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Batak Local Wisdom: Foundation for Disaster Mitigation and Human-Nature Harmony in North Sumatra

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ABSTRACT

The November 2025 floods and landslides in North Sumatra, claiming over 375 lives, reveal the catastrophic consequences of systematically ignoring Batak indigenous ecological knowledge amid massive deforestation of 1.6 million hectares (1990-2015) driven by palm oil expansion and tourism infrastructure development.This qualitative study employs interdisciplinary literature review and content analysis, synthesizing socio-cultural, ecological, and political dimensions from peer-reviewed journals and government reports. Batak cosmological concepts (Boru Deak Parujar, Hariara Sundung di Langit) embody empirically validated ecological principles governing forest zonation, watershed management, and disaster-prone area identification. Political ecology analysis exposes structural inequalities in forest governance (Law No. 41/1999) that systematically marginalized community-based management, enabling extractive industries to operate with impunity. Integration of indigenous knowledge with modern science requires paradigmatic transformation from anthropocentrism to ecocentrism, operationalized through formal recognition of customary law, establishment of multi-stakeholder Watershed Councils with veto authority, Ecological Fiscal Transfer mechanisms, and mainstreaming ecological performance indicators in government accountability systems.This study provides the first comprehensive political ecology framework linking Batak indigenous knowledge erosion with disaster vulnerability, offering concrete institutional mechanisms for knowledge integration beyond normative advocacy.

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1. Introduction

The natural disaster phenomena that struck the Tapanuli region and its surroundings since November 24, 2025, have resulted in significant material losses and numerous casualties. According to data from the National Disaster Management Agency as of January 6, 2026, at least 13,540 people were forced to evacuate due to flash floods and landslides that hit four districts in North Sumatra (Pemerintah Kabuoaten Tapanuli Selatan, 2026). This disaster is not an isolated

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singular event, but rather part of a long series of environmental degradation that has been ongoing for decades in North Sumatra and its surrounding areas. Environmental organizations such as the Indonesian Forum for the Environment (WALHI) North Sumatra believe that these disasters cannot be separated from forest destruction caused by massive logging and mining activities that disregard environmental ecosystems in the Sumatra region (WALHI, 2025).

The irony is that economic development has been moving in the opposite direction to environmental sustainability principles. Massive development of tourism destinations and plantations has triggered infrastructure development without considering environmental carrying capacity and local knowledge systems that have proven to maintain ecological balance for centuries. Land clearing for hotels and resorts on hillsides that local tradition considers prohibited for construction, forest clearing for road development and tourism facilities, as well as environmental pollution from tourism waste represent forms of violations against local wisdom principles that have maintained the region's ecological balance for centuries (Bukit et al., 2025).

This condition becomes increasingly concerning when placed in the context of massive deforestation that has plagued North Sumatra over the past three decades. Basyuni et al. (2018) reported that North Sumatra experienced forest cover loss reaching approximately 1.6 million hectares during the 1990-2015 period. Of the 33 districts or cities in this province, 25 districts experienced deforestation, with the highest rates occurring in Labuhanbatu and South Labuhanbatu Districts, reaching 2,238.08 and 1,652.55 hectares per year respectively. Forest cover decreased from 32.79% in 1990 to only 25.27% in 2015, while non-forest land increased significantly from 66.57% to 74.11% during the same period. Oil palm plantation expansion became the main contributor to deforestation, contributing 39.37% to forest conversion, with plantation areas increasing from 999,596.12 hectares in 1990 to 1,233,929.56 hectares in 2015.

In fact, the Batak Toba community possesses a complex traditional knowledge system in understanding and managing their environment. This knowledge is manifested in the form of myths, rituals, and cultural practices that have been passed down through generations for centuries. The concept of Debata Mulajadi Nabolon and Siboru Deak Parujar as entities governing earth, land, and forests reflects a profound understanding of the interdependence between humans and nature (Setiawan et al., 2024). However, in the era of modernization and rapid tourism infrastructure development, this traditional knowledge is increasingly marginalized and considered irrelevant to contemporary scientific approaches. Mythology that should serve as guidance in environmental management is now merely regarded as ancient legends lacking empirical basis.

This research departs from the premise that the Batak community's traditional environmental knowledge is not merely irrational beliefs or superstitions, but rather the result of extensive empirical observation of natural patterns in specific geographic regions. As articulated by Sukmawan and Setyowati (2021), mythology can encapsulate traditional ecological knowledge and promote sustainable practices. This knowledge has developed through trial and error processes conducted by previous generations in facing environmental dynamics, including cyclical natural disasters. Therefore, this research aims to explore how the local wisdom values of the Batak community, particularly those contained in their mythology and traditional belief systems regarding nature, can serve as an important foundation in natural disaster mitigation efforts in North Sumatra.

The urgency of this research lies in the critical condition of regions facing dual threats of climate change and intensive anthropogenic pressure. With the increasing frequency and intensity of hydrometeorological disasters in this region, a comprehensive approach is needed that does not solely rely on technocratic solutions, but also integrates local knowledge that has been tested for centuries. As found in research conducted by Atmadja (2010), where Balinese communities possess a holistic perspective integrating sekala and niskala dimensions in understanding the environment, similar concepts are also found in Batak tradition. This approach offers an alternative to the anthropocentric paradigm that has proven to fail in preventing environmental degradation and increasing disaster risk.

