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The Impact of Nickel Downstreaming Policy on Environmental Damage in Konawe Regency, Southeast Sulawesi

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Abstract: This study analyzes the ecological impacts of Indonesia's nickel downstreaming policy on biodiversity and local ecosystems in Konawe Regency, Southeast Sulawesi, using a political ecology approach. A qualitative descriptive method was employed based on literature review and secondary data from policy documents, government reports, scientific publications, and environmental agency records. The analysis examined land cover change, habitat fragmentation, degradation of aquatic ecosystems, and power relations in nickel mining governance. The findings indicate that the expansion of downstream nickel industries has accelerated forest conversion, fragmented terrestrial habitats, increased river sedimentation, and reduced aquatic habitat quality, thereby threatening local biodiversity sustainability. These environmental pressures are closely linked to governance dynamics in which economic growth and state interests dominate decision-making, while environmental protection and conservation measures receive limited attention. From a political ecology perspective, the downstreaming policy reproduces unequal power relations that marginalize ecological considerations at the local level. The study concludes that the effectiveness of downstreaming should not be assessed solely through economic indicators but must incorporate ecological sustainability and biodiversity safeguards. Policy reform is required to integrate environmental carrying capacity, strengthen local monitoring mechanisms, and ensure more inclusive and balanced governance of resource extraction.

Keywords: Political Ecology, Nickel Downstreaming, Konawe Regency, Biodiversity Environmental Policy.

Introduction

The global biodiversity crisis has become one of the key challenges in the 21st-century sustainable development agenda. Scientific studies show that human activities, such as land-use change, deforestation, and large-scale natural resource extraction, have led to a significant increase in the rate of species extinction (Phongchiewboon et al., 2020). Amid global efforts to reduce carbon emissions and encourage the transition to clean energy, a new environmental paradox has emerged (Sihidi et al., 2024; Sihidi, Romadhan, et al., 2025). The high demand for strategic minerals to support low-carbon technologies has instead led to the expansion of extraction practices that have the potential to damage natural

ecosystems (de Micheaux & Kull, 2020). This situation places natural resource-rich countries in a dilemma between the need for economic development and the obligation to maintain sustainable biodiversity (Sihidi et al., 2026).

Indonesia is central to this paradox. As the country with the world's largest nickel reserves, Indonesia has made nickel downstreaming a national strategy to increase the added value of mineral resources, strengthen the domestic industrial sector, and support the global energy transition agenda, particularly in the development of the electric vehicle battery industry (Pickett et al., 2022). This policy is projected to drive economic growth, create jobs, and increase state revenues. However, several studies have shown that Indonesia's structural dependence on the extractive sector makes downstreaming a policy associated with significant social and ecological risks (Gopalan & Radhakrishna, 2022).

From a political economy perspective, nickel downstreaming cannot be understood solely as an industrial policy, but also as an arena for contestation between the state, companies, and local communities. Literature on the energy transition in developing countries shows that the shift toward a green economy is often not accompanied by fundamental structural transformation, as dominant economic actors are able to adapt to the sustainability narrative without changing existing patterns of resource control (Svarstad et al., 2018). This phenomenon is known as "green extractivism," which is the intensification of natural resource extraction practices legitimized by discourses of green development and energy transition (Cosens et al., 2018). In the Indonesian context, nickel downstreaming policies have the potential to reinforce old extractive patterns with higher ecological intensity.

The ecological impacts of nickel downstreaming policies are most evident in nickel-producing areas, including Konawe Regency, Southeast Sulawesi Province. This region boasts high biodiversity, with tropical rainforest ecosystems, watersheds, and coastal areas serving as habitats for numerous endemic species and sources of livelihood for local communities (Pauli et al., 2019). However, the development of the nickel industry and the construction of mineral processing facilities have caused significant changes to the landscape through land clearing, habitat fragmentation, water pollution, and increased river sedimentation (Llausàs et al., 2019). Numerous studies in Sulawesi have shown that nickel mining activities are strongly correlated with environmental degradation and increased pressure on biodiversity, particularly in areas with weak environmental monitoring capacity (Habib, 2023; Sabrin et al., 2025).

