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Ecosystem Restoration and Conservation in Singkarak Lake Protection Area: Impacts of Reclamation

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SYNOPSIS

Reclamation and landfilling activities within protected zones pose serious threats to ecosystem sustainability by altering natural land–water interactions and violating the essential functions of Singkarak Lake's riparian buffer. This study aims to map the extent of reclamation, examine legal violations related to spatial and environmental permits, and assess ecological and economic losses. A mixed-methods approach was used, including geospatial analysis, normative legal review, and ecocentric valuation of environmental damage. Results show that 2,976 m^2 of land was illegally reclaimed within the protected lake boundary. Overlay with the regional spatial plan confirms non-compliance with zoning regulations and the absence of required permits. The total estimated loss amounts to Rp 3,383,291,152, largely driven by disrupted hydrological functions and reduced land utility.

https://www.galerisumba.com/pariwisata/87610306784/destinasi-liburan-yang-mengagumkan-danau-singkarak-pesona-alam-dan-misteri-kuno-di-sumatera-barat?page=2

INTRODUCTION

Lake degradation has become a sensitive national issue requiring urgent government intervention. Presidential Regulation No. 60 of 2021 on the Rescue of National Priority Lakes highlights severe pressures on many lakes in Indonesia, including watershed degradation, shoreline damage, declining water quality, reduced biodiversity, increased erosion and sedimentation, and the disappearance of endemic species. Uncontrolled reclamation in the Lake Singkarak buffer zone simultaneously degrades ecological integrity and causes significant economic losses for local communities. Coordinated efforts across ministries, local governments, and stakeholders are required to restore and safeguard these vital ecosystems.

Lake Singkarak is the largest tectonic lake in West Sumatra, located within the administrative boundaries of Tanah Datar and Solok Regencies. The lake receives water from the Sampur River in the north and the Sumani River in the south. It supports multiple community needs, including fisheries, irrigation, hydropower generation, domestic use, and tourism. Despite its ecological and economic significance, the lake's condition has deteriorated due to poor management and increasing human pressure. One major issue is illegal reclamation along the shoreline, particularly in the Singkarak Dock area in X Koto Singkarak District. Such reclamation activities are suspected to have caused environmental damage by altering natural land–water interactions and disrupting the ecological balance of the lake. Based on this context, the objectives of this study are: (1) to map the extent of the reclamation area, (2) to identify legal violations related to land use and environmental regulations, and (3) to assess the environmental impacts arising from the reclamation. The research was conducted in Jorong Kaluku, Nagari Singkarak, X Koto Singkarak District.

ARTICLE CONTENT

Research Methods

This study is multidisciplinary research that combines various approaches to data collection and assessment in order to address the problem. The study uses several methods, including geo-information mapping techniques, legal study methods, and environmental impact evaluation methods. The data used in this study consist of primary and secondary data. Primary data include interviews with local community activities and policy stakeholders, as well as aerial photographs of the reclaimed area. Secondary data include satellite images from Google Earth in 2016 and 2021, legal spatial planning maps in the form of regional spatial planning regulations (RTRW), inventories of legal products from the government, and literature related to the problem.

Mapping of Reclamation Areas

This study used on-screen digitization techniques to collect and analyze spatial data on reclamation areas along the lakeshore. The reclaimed zones were delineated from Google Earth satellite imagery and verified by comparison with aerial photographs obtained from drone surveys (Hidayat and Hanif, 2020).

Normative Legal Assessment

For the identification of legal violations in spatial utilization in this study, a normative legal study method was used. In this method, which is fundamental in positive law, a secondary data approach was applied through a literature study by reviewing related legislation and literature relevant to the problem being researched. At this stage, deductive reasoning was used, in which jurisprudence and doctrine were placed as the major premise (Benuf and Azhar, 2020).

Extensive Economic Analysis (Ecocentric)

The calculation of losses resulting from pollution and/or environmental damage considers the overall value of nature and living systems. Extensive economics is characterized by an economic perspective based on ecocentrism, which recognizes the intrinsic value of ecosystems and natural resources (Wasis 2006; Wasis et al. 2018b).

