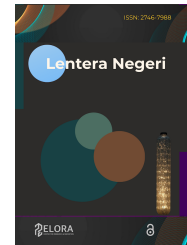




Contents lists available at [Elora Center](#)

Lentera Negeri

Journal homepage: <https://lentera.eloracenter.org/lentera>



The impact of the Indonesian nickel industry downstreaming policy especially

Ali Martin, Ismiyatun, Saadatul Musthoifiyah

Universitas Wahid Hasyim Semarang

Article Info

Article history:

Received Jun 02th, 2026

Revised Jun 29th, 2026

Accepted Jul 18th, 2026

Keyword:

Impact of foreign direct investment,
Multiplier effect,
Environmental damage

ABSTRACT

This study examines the impact of Indonesia's nickel industry downstreaming policy, focusing on Morowali Regency, Central Sulawesi. Employing a qualitative library research method, the study analyzes Foreign Direct Investment theory regarding market access, raw material utilization, and technology transfer to explain both positive and negative consequences of the policy. Findings reveal that downstreaming generates a substantial multiplier effect, including employment absorption, regional economic growth, and MSME expansion, particularly through companies such as PT GNI. Conversely, the policy produces severe negative impacts, including environmental damage, discharge of nickel waste into coastal waters, and landscape transformation. The study concludes that government and stakeholders must prioritize environmental protection, waste management, reforestation, and local worker employment, rather than focusing solely on mining profits, to ensure sustainable and balanced industrial development in nickel-producing regions.



© 2026 The Authors.

This is an open access article under the CC BY-NC-SA license
(<https://creativecommons.org/licenses/by-nc-sa/4.0>)

Corresponding Author:

Ali Martin,

alimartin@unwahas.ac.id

Introduction

Indonesia possesses the largest nickel reserves in the world, a natural endowment that has positioned the country as a central actor in the global supply chain for electric vehicle batteries, stainless steel, and other strategic technologies. Recognizing this comparative advantage, the Indonesian government under President Joko Widodo implemented a downstreaming policy that prohibits the export of raw nickel ore, compelling domestic and foreign investors to process nickel within Indonesian territory through smelting facilities rather than exporting unrefined materials abroad. This policy has triggered a rapid proliferation of nickel smelters, particularly concentrated in Morowali Regency, Central Sulawesi, where an estimated 116 smelters have been planned, with dozens already operational and absorbing tens of thousands of local and foreign workers. On the surface, this industrial expansion has generated a multiplier effect, evidenced by rising regional economic growth, increased Gross Regional Domestic Product, and the emergence of new economic activities surrounding the smelter zones. However, beneath this economic success story lies a troubling reality of environmental degradation. Reports indicate that nickel waste, including acidic tailings laden with heavy metals, is routinely discharged into coastal waters through deep-sea tailings disposal, devastating marine

biota in the Coral Triangle, one of the most biodiverse marine ecosystems on earth. Deforestation, landscape transformation, declining fish populations, and the marginalization of traditional fishing and farming communities have accompanied this industrial growth, revealing a stark contradiction between the economic promises of downstreaming and its ecological and social costs. This duality of rapid economic gain juxtaposed against environmental destruction constitutes the central empirical problem that necessitates serious scholarly attention (Jordy, 2025).

Existing scholarship offers partial explanations for the phenomena observed in Morowali but has yet to fully capture the complexity of the downstreaming policy's consequences. Literature on Foreign Direct Investment (FDI) has long emphasized its capacity to transfer technology, expand market access, and unlock industrial development in less developed countries through mechanisms such as licensing, turnkey projects, and technical assistance. Scholars such as Lu and colleagues have further argued that natural resource abundance functions as a magnet for foreign investment, generating advantages for both host and home economies while simultaneously posing risks to environmental sustainability. Similarly, theories concerning the multiplier effect explain how industrial investment can stimulate broader economic activity, including employment generation, growth in micro, small, and medium enterprises, and improvements in regional welfare indicators. Yet, these theoretical frameworks, largely developed within the context of conventional FDI and industrialization studies, have not adequately addressed the specific tension between resource-driven economic acceleration and ecological degradation that characterizes the Indonesian nickel sector. Much of the existing literature treats economic multiplier effects and environmental damage as separate analytical domains rather than as interconnected outcomes of a single policy intervention. Furthermore, prior studies have rarely examined this tension through the lens of Islamic economic ethics, which offers normative guidance on responsible resource management and environmental stewardship. This gap indicates that current theoretical approaches remain insufficient to comprehensively explain how a single downstreaming policy can simultaneously produce both substantial economic benefit and severe environmental harm within the same regional context (Abdullah & Sumner, 2025).

In light of the empirical realities and theoretical gaps outlined above, this research is conducted with the objective of comprehensively examining the impact of the Indonesian nickel industry downstreaming policy, with specific focus on the Morowali region of Central Sulawesi. More specifically, this study aims to identify and analyze both the positive and negative consequences arising from the implementation of this policy, encompassing its economic dimensions through the lens of the multiplier effect, as well as its environmental dimensions, including marine pollution from nickel waste disposal and large-scale landscape transformation. The research further intends to explore the underlying theoretical foundations relevant to Foreign Direct Investment, including its role in technology transfer, market dynamics, and resource utilization, in order to assess the extent to which these frameworks adequately explain the Morowali case. Additionally, this study seeks to evaluate the social consequences experienced by local communities, particularly fishermen and farmers whose livelihoods have been directly affected by industrial expansion and environmental degradation. By synthesizing economic, environmental, and social perspectives, this research aspires to provide a holistic understanding of how downstreaming policy operates in practice, beyond the often one-dimensional narrative of economic success promoted by government and industry stakeholders. Ultimately, the objective is to generate scholarly insight that can inform more balanced policymaking, ensuring that future industrial development in resource-rich regions like Morowali accounts equally for economic advancement and ecological sustainability, rather than privileging one at the irreversible expense of the other (Ramadhani & Paksi, 2025).