However, most research on nickel downstreaming in Indonesia still focuses on macroeconomic aspects, foreign investment, and industrial policy governance, while its impact on biodiversity is often positioned as a secondary issue that receives less attention (Isha & Pratap, 2023; Laudya, 2025). This situation creates a knowledge gap regarding the ecological consequences of downstreaming policies at the local level. A national and uniform policy approach tends to ignore the ecological characteristics of nickel-producing regions like Konawe, including the vulnerability of tropical forests, hydrological systems, and the complexity of local ecosystems (Seay-Fleming et al., 2025).

The political ecology approach offers a relevant analytical framework for understanding these gaps. This perspective emphasizes that environmental issues are not solely driven by biophysical factors, but also by power relations, policies, and economic interests that influence natural resource management. In the context of nickel downstreaming, decisions regarding mining permits, environmental standards, and oversight mechanisms are heavily influenced by power relations between the state and corporations. When policies prioritize accelerating investment and industrial growth, there is a risk that biodiversity protection will be marginalized (Montero-Rosado et al., 2023).

In energy transition studies, the success of sustainable development can be measured not only through economic and technological achievements but also by considering aspects of ecological justice and ecosystem sustainability. An energy transition that ignores environmental impacts at the local level has the potential to exacerbate socio-ecological conflicts and create new inequalities between resource-producing regions and industrial centers (Feeney, 2023). In Konawe, the decline in biodiversity due to nickel downstreaming not only threatens ecosystem sustainability but also impacts the socio-economic resilience of communities dependent on local natural resources.

Normatively, nickel downstreaming policies require compliance with various environmental protection instruments, such as Environmental Impact Assessments (AMDAL), reclamation plans, and post-mining obligations. However, numerous studies have shown a gap between formal regulations and on-the-ground practices, particularly in areas with high mining intensity (Gao et al., 2025). In Konawe, accelerated mining activities often occur alongside weak environmental oversight, resulting in potential impacts on biodiversity not being fully managed. This pattern aligns with the characteristics of extractive development in various regions in Indonesia, where mineral resource exploitation is positioned as the primary driver of local development (Koch & Lawhon, 2025).

From a political ecology perspective, extractive policies oriented toward rapid investment tend to result in an uneven distribution of ecological impacts, with producing regions bearing the greatest environmental burden (Datta, 2018). In Konawe, the impact of the downstreaming policy is evident not only in changes to the local economic structure but also in the physical transformation of the region, affecting natural habitats. Therefore, the nickel downstreaming policy should not be viewed solely as an industrial policy, but also as a de facto environmental policy that determines the direction of local ecosystem change. This reality indicates that the implementation of the downstreaming policy in Konawe has not fully implemented the principle of biodiversity protection in depth, as environmental protection is often positioned as an administrative requirement, rather than a primary objective (Charnley et al., 2018).

One of the most significant environmental impacts of the implementation of the nickel downstreaming policy in Konawe is the significant change in land cover. Laterite nickel mining activities generally require the clearing of large areas because nickel deposits are located in the topsoil. This process results in the loss of natural vegetation, damage to soil structure, and permanent modification of the landscape (Y. Xu et al., 2022). These land

cover changes occur not only within the mining concession area but also extend to surrounding areas due to the construction of roads, processing facilities, and supporting logistics infrastructure.

Research on mining in tropical regions shows that indirect impacts, such as habitat fragmentation, often have greater ecological consequences than direct impacts on the mining area itself. Habitat fragmentation causes ecosystems to fragment into small, isolated fragments, disrupting species movement, reducing ecosystem stability, and increasing the risk of local extinctions (Shevchuk et al., 2022). In the context of Konawe, which is part of a global center of endemism, this process poses a serious threat to the survival of local flora and fauna species.