Environmental economic valuation of environmental damage generally consists of three main components: (1) ecological losses, (2) economic losses, and (3) environmental recovery costs. The valuation process involves assigning a monetary value to pollution and environmental degradation in order to estimate the total losses caused by environmental damage.

Table 1 Standard calculation mark loss consequence damage environment

A	Loss Ecology	Rupiah/Ha (Rp)
1	Cost Turn on Water Management Function	40,500,000,
2	Cost Soil Formation	500,000
3	Recycling Costs Nutrient	4,610,000
4	Cost Water Management	22,810,000
5	Cost Erosion and Runoff Control	6,000,000
B	**Economic Loss**	**Rupiah/M² (Rp)**
1	Lost Land Use Life	32,000,000
C	**Recovery Environment**	**Rupiah/M² (Rp)**
1	Recovery Water Management Function	40,500,000,
2	Land Recovery	500,000
3	Recovery Nutrient	4,610,000
4	Recovery Water Management	22,810,000
5	Erosion and Runoff Recovery	6,000,000

Source: (1) Regulations Minister of Finance No. 7 of 2014 concerning change make a loss consequence pollution and damage environment , (2) Law No. 17 of 2003 concerning State finances , (3) Law No. 1 of 2004 concerning State treasury

Because this study uses multiple methods and approaches, including technical, legal, and environmental data analyses, the research process is presented in the following flowchart to facilitate understanding.

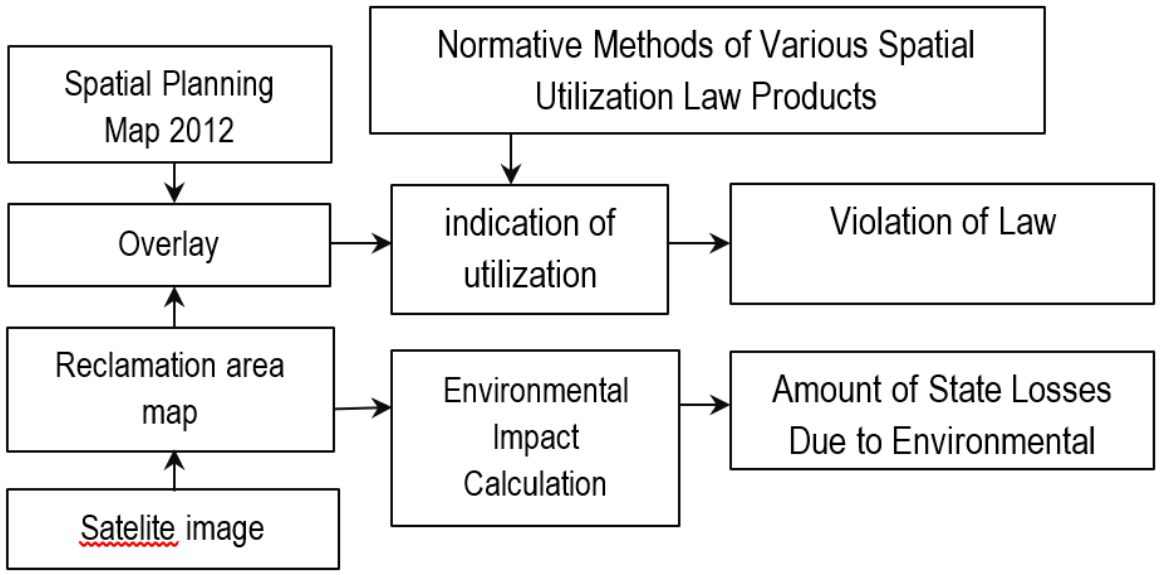

Figure 1 Flowchart study

RESULTS AND DISCUSSION

Dynamics of Reclamation Areas

This study used pre-reclamation satellite imagery from 2015 and post-reclamation imagery from 2021, verified with aerial photographs from 2022, to digitize and identify reclaimed areas along the shoreline of Lake Singkarak. Spatial analysis shows that 2,976 m² of the lakeshore has been reclaimed, causing significant disruption to ecosystem structure and energy flow processes.