Building upon the realities described and the objectives established, it is argued that this research is essential because the Morowali case represents a critical and instructive example of the structural tensions inherent in resource-based industrialization strategies pursued by developing nations. The hypothesis advanced in this study is that while the downstreaming policy has indeed generated substantial macroeconomic benefits at the national and regional levels, these gains have been achieved through an unsustainable trade-off that disproportionately burdens local ecosystems and vulnerable coastal communities, a dynamic that existing FDI and multiplier effect theories fail to adequately problematize. Without rigorous academic scrutiny, there is a significant risk that policymakers will continue to prioritize

short-term economic metrics, such as export value and employment figures, while neglecting the long-term environmental and social costs that threaten the very sustainability of the industry itself. Furthermore, as global demand for nickel continues to rise in tandem with the worldwide transition toward electric vehicles and renewable energy infrastructure, the patterns observed in Morowali are likely to be replicated in other resource-rich regions of Indonesia and beyond, making it imperative to understand and document these dynamics now. This research is therefore important not only for academic discourse but also for practical policy formulation, as it provides evidence-based insights that can guide the Indonesian government and relevant stakeholders toward a more balanced approach to natural resource governance, one that genuinely integrates environmental protection and social welfare alongside economic ambition (Hermawan & Trimayanti, 2026).

Method

The object of this research is the phenomenon of nickel industry downstreaming policy implementation in Indonesia, with particular attention directed toward Morowali Regency, Central Sulawesi, as the primary case study location. This region was selected as the focal point of analysis because it hosts one of the largest concentrations of nickel smelters in the country, including major industrial operations such as PT Indonesia Morowali Industrial Park (IMIP) and PT Gunbuster Nickel Industry (PT GNI), which together represent the practical manifestation of the government's downstreaming agenda. The phenomenon under investigation encompasses two interrelated dimensions that operate simultaneously within this region: the economic transformation generated through industrial investment, employment absorption, and regional revenue growth, and the environmental and social consequences arising from intensive mining and smelting activities, including marine pollution, deforestation, and landscape degradation. These two dimensions are not treated as isolated phenomena but rather as interconnected outcomes of a single policy framework, making Morowali a particularly rich and instructive case for examining the broader tensions inherent in resource-based industrialization. By focusing on this specific object of study, the research seeks to move beyond abstract policy discourse and instead ground its analysis in the concrete realities experienced by industry stakeholders, local communities, and the surrounding ecosystem. This object of research therefore serves as the empirical anchor through which the theoretical frameworks discussed in the literature review can be tested, contextualized, and critically evaluated (Rosada et al., 2023).

This research employs a qualitative library research design, also known as *kepastakaan* or literature-based methodology, which relies entirely on the examination of existing written sources rather than direct field observation or primary data collection through interviews and surveys. Within this framework, the study utilizes two categories of data: primary and secondary. Primary data in this research consists of literature directly relevant to the case of nickel industry downstreaming in Morowali, including news reports, government policy documents, statements from industry officials, and statistical data published by relevant institutions such as the Central Statistics Agency and the Ministry of Energy and Mineral Resources, all of which provide firsthand documentation of the phenomenon under investigation.

Secondary data, on the other hand, encompasses broader academic literature relevant to the key concepts underpinning this research, namely Foreign Direct Investment, the multiplier effect, and environmental impact, drawn from scholarly books, peer-reviewed journal articles, and prior scientific research conducted by other authors. This combination of primary and secondary data allows the research to construct a comprehensive understanding that bridges concrete empirical developments in Morowali with established theoretical frameworks found in the broader academic discourse. The library research approach is particularly suitable for this study because the subject matter, namely the multidimensional impact of a national policy, requires extensive synthesis of diverse sources rather than the isolated examination of a single data point.

The theoretical foundation of this research draws upon several established frameworks within the field of international economics and development studies. The primary theoretical lens applied is the concept of Foreign Direct Investment and its relationship to technology transfer, as articulated by Gheribi and colleagues in their 2018 study published in the *Economic and Environmental Studies Journal*, which posits

that FDI plays a critical role in transferring technology from home countries to host countries through mechanisms such as licensing, turnkey projects, and technical assistance arrangements. This research also draws upon the theory developed by Wencong Lu and colleagues in 2020, published in the *Sustainability Journal*, which examines the relationship between Foreign Direct Investment and natural resource abundance, arguing that resource wealth serves as a significant attraction for foreign investors while simultaneously generating both beneficial and detrimental outcomes for sustainability in host countries.

Additionally, the framework proposed by Anita Macek in 2021 regarding the broader contributions of FDI to host countries, including productivity enhancement, knowledge transfer, and the growing engagement of local suppliers within global supply chains, provides further theoretical grounding for understanding the economic dimensions of this research. These theories collectively serve as the conceptual lens through which the empirical findings concerning Morowali's nickel downstreaming policy are interpreted, allowing the research to assess the extent to which observed outcomes align with or diverge from established theoretical expectations regarding the impact of foreign investment in resource-rich developing economies.

The data collection process undertaken in this research follows a systematic procedure centered on the careful reading, review, and compilation of written and documented sources related to the subject matter under investigation. This process begins with the identification of relevant literature through academic databases, institutional repositories, and credible online news platforms, followed by a thorough reading of selected books, prior research studies, academic papers, journal articles, official reports, and magazine publications that address themes connected to nickel industry downstreaming, Foreign Direct Investment, and environmental impact in Indonesia.

Each source is carefully reviewed to extract relevant information pertaining to the research questions, with particular attention given to data concerning the economic multiplier effect generated by smelter operations, statistical figures related to employment and regional economic growth, and documented evidence of environmental degradation including marine pollution and deforestation in the Morowali area. Throughout this process, sources are cross-referenced and verified against one another to ensure the accuracy and reliability of the information being incorporated into the research, particularly given the sensitive and sometimes contested nature of data surrounding environmental damage and corporate accountability. This systematic literature collection technique ensures that the research findings are grounded in credible, verifiable, and contextually relevant evidence rather than speculative or unsubstantiated claims, thereby strengthening the overall validity of the study's conclusions (Rum et al., 2025).

The data analysis technique employed in this research is content analysis, a method that involves the systematic study and processing of collected textual data in order to identify recurring patterns, meaningful relationships, and significant information embedded within the literature reviewed. Through this technique, the various sources gathered during the data collection process are carefully examined and categorized according to thematic relevance, distinguishing between content related to the positive economic impacts of downstreaming, such as the multiplier effect and employment generation, and content related to negative consequences, including environmental damage, marine waste disposal, and landscape transformation.

This categorization process enables the researcher to identify both convergences and contradictions across different sources, thereby constructing a more nuanced and balanced understanding of the phenomenon under investigation. Furthermore, content analysis allows for the synthesis of theoretical frameworks discussed in the literature review with empirical evidence drawn from the Morowali case, facilitating an interpretive process that connects abstract economic theory with concrete, real-world outcomes. The analytical process also involves critically evaluating the credibility and perspective of each source, recognizing that government reports, industry statements, and civil society narratives may present differing interpretations of the same events. By employing this rigorous and systematic analytical approach, the research aims to produce findings that are not merely descriptive but also analytically robust, capable of contributing meaningful insight into the broader scholarly discourse on resource-based industrialization and its multidimensional consequences (Wicaksana & Putri, 2026).