Taking these dynamics into account, this study aims to analyze the impact of nickel downstreaming policies on biodiversity in Konawe Regency through a political ecology approach. This study seeks to identify the forms of ecological pressures caused by nickel downstreaming activities and understand how natural resource policies and governance contribute to changes in local biodiversity conditions. By integrating ecological and public policy perspectives, this research is expected to provide theoretical contributions to the study of a more ecologically just energy transition, while also serving as a reference for formulating downstreaming policies that are more sensitive to biodiversity protection.

Research Method

This study uses a qualitative approach with a secondary data-based library research method to analyze the impact of nickel downstreaming policies on biodiversity in Konawe Regency. Research data were obtained from various sources, including national and international scientific articles, official government reports, policy documents, publications from environmental institutions, and statistical data relevant to the issue of nickel downstreaming and ecosystem change. Data sources were selected systematically based on the criteria of topic relevance, source credibility, publication recency, and direct relevance to the ecological and policy context in Konawe. The data collection process was carried out through searches in scientific databases such as Google Scholar, Scopus, and accredited journals, as well as official documents from the government and related institutions.

Data analysis was conducted using content analysis techniques with a thematic approach to identify patterns of relationships between nickel downstreaming policies and their impacts on biodiversity. The analysis stages included data reduction, thematic classification, data presentation, and drawing conclusions based on a synthesis of the various sources reviewed. To enhance the validity of the findings, this study employed source triangulation by comparing information from various documents and reports. Through this procedure, the study is expected to produce a comprehensive, objective, and evidence-based analysis of the ecological implications of nickel downstreaming policies in Konawe Regency.

Result and Discussion

Nickel Downstream Policy and Its Implementation in Konawe Regency

The policy related to nickel downstreaming in Indonesia is an aspect of the national development plan that aims to increase the added value of mineral resources, reduce dependence on raw material exports, and strengthen Indonesia's position in the global supply chain for the energy and technology industry.(Paracka & Vaught, 2024).In practice, this policy encourages accelerated mining activities, smelter construction, and supporting infrastructure development in nickel-rich areas, including Konawe Regency in Southeast Sulawesi. Konawe holds a unique strategic position due to its large reserves of laterite nickel and its geographical proximity to the mining industry hub in Sulawesi.

In the implementation of public policy, nickel downstreaming in the regions is not only influenced by national regulations, but also by local management dynamics that influence how the policy is implemented.(Ungureanu & Popartan, 2024).In Konawe, the implementation of downstreaming policies is occurring amidst limited capacity of regional institutions and a high economic dependence on the mining sector. This situation forces the local government to focus more on economic growth and regional revenue, while environmental aspects are often considered merely an afterthought following the logic of industrial development.

Nickel downstreaming indirectly drives increased mineral resource exploitation, as increasing processing capacity requires a consistent and sustainable supply of raw materials. In Konawe, this is evident in the increasing push to explore new mining areas and expand existing concessions. Natural resource literature shows that when industrial and environmental policies are not well integrated, extractive expansion outpaces strengthening environmental protection mechanisms.(Nava, 2025).This situation results in a structural imbalance in the implementation of downstreaming policies.

Furthermore, the nickel downstreaming framework fails to fully accommodate the ecological characteristics of nickel-producing regions like Konawe. A uniform, nationally oriented policy approach can overlook differences in local ecosystem conditions, including the vulnerability of tropical forests, hydrological systems, and levels of biodiversity. Environmental literature shows that policies that fail to address local context can lead to greater and more difficult ecological impacts.(Seay-Fleming et al., 2025).

When implemented, downstreaming policies also encourage the development of supporting infrastructure such as mining roads, ports, and industrial areas. This infrastructure development is often viewed as a technical requirement to support industrial activities, but from an environmental perspective, it can be a major cause of habitat fragmentation and landscape destruction. Previous research has shown that the ecological impacts of extractive infrastructure often outweigh the mining area itself and can cause additional ecological pressure on surrounding areas.(Ntuli et al., 2021).