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Although there have been studies on local wisdom in environmental management in Indonesia, there exists a significant research gap regarding Batak local wisdom in disaster mitigation. First, existing studies such as Harahap et al. (2022) and Setiawan et al. (2024) remain descriptive-normative without empirical validation of the effectiveness of traditional practices in reducing disaster risk. Second, there has been no in-depth study on the dynamics of traditional knowledge transmission across generations amid modernization pressures, although Prayitno et al. (2025) demonstrate that modern economic factors can override traditional wisdom principles. Third, literature advocating the integration of local wisdom with modern science, such as Hasbiah (2015) and Rahman & Jalaluddin (2022), has not yet provided a concrete operational framework regarding institutional mechanisms and governance models to realize such integration in disaster mitigation systems. Fourth, political ecology analysis of power relations in natural resource management remains limited in the specific context of Batak communities, so strategies for strengthening indigenous communities' bargaining position in facing extractive pressures have not been adequately explored. This research attempts to fill these gaps through comprehensive synthesis among ecological perspectives, political ecology, and cultural anthropology to provide holistic understanding of the relevance of Batak local wisdom as a foundation for disaster mitigation amid contemporary ecological crisis.

2. Research Method

This research employs a qualitative approach using literature review methods and content analysis of various sources relevant to an interdisciplinary perspective that integrates social, cultural, ecological, and political dimensions. The qualitative approach was chosen because it allows researchers to explore deep understanding of complex phenomena involving dynamic interactions among traditional knowledge systems, cultural practices, ecological processes, and socio-political contexts simultaneously.

The literature review method is used to collect and analyze secondary data from various written sources covering several main dimensions. From the socio-cultural dimension, this research examines ethnographic research on Batak communities, studies on traditional knowledge systems and local wisdom, documentation of mythology and rituals related to environmental management, as well as analysis of social transformation and shifts in cultural values within the modernization context. From the ecological dimension, this research analyzes ecological and geographical studies of the Lake Toba area as a representation of geological objects, studies on ecosystem services and ecological functions of forests and vegetation, research on hydrometeorology and natural disaster risks in North Sumatra, as well as literature on the impacts of land use change on ecosystem functions. Meanwhile, from the political dimension, this research examines environmental governance and legal recognition of customary law systems, as well as research on power dynamics in natural resource management among the state, corporations, and indigenous communities. Research data sources include scientific articles from peer-reviewed national and international journals, and official reports from relevant government agencies.

Data analysis is conducted through an interpretive approach by identifying main themes emerging from various literatures, triangulating different sources to validate findings, analyzing the compatibility between local wisdom principles and modern ecological concepts, as well as exploring socio-political contexts that influence the application or neglect of local wisdom in development practices. This interdisciplinary approach enables researchers to holistically understand how Batak local wisdom not only contains valid ecological knowledge, but is also embedded in socio-cultural structures and influenced by broader political-economic dynamics..

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3. Results and Discussion

3.1. Geographical and Ecological Context of North Sumatra as the Crisis Background

The geomorphological characteristics of North Sumatra, dominated by hilly to mountainous topography with varying slope gradients, make this region highly vulnerable to hydrometeorological disasters. Rahayu et al. (2020) identified that areas with steep slopes (30-45 degrees) and very steep slopes (more than 45 degrees) are widely distributed across districts such as South Tapanuli, Mandailing Natal, Humbang Hasundutan, Central Tapanuli, North Tapanuli, South Nias, West Nias, Padang Lawas, Toba Samosir, Langkat, Samosir, Pakpak Bharat, and Karo. The combination of steep topography and high rainfall exceeding 3000 mm per year in several areas creates conditions highly susceptible to landslides and flash floods.

Further spatial analysis reveals a strong correlation between deforestation locations and disaster concentrations. Samosir et al. (2025) confirmed that districts with very high landslide vulnerability possess characteristics comprising a combination of slope gradients above 30%, high-intensity rainfall, Andosol and Oxisol soil types prone to erosion, as well as extrusive volcanic rocks that weather easily. More than 52% of North Tapanuli District falls into the very high vulnerability category, with another 42% in the high vulnerability category. These geographical conditions make the region a hotspot for hydrometeorological disasters.

The impact of deforestation on the hydrological functions of watersheds is also well documented. Prihantarto et al. (2025) reported that land cover changes due to flash floods in Simangulampe showed consistent degradation patterns, where open land increased by 9.86 hectares in the downstream zone due to debris material deposition, while in the middle watershed zone there was an increase of 5.48 hectares in open land due to erosion and landslides. Loss of vegetation with low to medium density reached 4.69 hectares and 1.93 hectares respectively, which previously functioned as surface runoff buffers and erosion barriers.

This geographical context demonstrates that the Lake Toba region and its surroundings are not isolated cases, but rather part of a broader ecological crisis in North Sumatra. Massive loss of forest cover has reduced soil infiltration capacity, increased surface runoff, and diminished watershed carrying capacity in regulating water systems. This condition validates the urgency to integrate Batak local wisdom that has historically proven to maintain the region's ecological balance through forest zonation systems, prohibitions against logging in critical zones, and sustainable agroforestry practices.

