

The Impact of Deforestation on Biodiversity Dynamics: A Study on Tropical Forest Ecosystems

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Abstract

This study aims to analyze the impact of deforestation on biodiversity dynamics in tropical forest ecosystems. The focus of the research is directed at changes in species composition, the loss of flora and fauna diversity, and their implications for ecosystem stability. The method used is a descriptive qualitative approach through literature review and analysis of various research results related to deforestation in tropical forest areas. Data was obtained from scientific journals, reports of environmental organizations, and relevant forestry policy documents. The results show that deforestation activities cause a significant decrease in the number of species due to the loss of natural habitats, fragmentation of forest areas, and disruption of the food chain. The change in biotic communities is characterized by a decline in the population of endemic species as well as an increase in the dominance of species that are more adaptive to environmental disturbances. In addition, deforestation also has an impact on ecosystem stability through the reduction of ecological functions such as nutrient cycling, carbon storage, and water management regulation. The findings of the study confirm that biodiversity sustainability is highly dependent on sustainable forest conservation and management efforts. Therefore, a habitat protection strategy, ecosystem restoration, and strengthening environmental policies are needed to minimize the negative impact of deforestation on tropical forest ecosystems.

Keywords: Deforestation, biodiversity, tropical forests, habitat fragmentation, ecosystem stability.

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INTRODUCTION

Tropical forests are one of the most complex and biodiverse ecosystems in the world. These ecosystems are home to millions of species of plants, animals, microorganisms, and various other organisms that interact with each other in a highly dynamic ecological network. The existence of tropical forests is not only important as a center for biodiversity, but also has global ecological functions, such as carbon storage, climate regulation, hydrological cycle control, soil protection, and the provision of natural resources for the surrounding community. Artaxo et al. (2022) explain that tropical forests play an important role in regulating the earth's

carbon, water, energy, and climate cycles, while Gibson et al. (2011) affirm that tropical primary forests have irreplaceable value in maintaining biodiversity.

Tropical forests have layered vegetation structures, ranging from forest floors, shrubs, lower canopies, to upper canopies. These structures create various ecological niches that allow many species to live, reproduce, and form ecological relationships such as predation, competition, symbiosis, pollination, and seed dispersal. The high variety of habitats within tropical forests makes this ecosystem very sensitive to environmental disturbances. When the structure of the forest changes, the ecological niche where various organisms live is also disturbed. Therefore, the destruction of tropical forests not only has an impact on the loss of vegetation cover, but also on the decline in habitat quality and the disruption of ecological processes that support the lives of various species.

In recent decades, the existence of tropical forests has come under increasing pressure due to human activities, especially massive deforestation. Deforestation is one of the most significant forms of land use change in affecting the structure and function of ecosystems. This activity is generally carried out for various interests, such as timber exploitation, agricultural land expansion, plantations, infrastructure development, mining, and industrial needs. While deforestation can provide economic benefits in the short term, the ecological impact is often much greater and lasts for the long term. Barlow et al. (2016) show that anthropogenic disturbances in tropical forests, including selective logging, fires, edge effects, and fragmentation, can magnify the loss of biodiversity conservation value compared to just looking at forest cover loss.

Biodiversity includes genetic variation, species variation, and ecosystem variation that are interconnected in forming a network of life. At the species level, deforestation can lead to population decline, habitat loss, reduced food sources, and an increased risk of local extinction. At the genetic level, a decrease in the number of individuals in a population can reduce the genetic variation required to adapt to changes in the environment. At the ecosystem level, deforestation can alter the composition of communities, disrupt the flow of energy, and weaken ecological functions that were previously balanced. Betts et al. (2017) found that global forest loss increases the risk of species threatening, especially in forest landscapes that were previously relatively intact.

The impact of deforestation becomes even more serious when it is followed by habitat fragmentation. Habitat fragmentation occurs when previously large and unified forest areas turn into small plots separated by farmland, roads, settlements, or other open areas. This condition causes the organism population to be isolated, so the movement of individuals between habitats becomes limited. As a result, reproductive opportunities decrease, genetic flow decreases, inbreeding risks increase, and the population's ability to adapt to environmental changes becomes weaker. Haddad et al. (2015) stated that habitat fragmentation can decrease biodiversity and disrupt ecosystem functions, including biomass and nutrient cycling.

