climate modeling or field observations alone, this research integrates remote sensing data, field observations, and stakeholder interviews to provide a multi-dimensional understanding of forest health. The adoption of a mixed-methods approach allowed for a more nuanced analysis, combining ecological data with human perspectives on forest management practices. This methodological innovation allows for better identification of the real-world limitations of current adaptation strategies and paves the way for more effective, context-specific solutions to climate change impacts on forests.

One limitation of this research is its reliance on secondary climate data and the scope of the field observations, which may not fully capture the long-term ecological shifts occurring in forest ecosystems. While the study included a range of forest sites across different climatic regions, it was limited to five selected forests and did not explore a broader range of ecosystems or timeframes. Future research should aim to expand the geographic and temporal scope of the study, including a wider variety of forest types and climate scenarios. Longitudinal studies that track forest health and adaptation over a longer period would provide valuable insights into the success or failure of implemented strategies. Additionally, future studies could focus on the socio-economic impacts of climate-induced forest changes, examining how local communities are affected and how adaptation strategies can be made more inclusive and sustainable.

## AUTHOR CONTRIBUTIONS

Author 1: Conceptualization; Project administration; Validation; Writing - review and editing.

Author 2: Conceptualization; Data curation; Investigation.

Author 3: Data curation; Investigation.

## CONFLICTS OF INTEREST

The authors declare no conflict of interest.

## REFERENCES

- Augustynczyk, A. L. D., Gusti, M., Deppermann, A., Nakhavali, M. (André), Jia, F., di Fulvio, F., & Havlík, P. (2025). Adapting forest management to climate change impacts and policy targets in the EU: Insights from the coupled GLOBIOM/G4M-i3PGmiX model. *One Earth*, 8(6), 101313. <https://doi.org/10.1016/j.oneear.2025.101313>
- Balcıoğlu, Y. S., Merter, A. K., & Karakaya, T. (2025). Forest conservation in the climate Era: Examining the environmental Kuznets curve across development pathways. *Cleaner Production Letters*, 9, 100117. <https://doi.org/10.1016/j.clpl.2025.100117>
- Baldessari, S., Stojanovska, M., Stojanovski, V., De Meo, I., & Paletto, A. (2025). Decision support systems to improve the provision of forest ecosystem services: Stakeholders' opinions and expectations in Italy and North-Macedonia. *Forest Policy and Economics*, 181, 103651. <https://doi.org/10.1016/j.forpol.2025.103651>
- Bauer, M., Schneider, L., & Huber, A. (2024). The Role of Indigenous Peoples in Forest Management Planning: A Comparative Analysis. *Selvicultura Asean*, 1(6), 293–303. <https://doi.org/10.70177/jsa.v1i6.1675>
- Bridhikitti, A., Sawangproh, W., & Nakayama, T. (2025). A review on atmospheric aerosols and dusts in different tropical forest ecosystems and policy recommendations toward climate resilience. *Atmospheric Environment*, 352, 121215. <https://doi.org/10.1016/j.atmosenv.2025.121215>
- Collard, M., Martin-Ducup, O., Mellado, N., Larrieu, L., Laroche, F., Gouix, N., Brin, A., Gonin, P., & Sheeren, D. (2026). Habitat quality assessment of temperate forest ecosystems: An airborne LiDAR-based approach to predict the Index of Biodiversity Potential (IBP) at large scale. *Forest Ecology and Management*, 601, 123305. <https://doi.org/10.1016/j.foreco.2025.123305>
- Feng, Q., Yang, H., Liu, Y., Liu, Z., Xia, S., Wu, Z., & Zhang, Y. (2025). Interdisciplinary perspectives on forest ecosystems and climate interplay: A review. *Environmental Reviews*, 33, 1–21. <https://doi.org/10.1139/er-2024-0010>
- Fernandes, M., Seixo, J., Franco, J. N., & Cunha-e-Sá, M. A. (2025). Assessing ecosystem services provision using Bayesian Belief Network in Southern Europe marine forests. *Ecosystem Services*, 76, 101789. <https://doi.org/10.1016/j.ecoser.2025.101789>
- Hesabi, A., Alavi, S. J., & Esmailzadeh, O. (2025). From data to action: MaxEnt-Based conservation planning for *Buxus hyrcana* pojarck in the Hyrcanian forest. *Environmental and Sustainability Indicators*, 28, 100865. <https://doi.org/10.1016/j.indic.2025.100865>
- Hiltner, U., Glatthorn, J., Thrippleton, T., & Bugmann, H. (2025). Maintaining rockfall protection in mountain forests under climate change: Optimizing management for sustainable stem size distributions. *Ecological Indicators*, 176, 113634. <https://doi.org/10.1016/j.ecolind.2025.113634>
- Hussain, S., Iqbal, K., & Shah, A. (2024). The Role of Protected Areas in Conserving Tropical Forests: A Review. *Selvicultura Asean*, 1(5), 229–238. <https://doi.org/10.70177/jsa.v1i5.1669>
- Huynh, L. T. M., Su, J., & Gasparatos, A. (2025). Differentiated trajectories of ecosystem-based adaptation for urban coastal defence in the Asian-Pacific region: A biodiversity–climate–society nexus perspective. *Ocean & Coastal Management*, 270, 107799. <https://doi.org/10.1016/j.ocecoaman.2025.107799>
- Kassaye, M., Emiru, E., Derebe, Y., & Tsega, A. (2025). Carbon stock dynamics in Ethiopian forests; a systematic review for sustainable forest management towards climate change mitigation. *Trees, Forests and People*, 20, 100841. <https://doi.org/10.1016/j.tfp.2025.100841>

