

The Impact of Deforestation of Protected Forests on Flood Disasters in North Sumatra

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Abstract:

Deforestation of protected forests is one of the environmental issues contributing to the increased risk of hydrometeorological disasters, particularly floods. This study aims to examine the impact of protected forest deforestation on flood risk in North Sumatra. The research employs a qualitative descriptive approach through a literature review, utilizing secondary data from scientific journals and official reports. The findings indicate that deforestation disrupts the hydrological functions of forests, such as reducing soil permeability and increasing surface runoff, which in turn elevates the frequency and intensity of floods. The resulting impacts include environmental degradation, declining public health, loss of natural habitats, infrastructure damage, and economic disruption. Therefore, this study highlights the importance of sustainable forest management and the implementation of effective disaster mitigation strategies.

Keywords:

Deforestation, Protected forests, Floods, North Sumatra

Introduction

Forest Areas Play A Vital Role In Sustaining The Survival Of All Living Creatures. In Addition To Serving as carbon sinks and oxygen producers, forests also provide habitats for various ecosystems that help maintain environmental balance.

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However, development activities across various sectors have led to forest degradation, which ultimately disrupts the natural balance and triggers the emergence of large-scale environmental disasters. Forests are vast areas covered with diverse tree species, whose existence is crucial for humans as they help maintain environmental stability. Based on dominant vegetation, forests can be classified into several types. Trees growing in forest areas play a role in preventing erosion, absorbing carbon dioxide, enhancing soil fertility, providing habitats for various species, storing rainwater reserves, and reducing wind speed. These various functions demonstrate the immense benefits of forests for life (Purwanto & Alam, 2021).

Data from the Ministry of Forestry shows that in 2024, the total area of forested land in Indonesia reached 95.5 million hectares, or approximately 51.1% of the total land area. Of this total, approximately 87.8 million hectares, or 91.9%, are located within forest areas. Forest areas in Indonesia consist of several categories, including protected forests, conservation areas, nature reserves, recreational forests, permanent and limited-use production forests, and production forests eligible for conversion (RI, 2025).

Forest protection in Indonesia is regulated by Law No. 41 of 1999 on Forestry, the implementation of which is reinforced through a number of subsidiary regulations, particularly Government Regulation No. 45 of 2004 on Forest Protection and Government Regulation No. 23 of 2021 on Forestry Management (BPK RI, 1999). These regulations serve as the legal basis for efforts to prevent forest degradation, protect forest rights, involve the community, and regulate the functions of forest areas, including protected forests and conservation areas (BPK RI, 1999).

In Indonesia, the high rate of deforestation and forest degradation has led to increasingly alarming forest damage. Deforestation is the process of permanent loss of forest areas due to logging and land clearing for conversion into non-forest areas, such as agriculture, settlements, plantations, and infrastructure development. The reduction in vegetation cover, which plays a role in maintaining ecological balance, occurs due to logging practices, large-scale timber exploitation, and land conversion into oil palm plantations, mining areas, and settlements. The impacts of deforestation and forest degradation not only degrade soil quality and biodiversity but also damage ecosystems and exacerbate climate change at the local level. Additionally, high rates of deforestation contribute to increased greenhouse gas emissions, leading to changes in rainfall patterns

and heightened climate uncertainty (Zahra, 2025). Uncontrolled deforestation also accelerates erosion and river sedimentation, thereby reducing water flow capacity. The development of settlements and infrastructure in riverbank areas and water catchment zones further narrows river channels and increases surface runoff, ultimately heightening the risk of flooding (Yuri, 2025).

Flash floods and landslides triggered by the deforestation of protected forests occurred in the regions of West Sumatra, North Sumatra, and Aceh in late November 2025, causing extensive damage. Heavy rainfall that lasted for several days caused rivers to overflow and hillsides to collapse. As a result, hundreds of villages were submerged by floodwaters, critical infrastructure was damaged, and the disaster claimed hundreds of lives (Nugroho, 2025). The National Disaster Management Agency (BNPB) reported that the number of victims from flash floods and landslides in Aceh, West Sumatra, and North Sumatra continued to rise. As of November 2025, a total of 2,726 hydrometeorological disaster events were recorded, including flash floods (Allya, 2025). In response to these conditions, the Governors of West Sumatra, North Sumatra, and Aceh simultaneously declared a 14-day state of emergency starting from late November 2025.