Results and Discussions

Results

Overview of Findings

The results of this library-based research reveal that the implementation of Indonesia's nickel industry downstreaming policy in Morowali Regency, Central Sulawesi, has produced a complex and multidimensional array of outcomes that can be broadly categorized into two opposing yet interconnected dimensions: positive economic impacts and negative environmental impacts. On the economic side, the establishment of large-scale smelter operations, particularly under companies such as PT Indonesia Morowali Industrial Park (IMIP) and PT Gunbuster Nickel Industry (PT GNI), has generated substantial employment opportunities, stimulated regional economic activity across multiple sectors, contributed significantly to local government revenue, and accelerated the overall pace of regional development in what was previously a relatively underdeveloped area. On the environmental side, however, this same industrial expansion has produced severe and, in many cases, irreversible ecological consequences, including the discharge of toxic nickel waste into coastal waters, large-scale deforestation, destruction of agricultural land, and irreversible transformation of the natural landscape that once characterized the Morowali coastline and surrounding highlands.

These findings confirm that the downstreaming policy operates not as a singular, uniformly positive intervention, but as a double-edged instrument of development that simultaneously accelerates regional economic growth while undermining the long-term ecological sustainability of the surrounding environment and the traditional livelihoods of communities who depend upon it, particularly fishermen and farmers. The data collected and synthesized from various credible sources, including official government statistics, investigative news reports, environmental advocacy organizations, and academic literature, consistently and repeatedly point to this fundamental duality as the defining and most significant characteristic of the Morowali case study. This comprehensive overview establishes the foundation for the more detailed, evidence-based examination of each specific impact category presented in the subsequent paragraphs, beginning with a thorough explanation of the positive multiplier effect before systematically proceeding to the severe negative environmental consequences that have inevitably accompanied the policy's rapid and largely unregulated implementation across the region (Purwana et al., 2026).

Multiplier Effect General Explanation

The first major finding of this research concerns the multiplier effect generated by the downstreaming of the nickel industry, which represents the most prominently cited and frequently celebrated positive outcome of the policy according to government sources and industry stakeholders alike. The multiplier effect, as a concept, refers to the broad and cascading economic influence that arises when investment in one particular sector generates ripple effects across numerous other interconnected sectors of the economy, thereby increasing overall national and regional spending, which in turn substantially affects income levels, consumption patterns, and standards of living throughout the affected community. In the specific context of Morowali, this effect manifests through the operations of major smelter companies that not only directly employ thousands of local and foreign workers but also stimulate the parallel growth of numerous ancillary industries, including trade, transportation, hospitality, and various service sectors that cater specifically to the daily needs of the rapidly growing industrial workforce and their families.

The Indonesian government, under the leadership of President Joko Widodo, has consistently positioned the downstreaming policy as a strategic and transformative mechanism designed to increase the added economic value of nickel commodities, deliberately moving the country away from its historical and economically disadvantageous role as a mere exporter of cheap raw materials toward becoming a sophisticated producer of processed, higher-value nickel-based products such as ferronickel and stainless steel precursors. This deliberate policy shift is explicitly expected to encourage broader national economic growth, reduce dependency on volatile international commodity markets, and simultaneously strengthen domestic industrial capacity and self-sufficiency. The findings of this research indicate that this theoretical and political expectation has, to a remarkably significant extent, materialized in practice within Morowali, as clearly evidenced by tangible and measurable improvements in regional employment figures, household income

levels, and the visible diversification of local economic activity, all of which are explored and substantiated with specific data in the following paragraphs (Pambudi, 2025).

Employment Absorption PT GNI Case

A particularly specific and well-documented example illustrating the multiplier effect in concrete practice is found in the detailed operations of PT Gunbuster Nickel Industry (PT GNI), a major foreign capital company engaged in nickel smelting through the adoption of advanced Rotary Kiln Electric Furnace technology, strategically located in Bunta Village, Petasia District, North Morowali Regency. The research findings clearly indicate that PT GNI has successfully absorbed thousands of local workers across both its initial construction phase and its subsequent ongoing operational stage, with the company maintaining continuous and active recruitment efforts specifically targeting local residents of the surrounding villages and districts, and with credible projections suggesting that total employment figures will reach tens of thousands of workers within the coming years as expansion continues.

This substantial and sustained absorption of local labor has translated into direct, measurable economic benefits for residents throughout the North Morowali area, as household incomes have visibly increased alongside the company's continuously expanding workforce and operational footprint. The presence and rapid expansion of PT GNI clearly demonstrates how a single major industrial operation possesses the capacity to generate truly significant employment opportunities within a relatively short and compressed period of time, fundamentally and rapidly altering the entire economic landscape of a region that was previously characterized by limited industrial development and economic stagnation.

This particular finding aligns closely with the theoretical proposition long established in development economics literature, which posits that Foreign Direct Investment plays an absolutely critical and indispensable role in job creation within host countries, particularly within labor-intensive sectors such as mining and large-scale industrial processing. However, it is equally important to note, as a counterbalancing observation, that the region's heavy reliance on a single dominant employer of this scale creates significant underlying economic vulnerability and structural fragility, as the broader prosperity of North Morowali becomes closely and almost exclusively tied to the continued operation, financial stability, and long-term commitment of this one company, a dangerous dependency that carries substantial inherent risks should the company's operations face any future disruption, relocation, or downsizing.

New Economic Activity Around the Factory

Beyond the direct employment benefits discussed above, the research findings further reveal that the establishment and rapid expansion of nickel smelters throughout Morowali has effectively catalyzed the emergence of entirely new and previously nonexistent economic ecosystems surrounding the major industrial zones. This significant phenomenon is clearly evident in the rapid and sustained growth of trade, services, and transportation sectors that have organically developed specifically to cater to the daily and ongoing needs of factory workers, company management, and the broader and increasingly complex industrial supply chain that supports smelter operations. Small retail shops, local eateries and food stalls, temporary and permanent lodging facilities, and various transportation services have proliferated extensively in areas that were previously characterized by extremely limited economic activity and minimal commercial infrastructure, clearly demonstrating a distinct and measurable secondary economic effect stemming directly from the primary industrial investment.