3.2. The Conception of Mother Earth in Batak Cosmology and Modern Ecological Relevance

The Batak Toba community possesses a profound conception of earth as a living entity requiring respect and care. In Batak cosmology, earth is personified as Boru Saniang Naga or Boru Deak Parujar, representing the feminine manifestation of cosmic forces governing life on earth. This conception parallels the concept of Mother Earth or Earth Mother found in various world traditions, as documented in cross-cultural research on earth mythology (Secheșan, 2013). Understanding earth as a life-giving mother is not merely a spiritual metaphor, but rather reflects recognition of humanity's fundamental dependence on ecological systems that sustain life.

In Batak creation narratives recorded in various manuscripts and oral traditions, Boru Deak Parujar is depicted as a goddess who taught her descendants to care for the earth and all its contents. Setiawan et al. (2024) noted that the Batak Toba community regards land, water, and forests as inseparable entities from human life, and therefore must be maintained with full responsibility. This conception contains fundamental ecological principles aligned with modern understanding of ecosystem interdependence and ecosystem services that support human life. Research by Roy (2020) demonstrates that in various traditions, including Balinese Hinduism, the concept of Mother

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Earth reflects understanding of the reciprocal relationship between humans and environment, where maintaining harmony with nature becomes a prerequisite for human welfare.

The Batak community's understanding of earth as a living entity possessing will and capable of responding to human actions reflects what in modern terminology is called ecosystemic thinking. In this perspective, humans are not masters or conquerors of nature, but rather integral parts of a broader ecological system. When the Batak community performs rituals to honor nature or conducts ceremonies at sacred places such as springs and sacred forests, they are essentially affirming their dependence on ecological functions provided by vegetation and hydrology. Tri et al. (2022) analyzed the theo-ecological meaning of traditional ceremonies as expressions of gratitude to the Creator that simultaneously function as environmental conservation practices. These ceremonies are not merely religious rituals without ecological significance, but constitute cultural mechanisms that reinforce social norms supporting conservation. When traditional ceremonies prohibiting tree felling in sacred places or regulating land clearing timing are conducted, these ecological norms are transmitted and reinforced in the community's collective consciousness.

From a modern ecological perspective, the conception of Mother Earth in Batak tradition can be understood as a symbolic representation of the life support system that provides various ecosystem services essential for human survival. These ecosystem services include provisioning of resources such as clean water, food, and timber, climate and water cycle regulation, water and air purification, as well as cultural and spiritual functions. When the Batak community treats certain places as sacred locations that must not be disturbed, they are essentially establishing conservation zones that protect critical ecological functions. Research by Harahap et al. (2022) demonstrates that Batak Toba traditional wisdom in maintaining the Lake Toba ecosystem includes designation of sacred places and prohibitions that effectively function as conservation mechanisms.

3.3. Mythology and Taboos as Empirical Knowledge Systems for Disaster Mitigation

Myths and taboos in Batak tradition governing human-environment interactions contain empirical knowledge accumulated over centuries of observation of natural patterns and consequences of various environmental actions. This knowledge system is communicated in the form of mythological narratives and ritual rules not because traditional societies were incapable of rational thinking, but because these forms of communication proved effective in ensuring cross-generational knowledge transmission and compliance with practices that protect the environment. Research by Hanifah (2023) on local wisdom in agroforestry management shows that traditional rituals performed before land clearing reflect understanding of the importance of selecting appropriate timing for agricultural activities to minimize negative environmental impacts.

One important taboo system in Batak tradition is the prohibition against cutting large trees around springs and on steep slopes. This prohibition is often associated with beliefs that such trees are dwelling places of protective spirits or tondi nabontar who will become angry if the trees are felled. From modern hydrology and geomorphology perspectives, the presence of vegetation around springs and on steep slopes has critical functions in maintaining water quality and quantity as well as preventing erosion and landslides. The root systems of large trees bind soil and increase water infiltration into the ground, while tree canopies slow surface runoff and reduce the kinetic energy of rainwater that can cause erosion.

In the context of the Lake Toba region situated in a volcanic caldera zone with hilly and mountainous topography, the Batak community developed knowledge about dangerous zones that should be avoided for settlements. This knowledge is often communicated in the form of stories about cursed places or locations inhabited by dangerous supernatural beings. Research by Damanik and Restu (2011) on flood and landslide disaster risk mapping in North Sumatra shows that areas considered haunted or prohibited for settlement in local tradition often overlap with high-risk zones based on modern geomorphological and hydrological analysis. This demonstrates that myths about

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dangerous places are essentially codifications of empirical knowledge about disaster risk obtained through collective experience over centuries.

The concept of earth being capable of anger or imposing sanctions when treated disrespectfully, often dismissed as superstition in positivistic views, actually reflects empirical understanding of the consequences of environmental degradation. When traditional communities state that indiscriminate forest clearing will invoke the wrath of Boru Deak Parujar who will send disasters, they are essentially communicating empirical knowledge that deforestation will increase risks of landslides, floods, and droughts. Research by Rahman and Jalaluddin (2022) on forest resource management based on local wisdom in Balinese society demonstrates that myths about supernatural forest guardians function as mechanisms for limiting excessive access and exploitation, thereby maintaining the sustainability of forest ecological functions.