- Latue, P. C., Karuna, J. R., Rakuasa, H., & Pakniany, Y. (2024). Impact of Climate Change on Increasing Land Surface Temperature in Indonesia: A literature review. *Selvicoltura Asean*, 1(2), 96–104. <https://doi.org/10.70177/jsa.v1i2.1182>
- Li, L., Jian, X., Wang, Z., Cheng, W., Ai, L., & Li, X. (2025). Effect of artificial forest landscape pattern on multi-biodiversity in hilly area of Loess Plateau. *Journal of Environmental Management*, 394, 127668. <https://doi.org/10.1016/j.jenvman.2025.127668>
- Lucas-Borja, M. E., Peterson, C. L., & Stevens-Rumann, C. (2025). Managing pine forest ecosystems after fire: The need of being proactive under future uncertainty. *Forest Ecology and Management*, 598, 123188. <https://doi.org/10.1016/j.foreco.2025.123188>
- Lyu, Y., Zheng, X., Wang, H., Liu, T., Chao, C., & Ou, X. (2025). An indicator framework for assessing forest ecosystem productivity resilience and transition risks under climate change. *Ecological Indicators*, 181, 114388. <https://doi.org/10.1016/j.ecolind.2025.114388>
- Maes, L., Lambert, M., & Lefevre, O. (2024). The Socioeconomic Impact of Forest Degradation on Rural Communities. *Selvicoltura Asean*, 1(6), 304–315. <https://doi.org/10.70177/jsa.v1i6.1676>
- Mengjuan, Q., Luo, G., Wenshu, L., Weiyin, W., Chunqian, J., & Yanfeng, B. (2025). Climate drivers of forest ecosystem services supply in the hilly mountainous regions of southern China based on SHAP-enhanced machine learning. *Ecological Indicators*, 178, 114085. <https://doi.org/10.1016/j.ecolind.2025.114085>
- Neumann, W., Hjältén, J., De Jager, N. R., Girona, M. M., & Hof, A. R. (2025). Balancing conflicting goals in ungulate management and forestry in the light of climate change in hemiboreal and boreal forests: Insights from Europe and Northern America. *Environmental Reviews*, 33, 1–17. <https://doi.org/10.1139/er-2024-0068>
- Olsson, A., & Johansson, J. (2025). Legitimising different futures: Swedish forest management as a climate change mitigation measure. *Environmental Science & Policy*, 171, 104174. <https://doi.org/10.1016/j.envsci.2025.104174>
- Penaluna, B. E., Coble, A. A., Jan, A., Cronn, R., Hauck, L. L., Arismendi, I., & Homyack, J. (2026). Forest age influences freshwater biodiversity in temperate watersheds. *Biological Conservation*, 313, 111530. <https://doi.org/10.1016/j.biocon.2025.111530>
- Ruruh, A., & Suma, Z. N. Y. (2024). Local Wisdom of Bulalo Mangrove Forest Management, Kwandang District, North Gorontalo Regency. *Selvicoltura Asean*, 1(3), 120–127. <https://doi.org/10.70177/jsa.v1i3.1203>
- Sandström, A., Beland-Lindahl, K., Mielewczyk, M., Niedzialkowski, K., Nilsson, J., Malovrh, Š. P., Renaud-Bernath, P., Sotirov, M., & Uhan, Z. (2025). Combating new challenges with old political solutions? Policy responses to climate change and climate-induced disturbances in European forests. *Forest Policy and Economics*, 178, 103561. <https://doi.org/10.1016/j.forpol.2025.103561>
- Santoro, S., Pagano, A., Francesconi, W., Mello, D., & Giordano, R. (2025). Biodiversity-Climate-Society Nexus assessment through Participatory System Dynamics Model. The case study of Amazon forest-based value chain. *Science of The Total Environment*, 991, 179893. <https://doi.org/10.1016/j.scitotenv.2025.179893>
- Schulte to Bühne, H., Tobias, J. A., Durant, S. M., & Pettorelli, N. (2025). Land use configuration shapes climate change vulnerability of gallery forests in a savannah ecosystem. *Global Ecology and Conservation*, 59, e03533. <https://doi.org/10.1016/j.gecco.2025.e03533>
- Shivaprasad, K. M., Sowmya, M. S., Danakumara, T., Gowda, M. M., Kumar, R., Kumar, S. D., & Kumar, B. S. (2025). Chapter 4—Forest fire and its impact on forest biodiversity. In P. Saikia, A. Kumar, M. L. Khan, & X. Lei (Eds.), *Forests for Inclusive and*

