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Sustainable reconstruction plan of abrasion affected areas based on spatial planning and risk analysis: A case study in Karawang, Indonesia

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Abstract

One of the coastal areas in Indonesia that was severely affected by coastal erosion or abrasion in Indonesia is the North coast of Karawang. Based on observations from 1988 to 2015, the occurrence of coastal erosion along the coastline for 33.74 km, or 45.81% of the total length of 73.65 km. The area of coastal land lost due to coastal erosion reached more than 404 ha, or coastal land lost annually between 1.31 to 6.23 ha. The Department of Public Housing and Settlement Areas of Karawang Regency built a housing estate to relocate residents affected by the abrasion disaster. However, this actually creates other problems because the location is apparently in the yellow zone based on the 2017 Karawang Regency Strategic Sanitation Data. So, it is very urgent to make a reconstruction plan for an area based on space planning and risk analysis, in order to achieve sustainable construction. Assessing reconstruction solutions divided into 5 zones consist of coastal zone, buffer zone, tourism and green open space zone, low density and agriculture zone, high density housing and central business district zone.

Keywords

Abrasion, Spatial planning, Risk analysis, Sustainable construction

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Introduction

One of the coastal areas in Indonesia that was severely affected by coastal erosion or abrasion in Indonesia is the North coast of Karawang. The level of damage to the coast in some of the areas was at a high level. Based on observations from 1988 to 2015, the occurrence of coastal erosion along the coastline for 33.74 km, or 45.81% of the total length of 73.65 km. The area of coastal land lost due to abrasion reached more than 404 ha, or coastal land lost annually between 1.31 to 6.23 ha [1][2][3]. Spatial planning that does not take into account the threat of natural disasters is very risky for communities because they are located in locations that have the potential to be directly affected by disasters. As a result, this infrastructure can be destroyed or seriously damaged during

a disaster, hampering accessibility and emergency response. Based on the initial visit carried out by the research team on May 7 2023, information was obtained that an urgent problem was that the road connecting the three hamlets was cut off due to abrasion.

Figure 1. The condition of the access road was cut off due to abrasion (May 7, 2023)

The abrasion phenomenon that hit the north coast of Karawang, especially in Cemarajaya Village, the worst incidents occurred in three hamlets so that residents affected by abrasion had to be relocated in stages (Figure 1). Pekerjaan Umum dan Perumahan Rakyat (PUPR) Karawang has built housing to relocate residents, already 78 of the 299 houses [4]. However, this actually creates other problems because the location turns out to be in the yellow zone based on the 2017 Karawang Regency Strategic Sanitation Data [5]. The reconstruction of areas affected by abrasion requires a comprehensive understanding of spatial planning and risk analysis [6]. Spatial planning plays a crucial role in determining the appropriate use of land and resources in coastal areas. It involves considering the potential impacts of climate change, such as sea-level rise and increased erosion, and developing strategies to mitigate these risks [6]. Risk analysis focuses on identifying and assessing potential hazards and implementing measures to reduce their impact [7][8].

Therefore, appropriate spatial planning and effective risk analysis are very important to face this challenge. Spatial planning will help organize safe and sustainable land use in coastal areas, while risk analysis will help identify, evaluate and reduce risks associated with abrasion. The objectives of this research evaluate existing spatial plans in the context of handling coastal erosion, analyze risk analysis related to the reconstruction of the area, and develop a reconstruction plan that are appropriate to the regulations and geographical conditions of the affected area to achieve sustainable development

Methods

This case study outlines a sustainable reconstruction plan that combines spatial planning and risk analysis to address the impacts of abrasion in the Karawang Regency.

Risk analysis

The initial phase involves a comprehensive evaluation of the areas affected by abrasion in Karawang Regency. This includes mapping the extent of coastal erosion, assessing vulnerability, and identifying specific risk factors associated with abrasion.

Development of sustainable spatial planning

Building on the risk analysis, Karawang Regency must establish sustainable spatial planning that takes into account the threat of coastal erosion. Key components include:

1. Zoning that designates safe areas for housing and economic activities, with restrictions on construction in high-risk areas.
2. Implementation of land-use regulations and sustainable designs for infrastructure and housing.