In addition to causing species loss, deforestation also triggers changes in the structure of biotic communities. Species that have high adaptability to open or disturbed habitats tend to be more able to survive, while endemic species, habitat specialists, large in size, or dependent on certain microhabitat conditions are more susceptible to population decline. These changes can shift the composition of the community from a complex community to a simpler one dominated by opportunistic species. If these conditions continue, then the ecological functions previously carried out by various species may weaken or even disappear.

Changes in biotic communities also have an impact on ecological interactions. The loss of certain species can disrupt predation relationships, competition, mutualism, pollination, and seed dispersal. Neuschulz et al. (2016) show that human disturbance of forests can decrease the process of plant regeneration, especially in the early stages such as

pollination and seed dispersal which rely heavily on the interaction between plants and animals. This shows that the impact of deforestation is not only seen in the reduction in the number of species, but also in the disruption of ecological processes that maintain the sustainability of ecosystems.

Disturbances in ecological interactions can reduce ecosystem stability. Ecosystem stability is related to the ability of an ecosystem to maintain its structure and function when faced with disturbances. Tropical forests that have high biodiversity generally have more complex ecological networks, so they are better able to maintain a balance of ecosystem functions. However, when deforestation removes key species or disrupts relationships between organisms, the ecosystem's ability to recover from disturbances becomes weaker. Marjakangas et al. (2020) show that tropical forest fragmentation can reduce mutualistic interactions between plants and animals, particularly seed dispersal interactions that are important for forest regeneration.

Deforestation is also closely linked to changes in climate and carbon functions. Tropical forests store carbon in the biomass of vegetation and soil, so their damage can release carbon into the atmosphere while reducing the ability of ecosystems to absorb carbon. Li et al. (2022) explain that deforestation not only reduces forest biomass directly, but can also trigger regional climate change in the form of increased temperatures and drying, which in turn decreases the ability of remaining forests to store carbon. Thus, deforestation has a dual impact, namely reducing biodiversity while weakening the function of forests in mitigating climate change.

Based on these conditions, it is important to study the impact of deforestation on biodiversity dynamics in tropical forest ecosystems. This research focuses not only on species loss, but also on changes in biotic communities and ecosystem stability as a consequence of deforestation activities. By understanding the relationship between deforestation, habitat fragmentation, community change, and ecosystem stability, the results of this study are expected to provide a scientific basis for more sustainable forest management. In addition, this research can also be considered in the development of conservation strategies that not only emphasize the protection of forest cover, but also on the maintenance of habitat quality, landscape connectivity, and the sustainability of the ecological function of tropical forests.

Thus, this study aims to examine the impact of deforestation on biodiversity dynamics in tropical forest ecosystems. The main focus of the research includes species loss, changes in biotic communities, and ecosystem stability as a consequence of deforestation activities. The results of this study are expected to strengthen scientific understanding of the importance of tropical forest conservation and support efforts to manage forest resources in a sustainable manner.

RESEARCH METHODS

This study uses a descriptive qualitative approach with a literature study method. A descriptive qualitative approach is used to provide an in-depth overview of the impact of deforestation on biodiversity dynamics in tropical forest ecosystems. The literature study method was chosen because this research relies on the search, collection, and assessment of various scientific sources relevant to the research topic. Data in this study were obtained from national and international journal articles, reports from conservation agencies, government documents, and publications from environmental organizations that discuss the issues of deforestation, habitat destruction, biotic community change, and biodiversity decline. These sources are used as a basis for understanding the relationship between deforestation activities and changes in ecological conditions in tropical forests.

The process of data collection and analysis is carried out through several systematic stages. The first stage is the identification of data sources by browsing the literature related to

deforestation and biodiversity. The second stage is literature selection based on the suitability of the topic, relevance of the discussion, quality of sources, and the relevance of the data to the focus of the research. Findings from various literature were then grouped by main themes, namely species loss due to deforestation, changes in the structure of biotic communities, and the impact of deforestation on the stability of tropical forest ecosystems. This grouping is carried out so that the data obtained can be analyzed in a directional manner and in accordance with the purpose of the research.

Data analysis is carried out by comprehensively interpreting findings from various sources to obtain a complete understanding of the phenomenon being studied. Each information obtained is compared and associated with the focus of the research, so that it can be seen the pattern of relationships between deforestation, habitat loss, species population decline, changes in biotic communities, and disturbances to ecosystem stability. This approach was chosen because it allows researchers to obtain a broad picture of the impact of deforestation on biodiversity based on a variety of different geographical and ecological contexts. Thus, the literature study method in this study can provide a strong scientific basis to explain the problem of deforestation and its implications for the sustainability of tropical forest ecosystems.