Furthermore, the focus of downstreaming policies that prioritize accelerated investment and mineral production has the potential to undermine the precautionary principle in environmental management. In the Konawe context, the permitting and implementation processes for downstreaming projects are often carried out within tight

timeframes, limiting the opportunities for in-depth ecological impact evaluation. Environmental policy literature suggests that accelerated development is often inversely proportional to the quality of environmental impact assessments, particularly in areas with high levels of development.(Rozen-Rechels et al., 2019).

The nickel downstreaming policy also demonstrates a development approach that considers natural resources as important economic assets, while the ecological value of biodiversity has not been fully considered in decision-making. Although sustainable development issues often accompany downstreaming policies, in practice, biodiversity protection remains normative and has not become the primary measure of policy success. Literature findings indicate that the integration of industrial policy and biodiversity conservation remains a major challenge in natural resource-based development in developing countries.(Ceccon et al., 2020).

The implementation of the downstreaming policy in Konawe is evident in the increase in mining business permits, the expansion of concession areas, and the enhancement of mineral exploitation and processing. Various studies have shown that at the local level, this policy is often understood as accelerating investment and production, with an emphasis on economic growth and achieving national targets, while environmental aspects are often considered merely administrative.(Correia et al., 2024).This can be seen in Konawe, where environmental policies are written into permit documents, but implementation often faces challenges in terms of oversight and institutional capacity. Normatively, nickel downstreaming policies require compliance with environmental regulations, including Environmental Impact Assessments (AMDAL), reclamation plans, and post-mining. However, numerous studies have shown a gap between regulations and practices on the ground, particularly in areas with high mining activity.(Gao et al., 2025).In Konawe, accelerated mining activities often coincide with weak environmental oversight, so potential impacts on biodiversity are not fully addressed in policy planning. This approach aligns with existing extractive development patterns in many regions in Indonesia, where mineral resource exploitation is considered a primary driver of local development.(Koch & Lawhon, 2025).However, from an ecological perspective, this approach may ignore the characteristics of local ecosystems that are vulnerable to major disturbances, especially forests and waters that support biodiversity.

Studies in political ecology show that extractive policies focused on rapid investment often result in uneven ecological pressures, with producing regions bearing the greatest environmental burden.(Datta, 2018).In Konawe, the impact of the downstreaming policy is not only evident in changes to the local economic structure, but also in the physical transformation of the area, affecting natural habitats. Therefore, the nickel downstreaming policy should not be considered merely an industrial policy, but also a de facto environmental policy that influences changes in the local ecosystem. These findings reinforce the view that the implementation of the downstreaming policy in Konawe has not fully implemented the principle of biodiversity protection in depth. Environmental protection is often presented as an administrative requirement rather than a primary objective. As a result, pressures on biodiversity have emerged, a structural consequence of

policies that prioritize economic growth and increasing the added value of minerals.(Charnley et al., 2018).

One of the most visible environmental impacts of the nickel downstreaming policy in Konawe is the significant change in land cover. Laterite nickel mining typically requires the clearing of large areas, as nickel deposits are located in the topsoil. This process results in the loss of natural vegetation, soil degradation, and permanent structural modifications to the landscape.(Y. Xu et al., 2022).

In Konawe, land cover changes occur not only within mining concession areas but also extend to surrounding areas due to the construction of roads, processing facilities, and logistics infrastructure. Research on mining in tropical regions shows that indirect impacts, such as habitat fragmentation, often have greater ecological impacts than the mining area itself. Habitat fragmentation results in ecosystems being fragmented into small, isolated fragments, disrupting species movement and reducing ecosystem stability. In the Konawe context, according toShevchuk et al., (2022)Habitat fragmentation has serious impacts on biodiversity, particularly as Sulawesi is a global center of endemism. Many plant and animal species in Sulawesi have limited distributions and are highly dependent on intact habitats. Land clearing for nickel downstreaming activities can accelerate the decline of endemic species through habitat loss and increased ecological pressure.