Results and Discussion

Risk analysis

Capacity value based on measurement of the IKD / Regional Resilience Index in 2022. The components hazards and vulnerabilities refer to the baseline. In 2022 Index Karawang Regency's disaster risk has fallen beyond the set target with a performance of 110.40% [4]. This success was driven by increased capacity and regional resilience in facing disasters. However, based on InaRISK data, the Karawang coast is still dominated by high risk of extreme wave and abrasion disaster, especially in the Cemarajaya which has a high level of risk (Figure 2 & Figure 3).

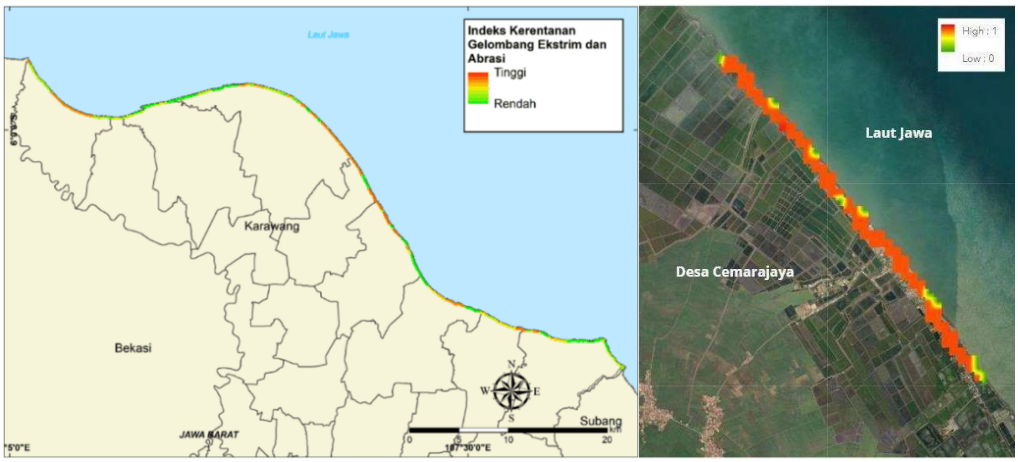

Figure 2. Map of vulnerability to extreme wave and abrasion disasters in Karawang (InaRISK BNPB, 2023)

Referring to data from Karawang Regency in Figures 2023 [4], regarding data on handling coastal and estuarine abrasion taken in 2022, in Karawang Regency there is a coastline length of 89 km with details of 17.92 km in good condition, 42.87 km in moderate condition, and 23, 21 in bad condition. This must be able to be anticipated and overcome with good planning, this is reinforced by the recommendations in the 2021-2026 RPJMD/ Rencana Pembangunan Jangka Menengah Daerah/ Regional Medium Term Development Plan evaluation report which states that the 2022 connectivity ratio in coastal areas should be increased so that it can accelerate the improvement in the welfare of farmers and fishermen.

Figure 3. Satellite Image of Cemarajaya Village, Cibuaya District in 2013-2023 from Google Earth Historical Imagery

Spatial planning

In the KLHS RPJMD 2021-2026 Karawang Regency document, increasing abrasion is a strategic issue that wants to be addressed. Referring to the 2016-2021 Karawang Regency RPJMD document, issues related to abration have been accommodated by the Karawang Regency Government by including the issue in the 2016-2021 General Policy and Development Program in relation to Infrastructure Development to Support Economic Development and Social Services which includes a Security Development Program Coastal Abrasion. However, after the program was implemented, referring to the Evaluation Report on the Results of the 2005-2025 Rencana Pembangunan Jangka Panjang Daerah (RPJPD) which was correlated with the 2016-2021 RPJMD regarding indicators for areas affected by flooding and abrasion, the RPJMD performance achievement was 32.25%. which means that the achievement rating is very low, which also means that the abrasion problem has not been able to be resolved properly.

Regarding spatial planning for the coastal areas of Karawang Regency, there are several summaries of policy directions as follows on the Table 1. It can be concluded that the direction of policies/programs/spatial planning activities for the coastal areas of Karawang Regency tends to provide development of coastal areas with a micro approach with the existence of policies regarding improving the quality of life of coastal areas related to social, economic and environmental aspects. Nevertheless, the Regional Government to be consistent in supervising policies, programs and activities related to regional spatial planning, especially in the coastal areas of Karawang Regency which face abrasion from year to year.