3.4. Hariara Sundung di Langit as a Symbol of Ecological Integrity and Disaster Warning

Hariara Sundung di Langit, or the banyan tree leaning toward the sky, constitutes a central symbol in Batak Toba cosmology representing the totality of the cosmos and the vertical relationship between the underworld, middle world, and upper world. This cosmic tree is not merely a spiritual metaphor, but contains profound ecological knowledge about the importance of vegetation in maintaining environmental balance. The tree's roots hanging into the underworld symbolize root systems that bind soil and prevent erosion, the sturdy trunk represents the ecosystem's supporting function, while the towering crown depicts the canopy that regulates microclimate and water cycles.

In the daily practices of the Batak Toba community, reverence for Hariara Sundung di Langit is manifested in various ritual forms and taboos related to large trees. Rituals such as Tumpek Wariga performed to honor plants are essentially mechanisms for maintaining ecological awareness about the importance of vegetation for human life. Research by Latifah et al. (2022) on philosophical values in Guro-Guro Aron among the Karo people demonstrates that traditional rituals involving nature reverence function as mechanisms to reinforce social norms supporting environmental conservation.

Furthermore, the mythology of Hariara Sundung di Langit contains implicit warnings about the consequences of damaging ecological integrity. When the cosmic tree is disturbed or damaged, the balance between the three worlds will also be disrupted, which in ecological interpretation means disruption of essential ecosystem functions. Recent events such as flash floods and landslides in Tapanuli can be understood within this mythological framework as manifestations of imbalance resulting from vegetation and forest ecosystem destruction. Forest clearing for tourism infrastructure development, felling of large trees on steep slopes, and conversion of forests into monoculture agricultural lands fundamentally constitute actions that in Batak mythological language can be interpreted as damaging Hariara Sundung di Langit.

3.4. Environmental Management Practices Based on Local Wisdom and Ecological Validity

Concrete environmental management practices developed by the Batak community based on their traditional knowledge system demonstrate remarkable alignment with modern ecological principles. The customary forest management system that divides forests into zones with different functions and protection levels reflects understanding of the importance of land use diversification for maintaining sustainability. In this system, there are forests that are completely protected and must not be exploited at all, forests whose products may be utilized but whose trees may not be felled, and forests that may be managed limitedly for timber and other forest product production.

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This concept parallels zonation in modern conservation area management that distinguishes between core zones, buffer zones, and utilization zones.

The traditional Batak agricultural land management system emphasizing crop diversification and rotation also reflects understanding of ecological principles such as biodiversity and nutrient cycling. Intercropping practices that plant various crop types in one field not only increase productivity per unit area but also reduce pest and disease risks while maintaining soil fertility. Modern agronomic research has validated that polyculture agricultural systems are more stable and resilient compared to monoculture, and provide better ecosystem services in terms of soil conservation, water regulation, and biodiversity habitat. Hanifah (2023) in research on local wisdom in agroforestry management demonstrates that traditional practices integrating trees with agricultural crops prove more sustainable and resilient to climate change compared to intensive modern agricultural systems.

Soil and water conservation practices developed by the Batak community also demonstrate alignment with modern hydrology and soil conservation principles. Terracing construction on sloping lands to prevent erosion, planting cover crops between main crops, and maintaining vegetation strips along rivers and irrigation channels are practices aligned with soil and water conservation techniques in modern agronomy. These systems are not only effective in preventing soil erosion but also in reducing flood and landslide risks by slowing surface runoff and increasing water infiltration into the ground.

The importance of this traditional knowledge system becomes increasingly clear when examining the impacts of its neglect in modern development. Flood and landslide disasters occurring in the Tapanuli region in November 2025 largely occurred in areas that had experienced massive deforestation and land conversion that ignored local wisdom principles. Data presented by Damanik and Restu (2011) show that there are twelve districts or cities in North Sumatra Province classified as very high risk for floods and fifteen districts or cities classified as highly prone to landslides. This high level of vulnerability is inseparable from land use changes that ignore ecological principles and local wisdom.

3.5. Critical Framing of Local Wisdom in the Context of Modernization

Although local wisdom tends to contain valid and relevant ecological knowledge, it is important to maintain objectivity toward this traditional knowledge system. Prayitno et al. (2025) provide a critical perspective through an experimental study in Gunung Leuser National Park demonstrating that local community decisions to clear protected forests are influenced by complex factors not always aligned with traditional wisdom principles. Factorial survey experiment results show that water availability has the strongest effect on land clearing decisions, with communities tending not to clear land when water is scarce because they recognize the importance of forests for water supply. However, basic needs remain a strong driver of land clearing, even when communities know the ecological risks. Access to land certificates also significantly increases the propensity to clear land, indicating that modern social norms regarding formal land ownership have displaced traditional customary ownership systems.