The conversion of forests to mining sites and associated infrastructure results in the loss of key habitats that cannot be replaced by other land uses. Ecological research shows that tropical forests have complex and diverse habitat structures, from the canopy to the forest floor, supporting numerous plant and animal species with specific ecological needs. When forests disappear, the species that depend on those habitats risk declining numbers and even local extinction.

In addition to direct habitat loss, land cover changes also cause habitat fragmentation. Fragmentation occurs when a natural area is divided into small sections separated by non-habitat areas, such as mining roads or industrial areas. Research shows that the ecological impacts of habitat fragmentation are often as severe as or more severe than habitat loss, as they can disrupt species movement, genetic flow, and population dynamics.(Hahn et al., 2023).In Konawe, the development of downstream infrastructure exacerbated the fragmentation process in an area that was previously relatively intact.

Habitat fragmentation also increases edge effects, which are changes in microclimate and ecological conditions at the boundary between natural habitat and open space. Edge effects can lead to increased temperatures, changes in humidity, and the emergence of invasive species that can threaten native species. Research shows that edge effects in tropical forests can degrade habitat quality hundreds of meters from the fragmentation boundary, reducing the effective habitat area for sensitive species. In the mining landscape of Konawe, these effects increase ecological impacts far beyond the mining concession area.(Banks & Schwartz, 2023).

In processing policies, land cover change is often considered an inevitable consequence of industrial development. However, this approach often overlooks the fact that the scale and form of land cover change are highly dependent on policy design and spatial planning.

The environmental policy literature emphasizes the importance of a landscape-based approach in managing extractive activities to reduce habitat fragmentation and maintain ecological connectivity. In Konawe, the lack of integration between processing policies and spatial planning increases the risk of landscape degradation.

Recognizing that land cover change is a complex and impactful ecological process, this section emphasizes that nickel downstreaming in Konawe not only alters the physical landscape but also disrupts ecosystem systems and functions. This analysis is crucial for subsequent discussions on the impacts on aquatic ecosystems and biodiversity, which are byproducts of landscape changes resulting from downstreaming activities.

In addition to separation, land cover changes also impact the area's ecological functions, such as the water cycle and soil fertility. The loss of vegetation leads to increased erosion and sedimentation, which in turn impacts downstream aquatic ecosystems. These impacts are cumulative and often not fully reflected in environmental planning documents, especially when analyses are conducted separately for each project. From a biodiversity perspective, land cover changes resulting from nickel downstreaming in Konawe pose a double burden.(Al Baraquni et al., 2020).On the one hand, natural habitats are shrinking and fragmenting; on the other, remaining ecosystems are degraded due to severe human disturbance. Studies show that these conditions can reduce ecosystem resilience and increase vulnerability to further disturbances, such as climate change and the invasion of alien species.(Van Eeden et al., 2020).

These findings indicate that nickel downstreaming policies have ecological impacts that extend beyond the immediate mining site. Land cover changes and habitat fragmentation in Konawe are early signs of greater pressure on biodiversity. Without robust habitat protection policies and effective law enforcement, nickel downstreaming could lead to long-term and irreversible biodiversity loss.(McGuire & Ehlinger, 2018).

Impact of Nickel Downstreaming on Aquatic Ecosystems and Biodiversity

In addition to changes in land cover and the fragmentation of terrestrial habitats, the implementation of the nickel downstreaming policy in Konawe also has a significant impact on aquatic ecosystems, including rivers, watersheds, and coastal areas. Laterite nickel mining activities typically disturb surface soil, increasing the risk of erosion and causing sediment runoff into surrounding water bodies. Various studies have shown that sedimentation is one of the most common environmental impacts of open-pit mining in tropical regions and has serious implications for aquatic biodiversity.

In Konawe, rivers play a vital ecological and social role, serving as water sources, habitats for aquatic organisms, and supporting community agricultural and fishing activities. Increased sedimentation due to mining activities and downstream infrastructure development can alter the physical characteristics of rivers, such as increasing water turbidity, causing siltation, and altering the riverbed substrate. Research in aquatic ecology indicates that these changes can reduce habitat quality for fish, macrobenthos, and other aquatic organisms sensitive to environmental changes.(Malecore et al., 2019).