This particular pattern of economic diversification closely reflects the classic multiplier effect described extensively in mainstream economic theory, wherein initial capital investment concentrated in one specific sector inevitably generates substantial downstream demand for goods and services in entirely unrelated sectors, thereby progressively broadening and strengthening the overall economic base of the affected region over time. The findings further and importantly suggest that this emergence of new economic activity has provided genuine opportunities for local entrepreneurs who previously possessed extremely limited access to formal economic participation, allowing many of them to successfully establish small businesses that directly and substantially benefit from the increased local population, foot traffic, and overall spending power brought about by the continuous presence of large-scale smelter operations. While this economic diversification undeniably represents a genuine and tangible benefit for many local residents, the research also carefully

notes that much of this newly generated economic activity remains heavily and almost entirely dependent on the continued presence, stability, and ongoing expansion of the nickel industry itself, thereby raising legitimate and serious questions regarding the long-term sustainability, resilience, and economic diversification of this particular development model should the nickel industry experience significant contraction, relocation, or decline at any point in the future (Rosada, 2025).

Regional Income Increase

The research findings demonstrate a clearly measurable and statistically significant increase in regional economic indicators following the establishment and rapid expansion of nickel smelters throughout Morowali, as comprehensively documented through official data published by the Central Statistics Agency (BPS) and corroborated by other credible governmental sources. According to this verified data, North Morowali's overall economic growth rate, which had remained confined within a relatively modest single-digit percentage range throughout 2021, experienced a remarkably sharp and dramatic acceleration by 2023, reaching an impressive 10.47 percent during the first semester of that year, before climbing even further to an extraordinary 36.42 percent during the early portion of the second semester of 2023. Similarly, and equally significant, the Growth Rate of Gross Regional Domestic Product (GRDP) for Morowali Regency as a whole showed substantial and consistent improvement over the same period, increasing by 8.6 percent compared to the previous year, with total GRDP reaching 20.20 percent in 2019 and rising further still to 28.83 percent in 2020. These key statistical findings, drawn from multiple corroborating sources, are summarized comprehensively in the table presented below for the purpose of analytical clarity and ease of reference (Lahadalia et al., 2024).

Tabel 1. Regional Income Increase

Indicator	Period	Value
Morowali GRDP	2019	20.20%
Morowali GRDP	2020	28.83% (increase of 8.6% YoY)
North Morowali Economic Growth	2021	Single-digit range
North Morowali Economic Growth	2023 (1st Semester)	10.47%
North Morowali Economic Growth	2023 (Early 2nd Semester)	36.42%
Smelters Operational (of 116 planned nationally)	2023–2024	29 operational
Smelter Companies Built in Morowali	2023–2024	58 companies
Estimated Workers Absorbed Nationally	2023–2024	174,000 workers
Average Workers per Smelter	Estimate	~3,000 workers
Integrated Industrial Areas (Sulawesi & Maluku)	National	8 areas

This comprehensive and well-sourced data strongly confirms that the downstreaming policy has produced a tangible, measurable, and genuinely significant positive effect on regional income and overall economic output, with economic growth rates accelerating dramatically and consistently within a remarkably compressed timeframe, clearly reflecting the rapid pace at which sustained industrial investment has fundamentally transformed the local economy of Morowali Regency over the course of just a few short years.

In addition to the direct employment and substantial regional income growth discussed in previous paragraphs, the research findings further indicate that the downstream nickel industry has generated meaningful and measurable positive spillover effects within both the Micro, Small, and Medium Enterprises (MSME) sector and the broader local education sector. Regarding the MSME sector specifically, the consistently increasing demand for goods and various services from local small businesses by PT GNI and numerous other companies associated with the broader nickel downstream industrial supply chain has effectively created entirely new market opportunities for small entrepreneurs throughout the region, allowing them to supply essential materials, food products, and ongoing services to the rapidly growing industrial workforce and its associated economic supply chains.

This particular finding strongly suggests that the genuine benefits of large-scale industrial investment are not confined solely to the direct employees of major smelter companies, but rather extend considerably outward to meaningfully benefit a much broader segment of the local population engaged in various small-scale economic activities throughout the region. In the education sector specifically, the research findings clearly reveal that the downstream nickel industry has stimulated substantially increased demand for skilled workers possessing relevant technical expertise and specialized training applicable to complex industrial operations, thereby creating strong economic incentives for local educational institutions and vocational training programs to actively develop and refine curricula specifically aligned with the practical needs of the nickel processing industry.

This important dynamic possesses genuine potential to meaningfully improve overall human capital development within the region, as local residents are increasingly encouraged and economically incentivized to pursue technical and vocational education in order to access higher-paying and more stable employment opportunities within the expanding smelter industry. While these particular findings undoubtedly represent positive and welcome developments for the region as a whole, the research also carefully and critically notes that the precise extent to which these economic benefits are genuinely and equitably distributed across the entire population, rather than being disproportionately concentrated among a relatively small and select group of skilled or well-connected workers, remains an important and unresolved consideration that warrants further dedicated scrutiny and investigation in future research efforts (Farawansa & Gultom, 2024).

In stark and troubling contrast to the consistently positive economic findings discussed extensively above, the research reveals substantial, well-documented, and deeply concerning evidence of severe environmental damage resulting directly from the aggressive downstreaming of the nickel industry throughout Morowali Regency. The findings clearly and consistently indicate that the rapid and largely unchecked expansion of nickel mining and smelting operations, proceeding almost entirely without adequate corresponding environmental regeneration measures or meaningful regulatory oversight, has produced significant and often irreversible ecological harm, including extensive deforestation, severe damage to fragile marine biota, and substantial disruption to long-established local ecosystems.

This troubling pattern of environmental degradation is entirely consistent with broader concerns repeatedly raised throughout the academic literature regarding the inherent negative sustainability impacts commonly associated with resource extraction industries more generally, particularly and especially when such industries expand at a rapid pace without corresponding and proportionate investment in environmental protection, monitoring, and rehabilitation infrastructure. The research findings further and importantly reveal that despite the considerable and well-documented economic benefits generated by the downstreaming policy, the Indonesian government has, in practice, consistently prioritized nickel mining and processing activities as a primary and preferred revenue source, frequently doing so at the direct expense of adequate and necessary environmental safeguards and protective regulations.