Table 1. Summary of Karawang's spatial planning

No	Policy/Program/Activity
1	Settlements on the coast must be equipped with adequate residential environmental infrastructure and facilities
2	Development of District solar and wind power generation facilities in coastal areas
3	Construction of new TPPAS / Tempat Pengolahan dan Pemrosesan Akhir Sampah / Waste Final Processing Site in coastal areas
4	Construction of public buildings for refugee centers in every disaster-prone area in coastal areas
5	Greening or developing green open space in every disaster-prone area in coastal areas
6	Development of disaster prevention techniques for areas prone to landslides, tidal waves and floods in coastal areas
7	Development of community ponds
8	Minapolitan development
9	Arrangement of fishermen's slum settlements
10	Improvement of slum rural environments
11	Development of underdeveloped rural areas and remote
12	Determination of zoning for coral reef areas in Karawang Regency which are located on the coast or coast in Pasirjaya and Sukajaya Villages, Cilamaya Kulon District and Cipareja Village, Tempuran District.

Sustainable reconstruction plan

Sustainable reconstruction plans for coastal areas are essential to address the unique environmental, social, and economic challenges that these regions face. Coastal areas are often highly vulnerable to the impacts of climate change, population growth, and environmental degradation. A well-designed plan can help ensure the long-term health and resilience of these valuable ecosystems while supporting the well-being of coastal communities. Regional Spatial Planning as a non-structural mitigation tool, one of them by determining the Karawang zoning plan by developing the Village concept Disaster Resilient Coasts.

The Ministry of ATR/BPN or Ministry of Agrarian divides coastal areas into 5 zones, consist of coastal zone, buffer zone, tourism and green open space zone, low density and agriculture zone, high density housing and central business district zone. So apart from being based on spatial planning and risk analysis, determining the Karawang coastal reconstruction plan is also carried out based on disaster zone provisions (Figure 4). The analysis results are displayed in the Table 2.

Some solutions to overcome coastal abrasion are artificial protection or by doing conservation, it is even better to do both. Artificial protection is done by constructing groin, jetty, breakwater, revetment, sand nourishment, and dewatering system. Determination of the type of structure by direction of ocean waves, bathymetry, tides, and the distance of the building from the coastline [9], as well as considering the level of risk a high level of risk, breakwaters and revetments are needed, for medium risks, groins and revetments are needed, and for low risks, revetments are sufficient. Apart from that, for areas with port planning, it is necessary to have a complete coastal security structure with revetments, groins and breakwaters.

While conservation can be done with the conservation of sand dunes, conservation of mangrove forests, and sustainable coastal programs. Based on the geographical type of the Karawang coast which includes sedimentary rocks formed from loose materials, especially marine and volcanic sediments, alluvium, as well as the sandy beach type, the suitable plant type is mangrove which has the highest survival rate, Rhizophora sp. Apart from that, in the Batujaya zone area which has a low risk of abrasion, it is ideal to build a wind power plant as a big step in achieving sustainable energy.

Table 2. Karawang coastal reconstruction plan

Area	Spatial Planning	Risk Analysis	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5
Pakisjaya	Mangrove & embankment	Medium	Groin and revetment	Mangrove	Embankment	Pakisjaya	Mangrove & embankment
Batujaya	Mangrove	Low	Revetment	Mangrove	Wind power plant	Agricultural fields	Settlement, refugee center public building, Cultural sites (temples)
Tirtajaya	Mangrove & Embankment	Low	Revetment and groin	Mangrove	Embankment	Agricultural fields	Settlement, refugee center public building
Cibuaya	Embankment	High	Breakwater and revetment	Mangrove	Embankment	Agricultural fields	Relocation of affected residents, relocation of village offices, refugee center public building
Pedes	Embankment	High	Breakwater and revetment	Mangrove	Embankment	Agricultural fields, fish auction	Settlement, refugee center public building
Cilebar	Agriculture & Embankment	High	Breakwater and revetment	Embankment	Agricultural fields	Agricultural fields	Settlement, refugee center public building
Tempuran	Tourism area	Medium	Port, breakwater jetty, and revetment, coral reef area	Coastal with shady plants	Tourism spot, huts, food and souvenir shops	Coastal tourist village	Hotel, settlement, refugee center public building
Cilamaya Kulon	Agriculture	Medium	Groin and revetment, coral reef area	Mangrove	Agricultural fields	Agricultural fields	Settlement, refugee center public building
Cilamaya Wetan	Agriculture & Embankment	Medium	Jetty and revetment	Embankment	Agricultural fields	Agricultural fields	Central business district, settlement, refugee center public building