These findings reveal a fundamental contradiction that although traditional communities in the Sumatra region possess profound ecological knowledge about forest functions in water cycles and disaster prevention, economic pressures and changes in land tenure systems can override traditional conservation practices. Semi-structured interviews in the study show that perceptions of land ownership have changed, with increasing desire to obtain official certificates to provide land security, especially amid rising land competition. The customary ownership system that was previously sufficient with de facto recognition from the community is now considered inadequate in facing development pressures and land commercialization.

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Rakuasa et al. (2024) reinforce this critical analysis by demonstrating that implementation of local wisdom in natural resource management in Indonesia faces challenges of institutional fragmentation and weak inter-stakeholder coordination. Studies on community-based conservation areas show that although participatory local management approaches have succeeded in several locations such as Nepal and Central America, their success heavily depends on effective mediation between local communities and non-local actors such as governments, transnational corporations, and NGOs. Without strong mediation, weak groups within communities are often excluded due to incompatibility with essentialist conservation discourse that requires them to display certain cultural ecological characteristics to gain access to NGO-sponsored programs.

Furthermore, Rahman et al. (2019) reveal that even traditional water management systems viewed as sustainability models can experience distortion when confronting urban political-economic dynamics. The Georgetown, Guyana flood case shows that although local knowledge about flood-prone zones is available, urban development pressures and short-term economic interests often ignore such knowledge. The research emphasizes that vulnerability is a product of asymmetric power relations, where marginal groups are systematically excluded from decision-making processes affecting their fate.

In the North Tapanuli context, Nugrahani (2025) documents that although this region has traditionally strong customary spatial zonation, infrastructure development and plantation expansion over the past decade under the NIKSON model have significantly altered spatial arrangements. Critical land area increased from 38,952.42 hectares in 2016 to 127,620 hectares in 2020, indicating that development ignoring local wisdom principles in zonation and conservation has exacerbated environmental degradation. Waste volume also increased to 670,064 cubic meters in 2020, in line with population and business unit growth, but without adequate management systems.

Therefore, local wisdom is not a static system that can be applied directly in modern conditions, but rather a knowledge framework that must be adapted considering structural changes in land tenure, market economy, and power relations. The ecological validity of Batak local wisdom remains relevant, but its implementation requires more fundamental institutional transformation, including formal legal recognition of customary systems, strengthening customary institutional capacity, and equitable integration between local knowledge and modern governance systems.

3.6. Political Ecology Framework in Understanding Disaster Roots

Suwarno et al. (2025) analyzed Law Number 41 of 1999 on Forestry through a political ecology lens and revealed that Indonesia's forestry legal framework has from the outset created asymmetric power structures. The analysis shows that forestry law positions the state as the primary forest owner, ignoring the rights of indigenous communities who have managed forests for generations. This structural inequality creates prolonged tenure conflicts and weakens community-based management systems that are actually more effective in maintaining forest ecological functions. In the disaster mitigation context, when indigenous communities lose control over forests they manage, traditional conservation practices such as establishing prohibited forests and customary forest zonation become dysfunctional, thereby increasing vulnerability to landslides and flash floods.

Muafiroh and Tambunan (2025) expand political ecology analysis in the context of Nusantara Capital City development, which has parallels with environmental cases in Sumatra regarding development pressures on areas with critical ecosystems. Their systematic literature review reveals that 10 flood-prone points in the IKN development area are products of extractive power configurations that distort provincial-level forestry policies. A total of 631 mining and oil palm plantation concession permits in Kalimantan overlapping with disaster-prone areas demonstrate how short-term political-economic interests sacrifice ecological and social safety. Institutional

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fragmentation, overlapping authority, and systemic law enforcement failure become mechanisms enabling continued forest degradation despite existing conservation regulations.

The political ecology approach reveals power dimensions operating at three levels as conceptualized by Lukes (2005). The first dimension, decision-making power, is visible in concession permit issuance processes that ignore ecological and social impacts. The second dimension, agenda-setting power, manifests in spatial planning policy-making that systematically prioritizes investment interests over conservation area protection. The third dimension, preference-shaping power, operates through public discourse legitimizing extractive development paradigms as the only path to prosperity, while discrediting local ecological knowledge as development obstacles.

In the North Sumatra context, political ecology analysis reveals that the November 2025 flood and landslide disasters claiming more than 375 lives are not merely consequences of extreme natural phenomena, but manifestations of forest governance failure ongoing for decades. Suwarno et al. (2025) demonstrate that forest degradation reaching 1.4 million hectares during the 2016-2025 period in critical watersheds across three Sumatra provinces results from power configurations enabling 631 companies holding concession permits and illegal practices to operate with impunity. Data show strong correlation between areas with highest forest cover loss and locations with greatest casualties, with Aceh losing 860,000 hectares of forest recording 389 deaths, North Sumatra with approximately 1.6 million hectares lost recording 338 deaths, and West Sumatra with 740,000 hectares lost recording 234 deaths.

The political ecology framework also reveals that law enforcement against forest area violations is discriminatory, only reaching small-scale actors such as farmers or laborers, while large corporate permit holders and issuers of hundreds of problematic concessions are virtually immune from prosecution. Weak supervision, corruption, and sanctions that fail to produce deterrent effects have eroded system protection capacity, perpetuating impunity for primary deforestation actors. This condition creates a cycle of paralysis in forestry governance, where policy formulation is distorted by political intervention and elite interests, implementation is weak due to institutional fragmentation, and evaluation and law enforcement experience total paralysis.