RESULTS AND DISCUSSION

The results of the literature review show that deforestation has a broad impact on the dynamics of biodiversity in tropical forest ecosystems. The impact is not only limited to the reduction of the number of species, but also includes changes in the composition of biotic communities, disruptions of ecological interactions, and weakening of ecosystem stability. Deforestation causes changes in habitat conditions directly through loss of vegetation cover, fragmentation of forest areas, and a decline in environmental quality. These conditions affect the ability of organisms to survive, reproduce, and carry out their role in maintaining the balance of the ecosystem. Therefore, the discussion in this study is focused on three main aspects, namely species loss due to deforestation, changes in biotic communities, and their impact on the stability of tropical forest ecosystems.

Species Loss Due to Deforestation

The loss of species not only impacts the reduction of biodiversity wealth, but also eliminates the ecological functions carried out by the organism. Each species has a specific role in the ecosystem, whether as a producer, consumer, predator, pollinator, seed disperser, or decomposer. If a species is lost, the ecological function it performs can be weakened or irreplaceable by other species. For example, the loss of seed-spreading animals can inhibit the regeneration of forest plants, while the loss of predators can lead to an imbalance in prey populations. Thus, the loss of species due to deforestation is an ecological problem that has a wide impact on the sustainability of tropical forest ecosystems.

Biotic Community Changes

Deforestation also causes significant changes in the composition of biotic communities. A biotic community is a collection of various organisms that live and interact with each other in an ecosystem. In intact forest conditions, biotic communities are formed through complex ecological relationships between plants, animals, microorganisms, and their physical environment. However, when forests are logged, the habitat structure changes so that the ecological relationship between organisms is disrupted. These changes can shift the

makeup of the community from a diverse and balanced state to a simpler and more unstable one.

Habitat fragmentation is one of the important impacts of deforestation. Fragmentation occurs when a previously large and unified forest area splits into small, separate parts. This condition causes previously interconnected populations of organisms to become isolated. Such isolation can limit the movement of individuals, inhibit genetic exchange, and decrease the chances of reproduction between individuals in a population. In the long term, fragmentation can weaken population resilience as genetic diversity decreases and the risk of local extinction increases.

Changes in biotic communities are also characterized by a decline in species sensitive to environmental disturbances and an increase in opportunistic or invasive species. Sensitive species typically require stable habitat conditions, tight vegetation cover, and the availability of certain resources. In contrast, opportunistic species are better able to survive in habitats that are disturbed, open, or undergo changes in vegetation structure. When forests are cut down, opportunistic species can develop more quickly due to reduced natural competitors and the opening up of new spaces for colonization. If this condition continues, the balance of the community may change and the dominance of certain species becomes stronger.

Changes in biotic communities are also seen in the reduced presence of apex predators. Apex predators have an important role in controlling prey populations and maintaining the balance of the food chain. When apex predators decline due to habitat loss or reduced food sources, populations of certain prey can increase uncontrollably. Such population explosions can put additional pressure on vegetation or other organisms in the ecosystem. These changes suggest that deforestation can disrupt trophic structures, which are the eating and eating relationships that are the basis for ecosystem balance.

In addition, disturbances to pollinators and seed spreaders can inhibit the regeneration of forest vegetation. Many tropical forest plants rely on specific animals to help with the pollination and seed dispersal process. If these animals experience a decline in population, the natural regeneration process of the forest can be disrupted. As a result, the composition of forest vegetation can change, the number of young plants decreases, and the forest's ability to recover after disturbance becomes weaker. Thus, changes in biotic communities due to deforestation occur not only in the number and type of species, but also in the ecological functions that sustain the sustainability of ecosystems.

Impact on Ecosystem Stability

Biodiversity has an important role in maintaining ecosystem stability. Ecosystems that have a high level of biodiversity generally have a greater ability to withstand environmental disturbances because each species performs a specific ecological function. Species diversity allows for a balancing mechanism when one of the components of the ecosystem is disrupted. However, as deforestation leads to reduced biodiversity, the ecosystem's ability to maintain its structure and function becomes increasingly weak.