This troubling pattern of prioritization has directly resulted in dramatically increased nickel production levels that have not been meaningfully balanced by corresponding environmental regeneration efforts, thereby creating dangerous conditions conducive to genuine social-ecological disasters within the heavily mining-affected areas of Morowali Regency. The findings strongly suggest that the extraction and subsequent processing of nickel ore inherently and unavoidably produces significant pollution through multiple interconnected pathways, thereby necessitating a far more detailed and comprehensive examination of the specific mechanisms through which this widespread environmental damage actually occurs in practice, namely through the systematic discharge of waste into sensitive marine environments and through large-scale, often permanent transformation of the surrounding terrestrial landscape, both of which are explored in considerably greater depth and detail in the two following paragraphs (Manurung et al., 2025).

A particularly severe and well-documented environmental consequence identified throughout this research concerns the systematic and ongoing discharge of nickel processing waste directly into Indonesian coastal waters surrounding the Morowali region. The findings clearly reveal that intensive smelting operations throughout Morowali produce genuinely significant quantities of highly acidic waste containing dangerous concentrations of heavy metals, much of which is routinely disposed of through a controversial

practice known as deep-sea tailings disposal (DSTD), a method widely considered cost-effective by industry operators despite being highly and demonstrably damaging to fragile marine ecosystems. Greenpeace Indonesia has specifically and repeatedly identified this particular waste disposal practice as one of the most significant environmental threats associated with the broader nickel downstreaming program, explicitly noting that the ongoing discharge severely pollutes marine biota throughout the Coral Triangle, widely recognized as one of the most biodiverse marine regions found anywhere in the entire world.

The research findings further document genuinely severe and well-documented consequences specifically affecting local fishing communities, including the widespread death of fish populations, visible contamination evidenced by darkened fish stomach contents that have effectively rendered local seafood completely unfit for human consumption, and the urgent need for local fishermen to travel increasingly long distances at substantially higher operational costs in order to reach viable and productive fishing grounds, often as far as the depths of the distant Banda Sea. Additionally, the findings reveal serious and ongoing contamination from thick mud sediment that consistently clogs fishing nets, alongside the presence of heated industrial waste fluids originating from drainage channels associated with PT IMIP operations, collectively resulting in persistently murky seawater, extensive coral reef damage, and the destruction of vital mangrove forest ecosystems along the affected coastline. The cumulative weight of these detailed findings clearly demonstrates that the systematic disposal of nickel processing waste into the sea represents one of the most ecologically destructive and socially damaging consequences of the entire downstreaming policy, directly and severely undermining the traditional livelihoods of coastal communities who depend almost entirely on marine resources for their economic survival, while simultaneously raising serious and unresolved ethical concerns regarding genuine environmental stewardship and corporate accountability (Rivota & Wardhana, 2026).

The final major environmental finding documented throughout this research concerns the genuinely dramatic and largely irreversible transformation of Morowali's natural landscape resulting directly from the rapid proliferation of nickel mining operations across the region. The findings clearly indicate that specific areas projected and targeted as nickel-rich zones, such as the Bahodopi coast extending toward South Bungku, have undergone substantial and visually striking ecological alteration, with previously dense, green, and biodiverse forests now subjected to massive and systematic clearing, leaving behind extensive exposed red soil that has become a visible and unmistakable signature characteristic of active nickel mining activity throughout the region.

The research further reveals that previously productive rice fields located along the coast, particularly stretching from Kolono Village to Fatuvia Hamlet, have been permanently replaced by asphalt roads specifically constructed to facilitate ongoing mining operations and ore transportation, while the once-thriving waters of Tomori Bay, formerly the temporary regional capital and a productive fishing area, have been substantially filled with mining sediment in order to construct dedicated ports for nickel ore barge transportation and parking. Notably and significantly, the findings document the existence of approximately 28 such ports already constructed along the regional coastline, effectively constituting extensive and ongoing coastal reclamation that severely disrupts the natural shoreline and directly threatens nearby mangrove forest ecosystems situated within the protected Morowali Nature Reserve.

The once exotic and vibrant blue waters that historically surrounded the region have reportedly turned a distinctly unnatural orange color due to continuous waste discharge, while broader national regional planning frameworks, such as the Master Plan for the Acceleration of Indonesian Economic Development (MP3EI), have explicitly designated the entire Sulawesi Economic Corridor as a priority mining zone, particularly given that the region already supplies approximately 50 percent of Indonesia's total nickel mining commodities to both domestic and international markets. These comprehensive findings collectively and conclusively demonstrate that the ongoing landscape transformation occurring throughout Morowali is not merely incidental or temporary, but rather represents a systemic, sustained, and continuously ongoing consequence of relentless industrial expansion, carrying significant and troubling implications for the region's long-term ecological integrity and the overall welfare of communities whose daily lives and livelihoods remain intricately and inextricably connected to the surrounding natural environment (Hayati, 2026).

Discussion

Synthesizing the Duality of Impact

The comprehensive findings presented above collectively and powerfully illustrate that the downstreaming of Indonesia's nickel industry in Morowali represents a profound and instructive case study in the inherent and seemingly irreconcilable tension between rapid economic development and genuine long-term environmental sustainability. The fundamental significance, or the genuine "so what," of these detailed findings lies in the critical recognition that economic prosperity and severe ecological destruction are not merely coincidental outcomes occurring entirely independently and side by side, but rather represent deeply interconnected and mutually reinforcing consequences stemming directly from the very same underlying policy mechanism.

The substantial multiplier effect generated by extensive smelter operations throughout the region, while undeniably and genuinely beneficial in terms of measurable employment generation, regional income growth, and broader economic diversification, has nevertheless been achieved specifically through an extraction-intensive industrial model that, by its very nature and operational logic, necessarily and unavoidably produces significant environmental externalities as an essentially inseparable byproduct of its core economic activities. This fundamental duality directly and forcefully challenges overly simplistic policy narratives that present downstreaming as an entirely unambiguous and unqualified success story, instead revealing a considerably more complicated and nuanced reality in which the very same mechanisms responsible for driving impressive economic growth, namely large-scale and intensive mining and smelting operations, are simultaneously and directly responsible for causing severe, well-documented, and often irreversible environmental harm.

The broader significance of this important finding extends considerably beyond the specific and localized case of Morowali, offering genuinely valuable and transferable insight into the deeper structural challenges consistently faced by resource-rich developing nations attempting to successfully balance rapid industrialization with genuine long-term sustainability commitments. Thoroughly understanding this fundamental duality is therefore absolutely essential for policymakers, scholars, and civil society alike, as it clearly underscores the urgent necessity of designing future industrial policies that explicitly and proactively account for environmental costs from the outset, rather than treating such costs merely as unfortunate externalities to be addressed only after significant and often irreversible damage has already occurred, representing a critical and directly applicable lesson with substantial relevance for future resource development initiatives throughout Indonesia and across other developing economies pursuing broadly similar industrialization strategies (Wafia et al., 2025).