Deforestation occurring in the protected forest areas of North Sumatra is one of the primary factors contributing to the increased frequency and severity of flood disasters. The decline in the ecological functions of forests, particularly in regulating water flow and preventing erosion, directly increases the region's vulnerability to hydrometeorological disasters. Therefore, a study on the impact of protected forest deforestation on flood events is critically important and urgently needed. This research is necessary to gain a comprehensive understanding of the relationship between deforestation and flooding, as well as to provide a scientific basis for formulating forest protection policies and more effective and sustainable disaster mitigation strategies.

Methodology

This study employs a descriptive research method to examine the impact of protected forest deforestation on flood disasters in North Sumatra. This is a qualitative study in the form of a literature review (library research). The qualitative methodology is based on references from several journals addressing similar themes. (Badriyah et al., 2023). The data used in this paper are secondary, obtained from previous studies and

research cited in accordance with scientific writing standards. Meanwhile, the data analysis technique used is qualitative descriptive analysis, which aims to examine the core issues surrounding the development of scientific knowledge within society by optimizing data examination techniques in the research process (M. Husnulloil et al, 2024).

Result and discussion

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1. Degradation of Surface Water Quality

Deforestation in the protected forest areas of North Sumatra plays a significant role in the occurrence of flash floods due to the disruption of the forest's hydrological functions. The loss of vegetation cover reduces the canopy's ability to retain and evaporate rainwater, decreases soil permeability due to damage to the root system and litter layer, and weakens the evapotranspiration process that should release water gradually. These conditions cause surface runoff to increase drastically and trigger a rapid surge in river discharge in the upstream areas of river basins (DAS), such as the Batang Toru and Gunung Leuser National Park regions, which have experienced widespread deforestation since 2016. The impact was evident in the severe hydrometeorological disasters that occurred in November–December 2025 in Central Tapanuli, North Tapanuli, and Langkat, which damaged thousands of settlements and destroyed infrastructure due to floods and landslides. Additionally, the floods carried sediment, eroded material, and pollutants that degraded water quality, clogged the water supply systems of the public water utility (PDAM), and contaminated reservoirs and groundwater. In the long term, reduced groundwater recharge due to declining forest cover causes many mountain springs to dry up during the dry season, triggering a cycle of floods and droughts that exacerbates the water availability crisis in downstream areas.

2. Deterioration in Public Health

Flooding in North Sumatra has led to a decline in public health due to a surge in cases of infectious diseases such as diarrhea, fever (including dengue fever), acute

respiratory infections, pneumonia, skin infections, hepatitis A, and leptospirosis. These are caused by standing water—which serves as a breeding ground for mosquitoes and bacteria—poor sanitation, limited access to clean water, contaminated food, and overcrowded evacuation centers with minimal hygiene. Damaged health facilities, including 3 hospitals and 37 community health centers, are hindering access to medical care, while stress, malnutrition, exposure to cold, and overcrowding are exacerbating chronic conditions such as diabetes and COPD. Ministry of Health data records hundreds of cases of fever, dyspepsia, and hypertension from late November to early December 2025, with the risk of long-term outbreaks rising by up to 400% for cough and fever in areas like Tuli Taha if sanitation is not immediately improved, making emergency prevention measures - including clean water distribution and refugee camp monitoring—essential .

3. Loss of Natural Habitats for Endemic Species

Large-scale deforestation on Indonesia's major islands has led to the shrinking of natural habitats, causing various species of flora and fauna to lose the space they need to live and reproduce, which ultimately increases the risk of extinction due to the limited remaining forest areas. Global conservation reports indicate that millions of species are highly dependent on forest ecosystems; thus, forest degradation has the potential to threaten the sustainability of the web of life that supports the overall balance of nature. Duenas et al. (2021) emphasize that habitat loss resulting from deforestation significantly endangers species that rely on forests as their primary habitat. The lack of suitable habitat leads to population decline and increases the likelihood of extinction. Sumatra Island itself serves as a habitat for several rare species, such as the Sumatran tiger, elephant, rhinoceros, and orangutan. The tangible impact of this environmental damage is evident from the discovery of a Tapanuli orangutan that died buried in mud in Central Tapanuli, North Sumatra, as well as a Sumatran elephant that perished in Pidie Jaya, Aceh, due to the flash floods that occurred in late November 2025.