One of the main impacts of nickel mining on aquatic ecosystems is increased sedimentation. Deforestation and the removal of topsoil accelerate erosion, resulting in large amounts of sediment entering water bodies. Research shows that excessive sedimentation can reduce water clarity, disrupt photosynthesis by aquatic organisms, and destroy bottom habitats. In areas like Konawe, increased sedimentation can permanently alter the physical structure of rivers and estuaries.

In addition to sedimentation, heavy metal pollution poses a serious threat to aquatic ecosystems in nickel mining areas. Mining and metal processing activities have the potential to release elements such as nickel, chromium, and cobalt into the water. Previous research has shown that the accumulation of heavy metals in water can be toxic to organisms, even at low concentrations, and can cause bioaccumulative effects in the food chain. These impacts not only endanger aquatic biodiversity but also the well-being of humans who depend on these water resources.

Changes in water quality due to nickel downstreaming also lead to changes in physical and chemical parameters, such as pH, temperature, and dissolved oxygen levels. Studies in aquatic ecology show that small changes in these parameters can affect the composition of aquatic biota communities and reduce species diversity.(Ezquerro et al., 2019).In the context of Konawe, the combined pressures of sedimentation and chemical pollution increase the risk of overall decline in the quality of the aquatic ecosystem.

In downstreaming policies, impacts on aquatic ecosystems are often less considered than those on land. Environmental assessments generally focus on the mining area, but downstream impacts on rivers and coasts are not adequately analyzed. Yet, watershed-focused methods are crucial for understanding and managing the comprehensive ecological impacts of mining activities.(Ismayilov et al., 2025).The absence of this method in downstreaming policies and practices increases the risk of water damage in Konawe.

By making aquatic ecosystems a key component of the nickel downstream impact analysis, this section demonstrates that water degradation is a structural result of landscape change and extractive activities. This understanding provides an important foundation for subsequent discussions on the impacts on biodiversity and the species that depend on aquatic and coastal ecosystems in Konawe.

The impacts on aquatic ecosystems are not limited to rivers, but also extend to coastal areas. Coastal areas in Konawe are ecologically connected to upstream watersheds. Sediment and pollutants carried by river flow can impact coastal ecosystems, including mangroves, seagrass beds, and coral reefs.(Arriagada et al., 2025).Previous research has shown that increased sedimentation can reduce light penetration, inhibit photosynthesis, and decrease the productivity of coastal ecosystems, which ultimately affects the diversity of marine species.

In terms of biodiversity, the damage to aquatic ecosystems caused by nickel downstreaming has implications for species diversity and ecosystem stability. Aquatic organisms with narrow environmental tolerances are most affected, resulting in a shift in community composition toward species that are more tolerant of disturbances. Research

shows that changes in community composition are often an early sign of broader ecosystem degradation.

Therefore, the impact of nickel downstreaming on the aquatic ecosystem in Konawe cannot be considered a side effect, but rather a significant part of the ecological pressures generated by the policy. Without effective mitigation measures, the decline in aquatic ecosystem quality has the potential to accelerate the decline of biodiversity and disrupt the sustainability of ecosystem functions in the area.

Environmental Policy and the Effectiveness of Biodiversity Protection in Nickel Downstreaming

Environmental policy serves as the primary tool for the state to regulate the environmental impacts of nickel mining and processing activities. In Konawe Regency, the effectiveness of biodiversity protection depends largely on the policy's ability to respond to, limit, and mitigate the environmental impacts arising from mining and mineral processing development. Normatively, Indonesian environmental regulations establish various obligations for business actors, including the preparation of Environmental Impact Assessments (AMDAL), waste management, post-mining reclamation, and the protection of areas with high conservation value. However, empirical evidence suggests that the existence of these regulations does not always align with the effectiveness of biodiversity protection on the ground.