Theoretical Implications FDI Theory

When carefully examined through the established theoretical lens of Foreign Direct Investment as outlined extensively in the earlier literature review, the empirical findings emerging from Morowali both meaningfully confirm and significantly complicate several existing theoretical assumptions commonly held within mainstream development economics literature (Xu et al., 2023). The literature reviewed previously, particularly the influential work of Gheribi and colleagues concerning technology transfer mechanisms and Macek's broader theoretical framework regarding FDI's substantial contributions to productivity enhancement and supply chain integration, generally suggests that foreign investment typically produces predominantly beneficial outcomes for host countries and their domestic economies.

The detailed findings from Morowali partially and meaningfully confirm this general theoretical expectation, as clearly evidenced by substantial and measurable technology transfer occurring through ongoing smelter operations, alongside genuinely meaningful integration of local suppliers into the broader nickel processing supply chain. However, these same findings also reveal a significant and important limitation embedded within conventional FDI theory, which tends to systematically underemphasize the substantial environmental costs specifically associated with resource-based investment, particularly and especially within extractive industries such as large-scale mining and mineral processing. Wencong Lu's important theoretical proposition, which holds that natural resource abundance simultaneously attracts substantial foreign investment while also generating both genuinely positive and seriously negative sustainability outcomes, proves to be by far the most accurate and analytically useful theoretical framework

for comprehensively explaining the complex Morowali case, precisely because it explicitly and directly acknowledges this fundamental duality rather than treating environmental impact as merely a peripheral or secondary concern (Şenyapar, 2024).

This important finding strongly suggests that future theoretical development within the broader FDI literature must deliberately move beyond purely narrow economic metrics of investment success and must instead meaningfully incorporate environmental sustainability as a genuinely central, rather than merely secondary, analytical dimension. The direct implication is that policymakers who rely primarily on conventional FDI theory to evaluate complex investment proposals may systematically and significantly underestimate substantial environmental risks, thereby highlighting the urgent need for more genuinely integrated theoretical and practical policy frameworks capable of simultaneously assessing both economic benefit and ecological cost before formally approving large-scale resource extraction projects of this nature and scale (Kusworo & Abdulkadir, 2025).

Why This Matters Multiplier Effect Reconsidered

The deeper underlying rationale, or genuine "why," underlying these comprehensive findings becomes considerably clearer when carefully considering the broader implications of the documented multiplier effect within the essential context of genuine sustainable development principles. While the substantial multiplier effect thoroughly documented throughout Morowali clearly demonstrates genuine and measurable economic value, effectively generating widespread employment, stimulating numerous ancillary industries, and meaningfully increasing overall regional income, this research firmly argues that an exclusive and narrow focus on multiplier effect metrics alone risks producing a fundamentally distorted and dangerously incomplete assessment of overall policy success. Conventional economic indicators such as GRDP growth figures and aggregate employment statistics, while undeniably important and informative, ultimately fail to adequately capture the full and complete cost of industrial development when severe environmental degradation simultaneously and progressively undermines the long-term economic viability of affected local communities, particularly and especially those communities heavily dependent on fishing and agricultural livelihoods for their economic survival (Shabbir & Salman, 2026).

This discussion specifically and forcefully emphasizes that the apparent and widely celebrated success of the multiplier effect observed in Morowali may ultimately prove to be economically unsustainable over the longer term, as the systematic destruction of traditional fishing grounds and productive agricultural land through ongoing pollution and extensive deforestation gradually but inexorably erodes the very economic foundation upon which these traditional livelihoods fundamentally depend, effectively transferring economic value from one productive sector to another rather than genuinely generating additive and sustainable economic growth. This particular finding matters profoundly because it directly challenges policymakers to fundamentally reconsider precisely how economic success is conventionally measured and officially reported, strongly advocating for the meaningful incorporation of comprehensive environmental and social cost accounting directly into official economic growth statistics and policy evaluation frameworks. Without such a fundamental reconsideration, the apparent and superficially impressive economic triumph of the downstream policy risks dangerously obscuring a considerably more troubling underlying reality of irreversible resource depletion and forced community displacement that conventional economic indicators are simply and fundamentally not designed or equipped to adequately capture or reflect (Aiguoabarueghian et al., 2024).

Islamic Economic Ethics Perspective

An especially important and distinctive dimension of this broader discussion concerns the deeper ethical implications of the research findings when carefully examined through the specific perspective of Islamic economics, which offers genuinely valuable normative guidance directly and meaningfully relevant to the severe environmental damage thoroughly documented throughout this research. As specifically noted within the findings section, mining exploration activities conducted in sensitive coastal areas that subsequently result in severe marine pollution and significant ecosystem destruction stand in direct and fundamental conflict with the core ethical principles deeply embedded within Islamic teachings regarding responsible and accountable stewardship of natural resources.

This particular ethical perspective consistently emphasizes that human beings, while certainly permitted and even encouraged to derive genuine benefit from available natural resources, simultaneously bear a fundamental and non-negotiable responsibility to actively preserve environmental sustainability for the genuine benefit of both present and future generations, a foundational principle that has been demonstrably and repeatedly violated through the documented practices of systematic nickel waste disposal and largely unchecked deforestation clearly observed throughout the Morowali region.

The genuine significance of deliberately incorporating this important ethical dimension into the broader discussion lies specifically in its unique capacity to provide a genuinely value-based and culturally resonant framework for evaluating industrial policy that extends meaningfully beyond purely economic or even secular environmental considerations alone (Cooke et al., 2022). This particular perspective strongly suggests that the severe environmental damage thoroughly documented throughout this research should not be assessed merely as a narrow technical or regulatory failure, but rather should be understood as representing a considerably deeper ethical breach concerning humanity's fundamental and sacred relationship with the natural world (Furqani & Echchabi, 2022). For a predominantly Muslim nation such as Indonesia, this particular ethical framework carries genuinely substantial weight and cultural resonance, strongly suggesting that meaningful policy reform aimed at addressing the negative consequences of nickel downstreaming should be firmly grounded not only in conventional economic or environmental science, but also in culturally and religiously resonant values that possess genuine capacity to mobilize broader public sentiment and stronger governmental commitment toward meaningful environmental rehabilitation and genuinely sustainable resource management practices going forward (Furqani et al., 2020).