4. Infrastructure Damage

The flash floods that struck North Sumatra reflect the systemic destruction occurring gradually due to massive deforestation in protected forest areas,

particularly the Batang Toru Watershed and Gunung Leuser National Park, which have weakened the ecological functions of water and sediment control. Extreme rainfall triggered a surge in river flow rates of 5–10 times the normal level, with flow speeds of 5–10 m/s carrying large amounts of eroded sediment, debris from illegal logging, and hazardous materials, causing walls to collapse, eroding building foundations, and submerging thousands of homes by more than 1.5 meters in the Central Tapanuli and North Tapanuli regions, resulting in the displacement of tens of thousands of residents. Further impacts were evident in the damage to transportation infrastructure, including the collapse of the Trans-Sumatra Highway in Langkat Regency over hundreds of kilometers, which cut off inter-regional access, hindered logistics distribution and evacuations, and isolated communities from food and medical supplies. In the education sector, more than 50 educational facilities—from elementary schools to university branches—in Langkat and South Tapanuli suffered severe damage or were completely destroyed, with learning facilities submerged in 1–2 meters of mud contaminated with agricultural chemicals, halting educational activities for months and increasing the risk of school dropouts and psychological trauma among thousands of students. At the same time, primary healthcare services have ground to a halt as community health centers and clinics lost medical equipment, medicines, and vaccines due to floodwaters contaminated with sewage, just as cases of injuries and infections surged sharply, while damage to over 100 places of worship—such as mosques, prayer halls, churches, and Buddhist temples—marked by collapsed roofs, cracked walls, and floors covered in thick mud, eliminated their functions as both places of worship and centers for solidarity and aid distribution, thereby significantly weakening community social resilience, particularly in areas with a subsistence agricultural base.

5. Paralysis of the Local Economy

The economic paralysis in the local economy caused by flash floods in North Sumatra represents a systemic disruption that has developed gradually as a consequence of massive deforestation in protected forest areas, particularly the Batang Toru Watershed and Gunung Leuser National Park. The initial impact was evident in the agricultural sector, as contaminated floodwaters submerged over

10,000 hectares of productive land—including rice paddies and oil palm plantations—resulting in crop damage and livestock deaths, with estimated losses reaching Rp2 trillion, disrupting local food supply chains and driving up prices of staple goods by 15–20%. Furthermore, the micro, small, and medium-sized enterprise (MSME) sector—which includes traditional market vendors, coastal fishermen, and home-based businesses—suffered near-total paralysis due to the loss of inventory swept away by floods, markets covered in mud, and a drastic decline in purchasing power resulting from the halt of daily income, with total capital losses estimated at Rp500 billion. At the same time, the tourism industry—particularly ecotourism around Gunung Leuser National Park—has seen a 70% drop in visitor numbers due to damaged accessibility and the degradation of the destination's image, directly impacting the loss of seasonal income for homestays, local guides, and food businesses that support thousands of households. This situation is exacerbated by a 40% drop in labor productivity in regions with low per capita regional GDP, alongside the rising number of approximately 50,000 temporarily unemployed displaced persons, disruptions in inter-regional goods distribution, and the massive reconstruction needs estimated at Rp5–7 trillion, which burden the provincial Regional Revenue and Expenditure Budget (APBD). In the medium to long term, prolonged economic stagnation deepens structural poverty through increased hidden unemployment, weakened regional competitiveness, and growing dependence on belated central government aid, thereby significantly hindering the economic recovery trajectory of vulnerable communities reliant on the subsistence agricultural sector.

Conclusion

Deforestation of protected forests in North Sumatra has been shown to have a significant influence on the increasing frequency and severity of flood disasters, especially in the Batang Toru Watershed and the Gunung Leuser National Park area. The loss of vegetation cover causes damage to the hydrological function of forests, such as decreased soil permeability, reduced rainwater interception ability, and increased surface runoff which triggers a rapid surge in river discharge. These conditions increase the risk of flash floods and landslides, especially when there is high rainfall, as reflected in the

hydrometeorological disaster that hit a number of areas of North Sumatra at the end of November 2025.

The impact of floods due to deforestation is not only limited to environmental damage, but also extends to various aspects of people's lives, including degradation of water quality, declining public health, habitat loss of endemic species, damage to infrastructure, and paralysis of the local economy. These findings confirm the strong influence between protected forest deforestation and increased flood risk in North Sumatra. Therefore, more assertive efforts to protect protected forests, control land use transfer, and implement integrated and sustainable disaster mitigation strategies are needed as the basis for the formulation of environmentally sound development policies. This study has limitations because it only uses secondary data without being supported by field data. In addition, the focus of the research is limited to the North Sumatra region. Further research is recommended to use a quantitative approach and expand the scope of the area so that the results are more comprehensive.

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Disclosure statement

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