Deforestation makes tropical forest ecosystems more vulnerable to climate change, pest attacks, diseases, soil erosion, floods, and other ecological disasters. The loss of vegetation cover leads to an increase in surface temperature, a decrease in humidity, as well as a change in water flow patterns. These conditions can affect organisms that depend on the stability of the forest microclimate. In addition, reduced vegetation also reduces the soil's ability to absorb and store water, increasing the risk of surface runoff and flooding. At the same time, soils that are no longer protected by forest roots and litter are more susceptible to erosion.

The decline in the number of species also has an impact on weakening ecosystem functions, such as nutrient cycling, decomposition of organic matter, carbon storage, and water system regulation. Decomposing organisms, for example, play an important role in decomposing organic matter and returning nutrients to the soil. If the decomposition community is disrupted, then the nutrient cycling process can slow down and soil fertility decreases. Similarly, the loss of forest vegetation can decrease the ability of ecosystems to store carbon. This has the potential to accelerate the increase in greenhouse gas concentrations in the atmosphere and exacerbate the impacts of climate change.

Ecosystem stability is also influenced by the sustainability of ecological interactions between species. The loss of one species can affect other species that have a direct or indirect relationship with it. For example, a decline in pollinator populations can decrease the reproductive success of certain plants. The decline of such plants can then affect animals that depend on fruits, seeds, or leaves as a food source. Thus, the impacts of deforestation can spread through ecological networks and cause wider disruptions to ecosystems.

Overall, the results show that the impact of deforestation not only occurs at the species level, but also affects the structure of biotic communities and the stability of the ecosystem as a whole. Deforestation causes habitat loss, decreases species populations, changes the composition of communities, disrupts ecological interactions, and weakens ecosystem functions. Therefore, tropical forest conservation is an important step in maintaining the sustainability of ecological functions and the existence of biodiversity. It is not enough to protect forests only by maintaining the area of forest cover, but also needs to pay attention to the quality of habitat, connectivity between forest areas, and the sustainability of the ecological processes that occur in them.

CONCLUSIONS AND SUGGESTIONS

Conclusion

Based on the results of the study, it can be concluded that deforestation has a significant impact on the dynamics of biodiversity in tropical forest ecosystems. These impacts can be seen from species loss, declining organism populations, changes in the structure of biotic communities, and disruption of ecosystem stability. Species with limited distribution, specific habitat needs, and low adaptability are the groups most vulnerable to habitat destruction due to deforestation.

Deforestation also causes habitat fragmentation that separates organism populations into small, isolated groups. This condition can reduce genetic flow, decrease reproductive opportunities, and increase the risk of local extinction. In addition, changes in biotic communities due to the dominance of opportunistic species and the reduction of sensitive species can disrupt the balance of the food chain, pollination processes, seed dispersal, and regeneration of forest vegetation.

The impact of deforestation on ecosystem stability can be seen from the weakening of ecological functions, such as nutrient cycling, decomposition of organic matter, carbon storage, water management, and soil protection from erosion. Thus, deforestation not only impacts the loss of vegetation cover, but also threatens the sustainability of tropical forest ecosystems as a whole. Therefore, the protection and sustainable management of tropical forests is an important need to maintain biodiversity and its ecological function.

Suggestions

Based on the results of the discussion, more targeted and sustainable efforts to conserve tropical forests are needed. The government, conservation agencies, communities, and related parties need to strengthen the protection of forest areas that have high biodiversity value, especially the habitats of endemic and endangered species. Supervision of forest logging activities also needs to be increased so that the use of forest resources does not exceed the carrying capacity of the ecosystem.

In addition, forest management should not only focus on the area of forest cover, but also pay attention to the quality of habitats and connectivity between forest areas. Efforts to restore and rehabilitate damaged forest areas need to be carried out by planting local species that are in accordance with the characteristics of the local ecosystem. Habitat connectivity also needs to be maintained through the construction of ecological corridors so that animal movement, genetic exchange, and natural regeneration processes continue.

Further research is recommended to use field data so that the impact of deforestation on biodiversity can be analyzed more specifically based on location, species type, and habitat degradation. Follow-up studies can also combine ecological, social, and economic approaches so that tropical forest management strategies can be designed more comprehensively. Thus, the results of research are not only beneficial for the development of science, but can also be the basis for the formulation of sustainable forest conservation and management policies.

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