Policy Implications

The comprehensive findings of this research carry genuinely substantial and direct implications for future policy formulation, strongly suggesting that the Indonesian government must fundamentally and urgently reconsider its current overall approach to managing the ongoing downstreaming of the nickel industry in order to meaningfully address the serious negative consequences clearly identified throughout this entire study. For what genuine purpose, then, should this comprehensive research ultimately inform concrete policy action moving forward? Primarily and most importantly, it strongly underscores the urgent and pressing necessity for environmental protection and meaningful rehabilitation to be treated as an absolute top priority equal to, rather than clearly subordinate to, narrow economic considerations alone, thereby requiring the government and all relevant stakeholders to collaboratively implement comprehensive waste management systems, dedicated river and coastal restoration programs, and ambitious reforestation initiatives specifically aimed at meaningfully mitigating ongoing flooding risks while genuinely restoring severely damaged ecosystems throughout the affected region (Kader, 2021).

Additionally, the specific findings regarding current employment patterns strongly suggest that meaningful policy reform should explicitly prioritize local Indonesian workers over foreign labor, given that many existing smelter operations have historically and consistently relied quite heavily on foreign employees despite the government's repeatedly stated official objective of genuinely improving Indonesian human resource development and domestic employment opportunities (Yu, 2025). The persistent confusion and clearly inadequate governmental response to environmental damage thoroughly documented throughout this research further and strongly indicates the urgent need for considerably clearer regulatory frameworks, substantially stricter enforcement mechanisms, and genuinely more transparent and accountable monitoring systems specifically designed to hold mining and smelter companies fully accountable for their ongoing environmental practices and corporate responsibilities (Basilici, 2023).

These specific and detailed policy implications are not intended merely as abstract theoretical recommendations, but rather represent genuinely practical and directly actionable steps that could meaningfully and substantially alter the current trajectory of ongoing environmental degradation presently observed throughout Morowali, provided that the government demonstrates genuine and sustained political will to successfully balance legitimate economic ambition with essential ecological responsibility, rather than continuing to prioritize short-term profit generation derived from nickel mining and processing activities over considerably more important long-term environmental integrity and broader social welfare considerations (Khalidin et al., 2024).

Broader Significance and Future Outlook

In drawing this comprehensive discussion toward its natural conclusion, the considerably broader significance of these detailed findings extends well beyond the specific and localized case of Morowali alone, offering genuinely valuable and transferable lessons for Indonesia's continued pursuit of resource-based industrialization strategies across numerous other regions, as well as for broadly similar policy initiatives being pursued by other developing nations that are similarly rich in valuable natural resources (Oloyede et al., 2023). As global demand for nickel continues to escalate dramatically alongside the ongoing worldwide transition toward electric vehicles and various renewable energy technologies, the troubling patterns of substantial economic benefit coupled with severe environmental harm thoroughly documented throughout this research are genuinely likely to be replicated in other mining-intensive regions across Indonesia and beyond unless meaningful and substantive policy reforms are proactively implemented in the near future.

This particular research therefore serves a genuinely important and timely function in carefully documenting and rigorously analyzing these complex dynamics at what represents a critical and pivotal juncture, providing solid empirical evidence capable of informing considerably more sustainable approaches to natural resource governance before similarly severe environmental damage potentially becomes entirely irreversible in other regions of the country (Hughes & Grumbine, 2023).

The comprehensive discussion presented throughout this entire section clearly demonstrates that genuine and lasting sustainable development fundamentally requires moving well beyond an overly narrow focus on conventional economic growth metrics toward a considerably more holistic and integrated evaluation framework that simultaneously and meaningfully accounts for both environmental integrity and broader social welfare, thereby helping to ensure that the genuine benefits of industrialization do not ultimately come at the entirely unacceptable cost of severe ecological destruction and forced community displacement (Nagle et al., 2023).

Ultimately and conclusively, the genuine scholarly value of this research lies precisely in its meaningful contribution toward a considerably more nuanced, balanced, and evidence-based understanding of nickel downstreaming policy as a whole, one that fully and honestly acknowledges both its genuine and substantial economic achievements alongside its equally serious and well-documented environmental shortcomings, thereby effectively equipping policymakers, academic scholars, and broader civil society alike with the essential evidence-based insight genuinely necessary to advocate persuasively for a considerably more sustainable and ethically responsible path forward for the future of Indonesia's vital nickel industry.

Conclusions

This research concludes that the downstreaming policy of Indonesia's nickel industry in Morowali Regency, Central Sulawesi, has produced a fundamentally dualistic impact that simultaneously generates substantial economic benefit and severe environmental harm. On the positive side, the policy has successfully created a significant multiplier effect, evidenced by extensive employment absorption through companies such as PT GNI and PT IMIP, accelerated regional economic growth as reflected in sharply rising GRDP figures, expanded opportunities for MSMEs, and improvements in technical education demand. Sustainable and integrated downstreaming strengthens domestic industry and protects Indonesia from commodity price fluctuations, reducing dependency on raw material imports that would otherwise leave the economy vulnerable to exchange rate shocks. However, this economic progress has come at a severe ecological cost, manifested through the discharge of toxic nickel waste into coastal waters, destruction of marine biota in the Coral Triangle, deforestation, and irreversible landscape transformation across the Bahodopi coast and surrounding areas. Without environmental rehabilitation measures such as reforestation and proper waste management, these natural disasters will continue to worsen. Therefore, sustainable downstreaming requires the Indonesian government to balance economic ambition with genuine ecological responsibility and social welfare for affected communities.