- 
- Sustainable Economic Growth (pp. 37–53). Elsevier. <https://doi.org/10.1016/B978-0-443-31406-3.00004-7>
- Singh, C., Khanduri, V. P., & Singh, B. (2025). From forest to future: A sustainable perspective on bamboo's nexus with biodiversity, indigenous knowledge, ecological resilience, and current status in Northeast India. *Trees, Forests and People*, 22, 101028. <https://doi.org/10.1016/j.tfp.2025.101028>
- Timis-Gansac, V., Dinca, L., Tudose, N. C., Constandache, C., Murariu, G., Cheregi, G., Moțiu, P. T., & Derecichei, L. M. (2025). Community-based conservation in mountain forests: Patterns, challenges, and policy implications. *Trees, Forests and People*, 22, 101041. <https://doi.org/10.1016/j.tfp.2025.101041>
- Undaharta, N. K. E., Dharmawan, I. W. S., Pratiwi, Siregar, C. A., Narendra, B. H., Sitepu, B. S., Sari, N., Abywijaya, I. K., Wiratmoko, M. D. E., Irawanto, R., Nugroho, A., & Siregar, U. J. (2025). Harnessing genomics for conservation and restoration of tropical peat-swamp forests: A review of tools, applications, and strategies. *Trees, Forests and People*, 22, 101088. <https://doi.org/10.1016/j.tfp.2025.101088>
- Vigués Jorba, J., Scherrer, D., Duchenne, F., Zellweger, F., Gossner, M. M., & Bollmann, K. (2025). Differential responses of taxonomic, functional and phylogenetic multi-taxa diversity to environmental factors in temperate forest ecosystems. *Ecological Indicators*, 178, 113855. <https://doi.org/10.1016/j.ecolind.2025.113855>
- Williams, B. A., Metzger, J.-P., Krieger, J. M., & Rhodes, J. R. (2025). Integrate biodiversity and resilience into climate-driven forest restoration strategies for the Atlantic Forest. *One Earth*, 8(6), 101321. <https://doi.org/10.1016/j.oneear.2025.101321>
- Zhang, P., Ni, L., Alofaysan, H., Sultan, M. S., & Karimov, N. (2025). Forest restoration and biodiversity enhancement across China: Regional case insights into ecosystem function recovery and conservation outcomes. *Ecological Indicators*, 178, 113985. <https://doi.org/10.1016/j.ecolind.2025.113985>
- 

**Copyright Holder :**

© Choi Seojin et.al (2025).

**First Publication Right :**

© Journal of Selvicoltura Asean

**This article is under:**