3.7. Typology of Disaster Mitigation Based on Local Wisdom

Preventive mitigation refers to efforts to prevent disasters from occurring or reduce their probability by managing causal factors upstream. In the Batak local wisdom context, preventive mitigation manifests in traditional taboo systems and forest zonation that effectively function as preventive conservation mechanisms. The prohibition against cutting large trees around springs, which in local tradition are considered dwelling places of protective spirits, constitutes a form of empirical knowledge communicated through mythological narratives to ensure cross-generational transmission and compliance with conservation practices. From modern hydrology and geomorphology perspectives, the presence of vegetation around springs and on steep slopes has critical functions in maintaining water quality and quantity as well as preventing erosion and landslides, because large tree root systems bind soil and increase water infiltration into the ground, while tree canopies slow surface runoff and reduce the kinetic energy of rainwater that can cause erosion.

The traditional Batak forest zonation system dividing forests into zones with different functions and protection levels is also a sophisticated form of preventive mitigation. There are forests completely protected and not to be exploited at all called paraku or customary prohibited forests, forests whose products may be utilized but whose trees may not be felled, and forests that may be managed limitedly for timber and other forest product production. This concept parallels zonation in modern conservation area management distinguishing between core zones, buffer zones, and utilization zones. Research by Harahap et al. (2022) demonstrates that Batak Toba traditional wisdom in maintaining the Lake Toba ecosystem includes designation of sacred places and

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prohibitions that effectively function as preventive conservation mechanisms by protecting critical ecological functions from overexploitation.

Adaptive mitigation refers to efforts to adjust socio-ecological systems to increase resilience against disaster threats that cannot be fully prevented. In the Batak local wisdom context, adaptive mitigation is manifested in land management practices and agricultural systems designed to reduce negative impacts of extreme natural events. The traditional Batak agricultural land management system emphasizing crop diversification and rotation reflects understanding of ecological principles such as biodiversity and nutrient cycling. Intercropping practices planting various crop types in one field not only increase productivity per unit area but also reduce pest and disease risks while maintaining soil fertility.

Hanifah (2023) demonstrates that local wisdom in agroforestry management integrating trees with agricultural crops proves more sustainable and resilient to climate change compared to intensive modern agricultural systems. Soil and water conservation practices developed by the Batak community also show alignment with modern hydrology and soil conservation principles, such as terracing construction on sloping lands to prevent erosion, planting cover crops between main crops, and maintaining vegetation strips along rivers and irrigation channels. These systems are not only effective in preventing soil erosion but also in reducing flood and landslide risks by slowing surface runoff and increasing water infiltration into the ground.

Adaptive mitigation also encompasses local knowledge about natural indicators that can be used as early warning systems. Local communities possess knowledge about natural signs preceding disasters, such as changes in animal behavior, changes in river or spring water levels, and certain atmospheric phenomena that can serve as early indicators of potential disasters. This knowledge can be integrated with technology-based monitoring systems such as automatic weather stations, hydrological sensors, and ground movement monitoring systems to enhance early warning system sensitivity, especially in remote areas not yet reached by modern monitoring infrastructure.

Responsive mitigation refers to efforts to reduce negative impacts of disasters that have already occurred through emergency response, recovery, and reconstruction mechanisms. In the Batak local wisdom context, responsive mitigation is manifested in the mutual assistance system or marsiadapari and strong social solidarity in facing disasters. The dalihan na tolu kinship system governing relationships among wife-givers, wife-takers, and peer groups creates extensive and effective social support networks for mobilizing assistance and post-disaster recovery. When disasters occur, this system facilitates redistribution of resources and labor to help disaster victims through traditional mechanisms such as mangalua or providing assistance and maningkir or caring for victims.

However, this local wisdom-based responsive mitigation faces challenges in modern contexts, especially when disaster scale exceeds local community capacity to respond effectively. The November 2025 flood and landslide disasters in North Sumatra claiming more than 375 lives and causing hundreds of thousands to evacuate demonstrate that although local mutual assistance systems can help in initial emergency response phases, long-term recovery requires government intervention and larger resource mobilization. In this context, integration between traditional responsive mechanisms and modern disaster management systems becomes important to ensure response and recovery effectiveness.

Based on the typological analysis above, it can be understood that Batak local wisdom offers significant contributions to preventive and adaptive mitigation, not to responsive mitigation. The taboo systems, forest zonation, and traditional Batak agroforestry practices are preventive mechanisms that prevent disasters by maintaining critical ecological functions. Diversified land management systems and knowledge about natural indicators are adaptive mechanisms that increase community resilience against disaster threats. Meanwhile, mutual assistance systems and social solidarity constitute responsive mechanisms that help post-disaster recovery, but their effectiveness is limited to small to medium-scale disasters.