Activity Status Identification Reclamation

Overlay analysis between reclamation activities and the Solok Regency spatial planning map identified both legal and illegal reclamation within the Lake Singkarak buffer zone, located less than 100 meters from the highest lake water level and designated as a locally protected area. The RTRW map shows no allocation for infrastructure or settlement development around the lake, confirming that the entire lakeshore is zoned as a protected area.

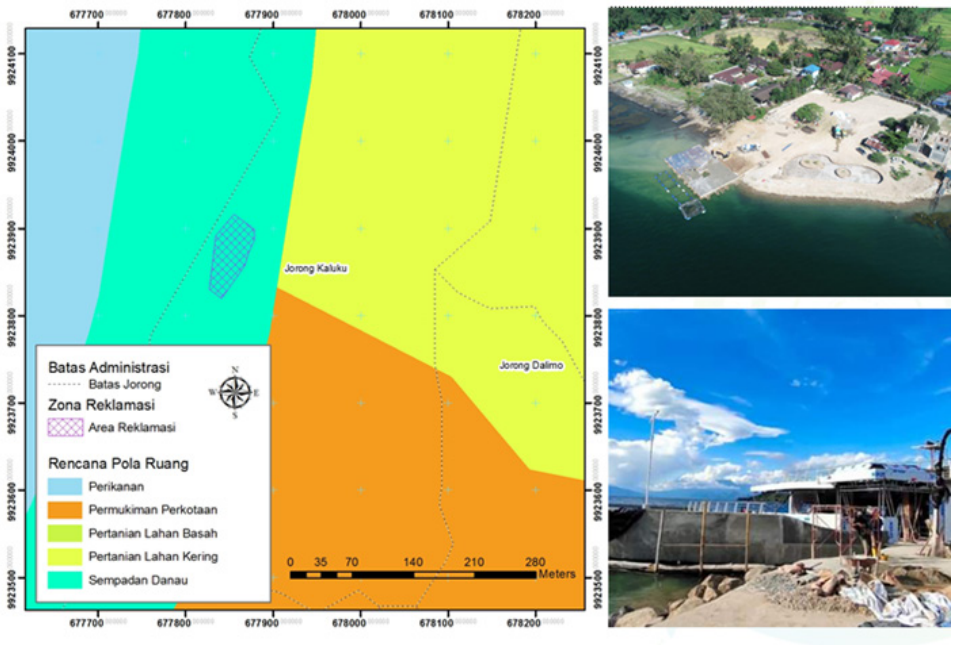

Figure 2 Location area map reclamation lake with area of 2,976 m 2 and RTRW Map of Regional Regulation No. 1 of 2013, Solok Regency , Singkarak Lake Area

Table 2 Calculation impact loss consequence reclamation of Lake Singkarak

A	Loss Ecology	Rupiah (Rp)
1	Cost Turn on Water Management Function	1,205,280,000
2	Cost Soil Formation	148,000
3	Recycling Costs Nutrient	1,364,560
4	Cost Water Management	6,788,256
5	Cost Erosion and Runoff Control	1,776,000
	Total	**1,215,485,576**

	Loss Consequence Reclamation	Rupiah (Rp)
1	Ecological Loss	1,215,485,576
2	Economic Loss	952,320,000
3	Kergian Environment	1,215,485,576
	Total	**3,383,291,152**

B	Economic Loss	Rupiah/M² (Rp)
1	Lost Land Use Life	952,320,000
	Total	**952,320,000**

C	Recovery Environment	Rupiah/M² (Rp)
1	Recovery Water Management Function	1,205,280,000
2	Land Recovery	148,000
3	Recovery Nutrient	1,364,560
4	Recovery Water Management	6,788,256
5	Erosion and Runoff Recovery	1,776,000
	Total	**1,215,485,576**

Source : Results of data analysis for 2025

Under Solok Regency Regulation No. 1 of 2013 and the ATR/BPN Ministerial Regulations Nos. 14 and 12 of 2021, lake buffer zones are designated as protected areas with strictly limited land-use functions. Legal analysis and official confirmation from environmental authorities indicate that the reclamation activity lacked permits, did not meet public or national strategic needs, and is therefore illegal and contrary to applicable spatial planning regulations.