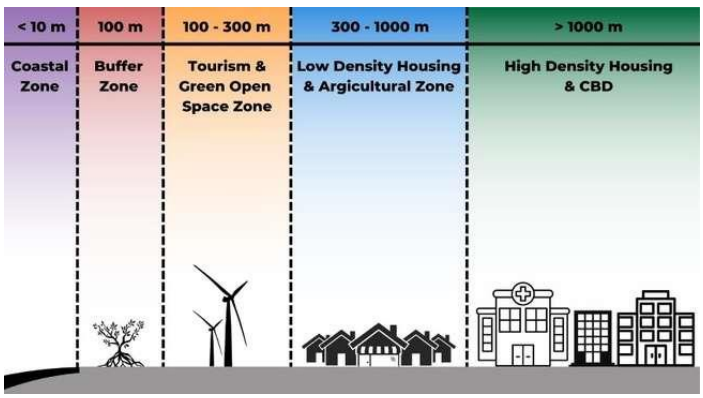

Figure 4. Coastal reconstruction illustration

Conclusion

Sustainable refers to the ability to maintain or support something over the long term without depleting resources, causing environmental harm, or negatively impacting social and economic aspects. Sustainability aims to strike a balance between meeting present needs and ensuring that future generations can also meet their needs. By following this sustainable reconstruction plan based on spatial planning and risk analysis, Karawang Regency can mitigate the impacts of coastal abrasion, build resilience, and secure a better future for its coastal communities. This case study demonstrates the importance of combining environmental preservation, infrastructure development, and risk reduction in a holistic approach to address abrasion-related challenges. Assessing reconstruction solutions that are appropriate to the geographical conditions of the affected areas, risk analysis, RTRW policies, and other government regulations, the reconstruction plan should ideally be divided into 5 zones, coastal zone, buffer zone, tourism and green open space zone, low density and agriculture zone, high density housing and central business district zone.

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References

[1] A. K. Fauzie, "Assessment and management of coastal hazards due to flooding, erosion, and saltwater intrusion in Karawang, West Java, Indonesia," *Journal of Coastal Sciences*, vol. 3, no. 2, pp. 8–17, 2016.

[2] A. K. Fauzie, "Short- and medium-term coastal abrasion and accretion rate analysis using GIS in Karawang, West Java," *Creative Research Journal*, vol. 3, no. 02, p. 91, Jan. 2018, doi: 10.34147/crj.v3i02.84.

[3] M. Nopiana, F. Yulianda, and A. Fahrudin, "Condition of shore and mangrove area in the coastal area of Karawang Regency, Indonesia," vol. 13, no. 2. 2020. [Online]. Available: http://www.bioflux.com.ro/aacl

[4] BPS Karawang. "Kabupaten Karawang Dalam Angka 2023". 2023

[5] M. D. Mahmudin, "Analisis Perubahan Penggunaan Lahan Akibat Abrasi Menggunakan Citra Landsat Di Sempadan Pantai Cibuaya Kabupaten Karawang," 2016. [Online]. Available: https://api.semanticscholar.org/CorpusID:134822542

[6] T. Matthews, "Spatial planning and climate change," *Australian Planner*, vol. 48, no. 4, pp. 321–322, Dec. 2011, doi: 10.1080/07293682.2011.559173.

[7] P. Driessen *et al.*, "Governance Strategies for Improving Flood Resilience in the Face of Climate Change," *Water (Basel)*, vol. 10, no. 11, p. 1595, Nov. 2018, doi: 10.3390/w10111595.

[8] S. Mohammed *et al.*, "Estimating Human Impacts on Soil Erosion Considering Different Hillslope Inclinations and Land Uses in the Coastal Region of Syria," *Water (Basel)*, vol. 12, no. 10, p. 2786, Oct. 2020, doi: 10.3390/w12102786.

[9] R. P. Pasaribu, A. Irwan, L. Soeprijadi, and C. Pattirane, "Studi Alternatif Bangunan Pengaman Pantai di Pesisir Kabupaten Karawang," *PELAGICUS*, vol. 1, no. 2, p. 83, May 2020, doi: 10.15578/plgc.v1i2.8875.