References

- Abdullah, I., & Sumner, A. (2025). *Linkage Development As Industrial Policy: The State And Structural Transformation In Resource-Rich Countries* (Issue 29/25). Wider Working Paper.
- Aiguobarueghian, I., Adanma, U. M., Ogunbiyi, E. O., & Solomon, N. O. (2024). An Overview Of Initiatives And Best Practices In Resource Management And Sustainability. *World Journal Of Advanced Research And Reviews*, 22(2), 1734–1745.
- Basilici, M. C. (2023). *Prejudicial Bullying Involving Ethnic Groups In School: The Role Of Environmental Aspects And Psychological Mechanisms*.
- Cooke, F. L., Dickmann, M., & Parry, E. (2022). Building Sustainable Societies Through Human-Centred Human Resource Management: Emerging Issues And Research Opportunities. In *The International Journal Of Human Resource Management* (Vol. 33, Issue 1, Pp. 1–15). Taylor & Francis.
- Farawansa, S. M., & Gultom, E. R. (2024). Diagnosis Of Nickel Industry Downstreaming Policy In Export Restriction Towards Increasing Economic Added Value In Indonesia. *Jurnal Legalitas*, 17(1), 1–16.
- Furqani, H., Adnan, G., & Mulyany, R. (2020). Ethics In Islamic Economics: Microfoundations For An Ethical Endogeneity. *International Journal Of Ethics And Systems*, 36(3), 449–463.
- Furqani, H., & Echchabi, A. (2022). Who Is Homo Islamicus? A Qur'anic Perspective On The Economic Agent In Islamic Economics. *Isra International Journal Of Islamic Finance*, 14(2), 206–220.
- Hayati, A. N. (2026). Indonesia's Nickel Export To China After The 2020 Ban: Prospects, Challenges, And The Islamic Trade Policy Perspective. *Al-Mustashfa: Jurnal Penelitian Hukum Ekonomi Syariah*, 11(1), 1–17.
- Hermawan, A., & Trimayanti, I. (2026). Indonesia's Downstream Strategy As An Economic Geopolitics. *Jurnal Ekuisci*, 3(5), 560–579.
- Hughes, A. C., & Grumbine, R. E. (2023). The Kunming-Montreal Global Biodiversity Framework: What It Does And Does Not Do, And How To Improve It. *Frontiers In Environmental Science*, 11, 1281536.
- Jordy, J. (2025). Untangling Nickel Downstreaming: A Political Economy Analysis Of Indonesia's Morowali Industrial Park. *International Journal Of Social And Political Sciences*, 2(2), 150–161.
- Kader, H. (2021). Human Well-Being, Morality And The Economy: An Islamic Perspective. *Islamic Economic Studies*, 28(2), 102–123.
- Khalidin, B., Musa, A., Fardesi, M., & Ulfia, N. (2024). Islamic Economics Towards The Sustainability Of Economic Development. *International Journal Of Social Science Humanity & Management Research*, 3(11).
- Kusworo, D. L., & Abdulkadir, A. O. (2025). Repositioning Administrative Sanctions For Deforestation Due To Nickel Downstream Industry In Indonesia And Nigeria. *Journal Of Judicial Review*, 27(2), 549–572.
- Lahadalia, B., Wijaya, C., Dartanto, T., & Subroto, A. (2024). Nickel Downstreaming In Indonesia: Reinventing Sustainable Industrial Policy And Developmental State In Building The Ev Industry In Asean. *Journal Of Asean Studies*, 12(1), 79–106.
- Manurung, H., Winarko, R., Jiang, C., & Mackey, P. J. (2025). The Decade 2014–2024 For Nickel Processing In Indonesia: Production Trends, New Developments, And Sustainability Issues. *International Symposium On Nickel And Cobalt*, 491–511.
- Nagle, T. T., Müller, G., & Gruyaert, E. (2023). *The Strategy And Tactics Of Pricing: A Guide To Growing More Profitably*. Routledge.
- Oloyede, A. A., Faruk, N., Noma, N., Tebepah, E., & Nwaulune, A. K. (2023). Measuring The Impact Of The Digital Economy In Developing Countries: A Systematic Review And Meta-Analysis. *Heliyon*, 9(7).
- Pambudi, P. A. (2025). The Paradox Of Nickel Investment In Indonesia. *Environmental Pollution Journal*, 5(3), 299–319.
- Purwana, A. S., Nurkhamid, M., & Rachman, M. C. (2026). The Indonesian Nickel Downstream Industry: Analysis And Economic Impacts. *Jurnal Ekonomi Dan Studi Pembangunan*, 18(1), 1–25.
- Ramadhani, E., & Paksi, A. K. (2025). The Price Of Progress: An Assessment Of Indonesia's Nickel Downstreaming Policy For The Global Energy Transition. *Bio Web Of Conferences*, 199, 2002.
- Rivota, D. R., & Wardhana, A. R. (2026). Navigating The Complexities Of Indonesia's Journey To Develop

- A Downstream Nickel Industry. In *Downstream Diversification Of Mineral-Rich Countries: Challenges And Opportunities To Add Value In Energy Transition Supply Chains* (Pp. 251–280). Springer.
- Rosada, F. (2025). Reforming Environmental Governance In Response To Indonesia's Nickel Industrial Policy: A Critical Assessment Of Sustainability Challenges. *Global: Jurnal Politik Internasional*, 27(1), 75–102.
- Rosada, F., Wibisana, R. A. A., & Paksi, A. K. (2023). The Impact Of Indonesia-China Nickel Cooperations On Indonesia's Economy And Environment. *Nation State: Journal Of International Studies*, 6(2), 96–116.
- Rum, J., Damayanti, D., Rofik, M., & Zulhijjah, M. (2025). Analysis Of Regional Economic Stabilization Strategy Of Southeast Sulawesi In The Era Nickel Industrialization. *Al-Kharaj: Journal Of Islamic Economic And Business*, 7(4).
- Şenyapar, H. N. D. (2024). Unveiling Greenwashing Strategies: A Comprehensive Analysis Of Impacts On Consumer Trust And Environmental Sustainability. *Journal Of Energy Systems*, 8(3), 164–181.
- Shabbir, M. S., & Salman, R. (2026). Sustainable Development Policy Interventions: Stakeholder Engagement And Environmental Policy In Practice. *Business Strategy And The Environment*, 35(2), 1997–2013.
- Wafia, U., Nurdin, R. R., Mahostr, A., Parinding, K. A., & Guampe, F. A. (2025). From Nickel Industrial Hub To A Sustainable Blue Economy: The Case Of Morowali, Indonesia. *Proceedings Of Tadulako International Conference On Economics And Business*, 1(1).
- Wicaksana, M. A., & Putri, N. I. P. (2026). The Impact Of Nickel Downstreaming Policy On The Transformation Of The Economic Structure Of Konawe Regency, Southeast Sulawesi. *Jurnal Ekonomi, Manajemen, Dan Bisnis*, 4(1), 11–19.
- Xu, S., Khandelwal, A., Li, X., Jia, X., Liu, L., Willard, J., Ghosh, R., Cutler, K., Steinbach, M., & Duffy, C. (2023). Mini-Batch Learning Strategies For Modeling Long Term Temporal Dependencies: A Study In Environmental Applications. *Proceedings Of The 2023 Siam International Conference On Data Mining (Sdm)*, 649–657.
- Yu, D. (2025). Toward Integrated Urban Observatories: Synthesizing Remote And Social Sensing In Urban Science. *Remote Sensing*, 17(12), 2041.