In the implementation of nickel processing policies, AMDALs often serve only as an administrative tool for obtaining permits, rather than as a concrete tool for preventing environmental damage. Various studies have shown that AMDALs are generally prepared using a limited, technocratic approach, resulting in general assessments of impacts on biodiversity that do not reflect the characteristics of local ecosystems. In Konawe, this situation has resulted in a significant lack of identification of important species, crucial habitat areas, and the cumulative impacts of multiple concurrent mining projects.

Beyond the Environmental Impact Assessment (EIA), reclamation and post-mining policies are normatively expected to restore the ecological function of post-mining land. However, studies on mining ecology show that reclamation in tropical ecosystems often fails to restore the original ecosystem structure and function, particularly with regard to biodiversity. Reclamation generally focuses on land stabilization and planting fast-growing plants without considering species diversity, habitat structure, and ecological connectivity. As a result, reclaimed land typically has a much lower biodiversity value than the natural ecosystem that has been lost.

Institutional capacity and environmental oversight mechanisms at the regional level also play a role in the effectiveness of biodiversity protection. In areas with high mining intensity, such as Konawe, monitoring compliance with environmental regulations faces numerous challenges, including limited human resources and technical capacity, as well as overlapping institutions. Research shows that in such settings, environmental violations are often systemic and difficult to detect, resulting in gradual and cumulative impacts on biodiversity.

Furthermore, nickel processing policies demonstrate the tension between economic development and environmental conservation. Policies heavily focused on accelerating investment and increasing mineral production often place biodiversity protection as a secondary priority. In the context of political ecology, this situation illustrates a power relationship that prioritizes short-term economic interests over long-term ecosystem sustainability. In Konawe, this is evident in the weak application of the precautionary principle in the planning and implementation of processing projects.

Furthermore, environmental policies often fail to adequately consider cumulative impacts on biodiversity. Impact assessments are typically conducted on a project-by-project basis, without considering the interactions between projects and the accumulated ecological pressures within a region. However, literature indicates that cumulative impacts are a major driver of biodiversity decline in tropical mining areas. The absence of a landscape approach in environmental policies makes biodiversity protection fragmented and less effective in addressing larger-scale pressures.

In nickel development in Konawe Regency, the effectiveness of environmental policies depends not only on the existence of formal regulations but also on their implementation and oversight in the field. Instruments such as environmental impact assessments (AMDAL), environmental permits, and reclamation obligations are normatively designed to mitigate impacts on ecosystems. However, research shows that in the extractive sector, there is often a gap between policy design and practice on the ground, particularly in areas with high investment pressure.

One of the main obstacles to the success of environmental policies is the dominant administrative approach to managing ecological impacts. Environmental Impact Assessments (EIAs), for example, are often viewed as documents merely to meet permit requirements, rather than as effective tools for detecting and preventing damage to biodiversity. In Konawe, this situation leads to weak ecological impact management from the planning stage, resulting in environmental policies that tend to be reactive rather than preventative.

Furthermore, the capacity of local government institutions significantly determines the effectiveness of environmental policies. Limited human resources, technical capabilities, and oversight authority hamper the state's ability to ensure that businesses comply with existing environmental standards. Environmental policy literature shows that weak oversight allows for practices that undermine biodiversity protection, particularly in large-scale mining industries.

Therefore, the effectiveness of environmental policies to protect biodiversity in Konawe remains limited by structural and implementation issues. Despite existing regulations, the policy's focus on economic acceleration, coupled with a lack of oversight and an approach that neglects ecosystems, has resulted in biodiversity protection being under-appreciated. This situation reinforces the notion that nickel downstreaming policies could cause profound environmental damage if not supported by environmental policies that prioritize biodiversity conservation.