Referring to Article 69 (1) of the Undang-Undang Cipta Kerja, any person who conducts business and/or activities that utilize spatial areas without possessing a spatial utilization conformity permit, as referred to in Article 61 letter (a), resulting in changes to spatial functions, shall be subject to criminal sanctions of imprisonment for a maximum of three years and a fine of up to IDR 1,000,000,000 (one billion rupiah). In addition, reclamation activities carried out without an environmental permit are illegal and are further regulated in Government Regulation No. 5 of 2021 concerning Risk-Based Business Licensing and Government Regulation No. 22 of 2021 concerning the Implementation of Environmental Protection and Management.

The valuation results show total state losses of Rp 3,383,291,152, consisting of ecological losses of Rp 1,215,485,576, economic losses of Rp 952,320,000, and environmental recovery costs of Rp 1,215,485,576, with the largest impact related to water resource restoration and land-use change. Environmental economic valuation assigns monetary values to pollution and environmental damage as a basis for compensation, restoration, and the sustainable management of natural resources.

CONCLUSION AND SUGGESTIONS

Spatial analysis using pre-reclamation satellite imagery (2015) and post-reclamation data (2021), validated with aerial photographs (2022), identified 2,976 m² of reclaimed land within the Lake Singkarak buffer zone. This reclamation has significantly disrupted lakeshore ecosystems and energy flow processes. Environmental economic valuation indicates total losses of Rp 3,383,291,152, comprising ecological losses of Rp 1,215,485,576, economic losses of Rp 952,320,000, and environmental recovery costs of Rp 1,215,485,576, with the highest impact related to water resource restoration. These findings highlight the need for stricter enforcement of lake protection regulations and the prioritization of ecosystem restoration in reclaimed buffer areas.

FUTURE DIRECTIONS

The findings of this study demonstrate that reclamation activities within the Lake Singkarak buffer zone have caused measurable ecological and economic losses, highlighting the urgent need for stronger governance and restoration efforts. Future actions must prioritize ecosystem recovery while preventing further degradation of lake protection areas.

First, local and regional governments should strengthen law enforcement and spatial planning compliance by strictly regulating land use within lake buffer zones. Reclaimed areas that violate existing regulations should be subject to ecological restoration obligations, including shoreline rehabilitation, reforestation with native vegetation, and the recovery of hydrological functions. Integrating environmental economic valuation into licensing and monitoring processes is also essential to ensure that environmental damage is fully accounted for in decision-making.

Second, long-term ecological monitoring should be established to assess changes in water quality, biodiversity, and sedimentation dynamics in Lake Singkarak. The use of remote sensing, GIS-based monitoring, and community-based reporting systems can enhance transparency and enable the early detection of illegal or harmful activities.

Third, researchers are encouraged to expand interdisciplinary studies that combine ecological assessment, socio-economic valuation, and legal analysis to better understand the cumulative impacts of reclamation and other land-use changes in lake ecosystems. Comparative studies across different lake protection areas in Indonesia would also contribute to stronger national policy frameworks.

Finally, public participation plays a critical role in lake conservation. Local communities, civil society organizations, and the broader public are encouraged to actively engage in monitoring, advocacy, and sustainable lake management initiatives. Raising public awareness about the ecological functions of lake buffer zones and the long-term consequences of reclamation is vital for fostering collective responsibility. Protecting Lake Singkarak requires coordinated action from government institutions, researchers, and society. Immediate and sustained efforts are necessary to safeguard freshwater ecosystems and ensure their ecological and socio-economic benefits for future generations.

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Muhammad Hanif is a geospatial scientist specializing in remote sensing, SAR technology, and Geo-AI for earth observation. He holds a Bachelor's degree in Geography from Universitas Negeri Padang and a Master of Science from Khon Kaen University, Thailand, and is currently pursuing a PhD at Khon Kaen University. His research focuses on advanced satellite data analysis for environmental and spatial applications. Hanif is an active member of EEAT, I-4, and the Association of Indonesian Geospatial Experts (PAGI).

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Ilham Gusri Randa is a Geography graduate from Universitas Negeri Padang with strong expertise in Geographic Information Systems (GIS). He is experienced in spatial data processing, mapping, and geospatial analysis to support environmental assessment and spatial planning.