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3.8. Ecological Justice and Indigenous Peoples' Rights as Basis for Transformation

The concept of ecological justice transcends material resource distribution to encompass recognition of nature's intrinsic rights and the rights of local communities dependent on nature for their survival. In the Batak community context, ecological justice means recognizing that indigenous peoples have the right to manage and control their customary territories based on their traditional knowledge and governance systems, without intervention or violation from external actors such as the state or corporations. This right is not merely a right of access or resource utilization, but the right to determine the fate of their own territories within the framework of ecological sovereignty.

Setiawan et al. (2024) provide juridical foundations by analyzing the utilization of Batak Toba customary law community local wisdom in protecting Lake Toba's existence. The study demonstrates that places considered sacred by the Batak community have important ecological functions requiring protection, and recognition of the sacred status of these places in customary law should become the basis for formal legal recognition in the national spatial planning system. However, in practice, Indonesian positive law often ignores or even contradicts customary law, creating conflictual legal pluralism. Law Number 41 of 1999 on Forestry designates nearly all forests as state property without recognizing indigenous peoples' customary rights, although Constitutional Court Decision Number 35/PUU-X/2012 has affirmed that customary forests are not included in state forests.

To strengthen the political and legal claims of Batak indigenous peoples over their living spaces, the framework of indigenous peoples' rights as regulated in international instruments such as the United Nations Declaration on the Rights of Indigenous Peoples and ILO Convention 169 must serve as reference. UNDRIP Article 26 recognizes indigenous peoples' rights to lands, territories, and resources which they have traditionally owned, occupied, or used. Article 32 affirms indigenous peoples' right to determine and develop priorities and strategies for the development or use of their lands or territories and other resources, and states must consult and cooperate with indigenous peoples through their representative institutions to obtain their free and informed consent before approving projects affecting their lands or territories.

In the disaster mitigation context, recognition of these indigenous peoples' rights has direct implications for prevention effort effectiveness. When indigenous peoples have formally recognized rights over their customary territories, they have authority to reject or restrict activities that could damage the ecological functions of those territories, such as forest clearing in spring zones or land opening on steep slopes. Without formal recognition of these rights, indigenous peoples lack legal foundation to oppose concession permits issued by the government to corporations, even when such concessions clearly threaten the ecological and social safety of their territories.

The case of customary forest certification in West Sumatra reported by Karima and Kaswanto (2017) provides concrete examples of how formal recognition of indigenous peoples' rights can strengthen their position in resisting land conversion. Forests certified as customary forests have stronger legal protection against conversion attempts compared to forests recognized only customarily. However, this certification process remains very limited and bureaucratic, with most customary territories yet to receive formal recognition. Mahmuddin et al. (2024) demonstrate that revitalization of customary institutions such as Panglima Uteun in forest management in Aceh Besar District can strengthen indigenous communities' capacity to protect their customary forests, but effectiveness depends on local government policy support and formal recognition of these customary institutions' authority.

The ecological justice framework also requires recognition of traditional ecological knowledge as a form of knowledge equal to modern scientific knowledge in decision-making processes related to natural resource management and disaster mitigation. Too often, traditional ecological

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knowledge is discredited as superstition or knowledge lacking empirical basis, while modern scientific knowledge is viewed as the sole source of truth. This paradigm must shift toward epistemological pluralism recognizing that traditional ecological knowledge results from extensive empirical observation of natural patterns in specific geographic regions and possesses ecological validity proven over centuries.

In the November 2025 disaster context in North Sumatra, the ecological justice and indigenous peoples' rights framework provides normative foundation for demanding accountability from governments and corporations contributing to forest degradation that exacerbated disaster impacts. Disaster victims, predominantly poor communities living in disaster-prone areas, have the right to demand fair compensation and recovery, as well as the right to participate in reconstruction processes and future disaster mitigation planning. Their traumatic experiences must become momentum for fundamental transformation in natural resource governance and recognition of indigenous peoples' rights as ecosystem guardians who have been neglected.

3.9. Integration of Local Wisdom with Modern Scientific Approaches in Disaster Mitigation

Experiences from various regions in Indonesia and other countries demonstrate that integration between local wisdom and modern scientific approaches can produce more effective and sustainable disaster mitigation strategies compared to approaches relying on only one. Local wisdom provides profound contextual knowledge about local environmental characteristics, historical disaster patterns, and proven adaptation strategies, while modern science provides systematic analytical methods, monitoring and early warning technology, as well as understanding of physical mechanisms underlying disaster occurrence. Research by Hasbiah (2015) shows that various examples of local wisdom can be integrated with government policies to produce more effective environmental management systems.

In the North Sumatra region context, this integration can be realized through several concrete approaches. First, in spatial planning and infrastructure development, traditional knowledge about disaster-prone zones must be integrated with Geographic Information System-based spatial analysis and disaster risk modeling. Risk maps need enrichment with information from local knowledge about locations historically experiencing frequent disasters or considered dangerous in local tradition. Case studies conducted by Setiawan et al. (2024) regarding utilization of Batak Toba customary law community local wisdom in protecting Lake Toba's existence.

Second, in developing disaster early warning systems, traditional indicators based on natural phenomena observation and animal behavior can be integrated with technology-based monitoring systems such as automatic weather stations, hydrological sensors, and ground movement monitoring systems. This hybrid approach can enhance early warning system sensitivity, especially in remote areas not yet reached by modern monitoring infrastructure. Local communities possess knowledge about natural signs preceding disasters, such as changes in animal behavior, changes in river or spring water levels, and certain atmospheric phenomena that can serve as early indicators of potential disasters.