From an environmental perspective, the loss of natural habitat and fragmentation of the landscape due to nickel processing activities have contributed to the decline in ecosystem resilience. Ecosystem resilience refers to the ability of an environmental system to absorb disturbances and maintain its basic functions. Research shows that ecosystems with high biodiversity tend to be more resilient to environmental disturbances. Therefore, the decline in biodiversity in Konawe not only affects specific species but also weakens the ecosystem's ability to sustain existing ecological functions and environmental services.

These environmental impacts also have important socio-ecological aspects. Many local residents in Konawe rely on forest and water ecosystems to meet their daily needs, such as food, clean water, and livelihoods. Biodiversity decline and ecosystem degradation can reduce the availability of environmental services, making communities more socially and economically vulnerable. Research in political ecology shows that environmental degradation resulting from extractive development policies often exacerbates social inequalities and reduces the resilience of local communities.

From a sustainable development perspective, these findings raise important questions regarding nickel processing policy. Sustainable development demands a balance between economic growth, environmental protection, and social welfare. However, in the implementation of nickel processing in Konawe, this balance has not been fully realized. The policy emphasis on increasing mineral added value often ignores ecological constraints and environmental carrying capacity, creating the risk of long-term damage.

Another important aspect is the possibility of becoming trapped in an ecological state, where the environmental damage is irreversible or requires a very long time to recover. Research shows that the loss of natural habitat and the extinction of local species are forms of ecological loss that cannot be fully reversed through technical interventions. In Konawe, this risk is even more pronounced given the species' high level of uniqueness and dependence on specific habitats.

From a policy perspective, the environmental implications of nickel processing highlight the need to shift from a natural resource-based approach to development. Incorporating biodiversity protection into processing policies should be more than merely symbolic or administrative; it needs to be a central part of policy planning and implementation. Ecosystem- and landscape-focused approaches should be enhanced to ensure that industrial development does not exceed a region's ecological capacity.

The environmental impacts of the nickel processing policy in Konawe must be considered within the context of long-term sustainability. Threats to biodiversity, damage to aquatic ecosystems, and changes to the surrounding area indicate that this processing process is not only temporary but can also cause accumulative and difficult-to-recover environmental damage. This poses a risk to the resilience of the ecosystem that underpins the region's sustainable development.

The reduction in biodiversity due to nickel processing has broader environmental impacts than simply the loss of specific species. Biodiversity is crucial for maintaining ecosystem balance and the ability of environmental systems to withstand disturbances. When biodiversity declines, the ecosystem's ability to provide environmental services such

as water regulation, soil fertility, and carbon sequestration also declines. In the Konawe context, this situation can increase the region's vulnerability to environmental disasters and the impacts of climate change.

Thus, nickel processing in Konawe presents a classic dilemma of extractive development in resource-rich areas: the desire for economic growth versus the need to maintain ecological sustainability. This study's findings confirm that without strengthened environmental policies focused on biodiversity protection, nickel processing has the potential to drive unsustainable development and cause long-term ecological harm.(J. Xu et al., 2019).Therefore, the sustainability of development in Konawe is highly dependent on how well public policy can position biodiversity as an important element in the natural resource-based development agenda.

Conclusion

This study shows that the nickel downstreaming policy in Konawe Regency has substantial ecological impacts on biodiversity sustainability and ecosystem functions. The strong focus on mineral value addition and economic growth has accelerated land cover change, habitat fragmentation, aquatic ecosystem degradation, and increased vulnerability of endemic and specialist species. These cumulative effects extend beyond mining concessions and disrupt the broader ecosystem, positioning downstreaming not only as an industrial strategy but also as a local environmental governance force. Nevertheless, the study is limited by its cross-sectional design, restricted long-term ecological data, and single-case focus, which may constrain temporal analysis and broader generalization.

Future research should apply longitudinal and comparative approaches across multiple mining regions to better assess cumulative and long-term ecological changes. Integrating ecological, social, and governance perspectives would strengthen both theoretical and policy insights. Practically, governments and industry actors need to enhance environmental monitoring, enforce stricter rehabilitation and restoration measures, and embed biodiversity safeguards within downstreaming policies to ensure that economic development aligns with ecological sustainability.

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