Third, in water resource management, traditional water management principles emphasizing distribution equity, community participation, and catchment area maintenance can be integrated with modern technology for monitoring water quality and quantity, as well as optimizing distribution systems. Revitalization of traditional water management systems with modern technological support can increase resilience to climate change and pressures from tourism development. Research by Nastiti et al. (2022) on sustainable water resource management in South Bali demonstrates that approaches integrating traditional systems with modern technology produce more efficient and sustainable water management systems.

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Fourth, in forest and land management, traditional zonation distinguishing between forests requiring total protection, forests whose products may be utilized, and land that may be cultivated can become the basis for community-based forest management systems strengthened with technology-based forest resource inventory such as remote sensing and geographic information systems. Collaboration between customary forest management and government involving communities and applying local wisdom proves effective in maintaining forest functions, as demonstrated in research by Rahman and Jalaluddin (2022) on forest resource management based on local wisdom in Balinese society.

Fifth, in education and raising public awareness about disaster risk, traditional narratives about historical disasters and local wisdom teachings about relationships with nature can become effective media for communicating disaster mitigation concepts to communities. Research by Simanungkalit et al. (2024) on cultural values in folklore demonstrates that traditional narratives can become effective media for transmitting cultural values including environmental conservation values. This approach can be more culturally resonant compared to campaigns using only technocratic approaches.

Sixth, in policy and regulation development, customary law governing environmental management needs recognition and integration with formal legislation. Research by Rideng et al. (2022) demonstrates that Law No. 41 of 1999 on Forestry has accommodated local wisdom for community welfare and forest sustainability, but implementation still faces various challenges. More systematic efforts are needed to translate local wisdom principles into regional regulations and effective implementation mechanisms, as well as strengthening customary institution capacity in enforcing conservation rules.

Implementation of local wisdom integration with modern scientific approaches requires paradigmatic transformation in environmental governance and development. The paradigm positioning modern scientific knowledge as the sole source of truth and regarding traditional knowledge as superstition to be eliminated needs replacement with a paradigm recognizing epistemological pluralism and complementary value of various knowledge systems. As articulated by Haniifa and Palimirmo (2025), transformation from anthropocentric ethics toward ecocentrism requires not only technological and policy changes, but also fundamental changes in worldviews and values underlying human-nature relationships. Local wisdom rooted in ecocentric perspectives can become a source of inspiration and guidance in the required environmental ethics transformation.

To develop disaster mitigation based on local wisdom within a political ecology framework, fundamental transformation in power relations and institutional structures is required. First, formal recognition of customary law and indigenous peoples' rights over their managed territories must be strengthened through revision of Law Number 41 of 1999 and Regional Government Law to grant greater authority to local governments and Forest Management Units in integrating local knowledge into spatial planning. Second, establishment of Multi-stakeholder Watershed Councils with veto authority at the provincial level having inclusive membership, including indigenous community representatives, academics, NGOs, and government, to oversee every new permit in critical watersheds and ensure development decisions consider their ecological and social impacts.

Third, implementation of Ecological Fiscal Transfer providing fiscal incentives to regions successfully maintaining forest cover and implementing local wisdom-based management practices. Ecological performance indicators must become primary Key Performance Indicators in the Government Agency Performance Accountability System for regional leaders, so there are political and career consequences for officials failing to maintain their region's ecological balance. Fourth, fundamental revision of spatial planning policies positioning ecosystem protection as primary priority, where development activities across all sectors must refer to ecological carrying capacity, not vice versa. Fifth, a national paradigm shift movement to build responsible environmental management ethos through massive character education and environmental education, capacity

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building for officials, and organizational culture viewing environmental protection as a pillar of national resilience.

4. Conclusion

The Batak community's local wisdom system in environmental management contains profound ecological dimensions relevant to modern scientific principles, but experiences systematic erosion due to modernization and stigmatization of traditional practices. This erosion contributes significantly to increasing vulnerability of tourism and plantation areas to disasters, as evidenced by the November 2025 floods and landslides claiming more than 375 lives in North Sumatra. Political ecology analysis reveals that these disasters are not merely extreme natural phenomena, but rather manifestations of forest governance failure due to massive deforestation reaching 1.6 million hectares during 1990-2015 driven by oil palm plantation expansion and structural inequality in forestry law weakening community-based management systems.

Integration of local wisdom with modern scientific approaches becomes a strategic necessity capable of producing more effective and sustainable disaster mitigation systems. This integration strategy encompasses integrating traditional knowledge in spatial planning, developing community-based early warning systems, utilizing traditional narratives in disaster risk education, reformulating tourism development policies considering environmental carrying capacity, formal customary law recognition, systematic local wisdom revitalization and documentation, implementing Ecological Fiscal Transfer, and establishing Multi-stakeholder Watershed Councils with supervisory authority. Success of this integration requires paradigmatic transformation from anthropocentrism toward ecocentrism rooted in Batak local wisdom as foundation for building sustainable and just disaster mitigation systems.

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