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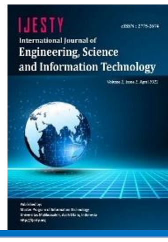

Optimum Risk-Based Management on the Lhokseumawe City Ring Road which is Vulnerable to Coastal Abrasion

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Abstract

The city of Lhokseumawe, which is one of the cities that has a topography such as a bay and a very busy area as the center of government, business, and services, has also experienced congestion. In 2012, the Lhokseumawe City Government has started planning to build a 7.6 Kilometer Lhokseumawe City Ring Road, starting from Sp.Kandang – Pusong and Sp. Lestari – Loskala. The ring road construction is along the shores of Ujong Blang Beach and KP3, where Ujong Blang Beach and KP3 since 1998 until now continue to experience abrasion. The purpose of this study was to determine the level of abrasion speed of Ujong Blang Beach and KP3 Beach and risk factors other than abrasion for an optimal risk-based management model approach to the Lhokseumawe City Ring Road as coastal infrastructure that is prone to abrasion and other risks. The method used to determine the abrasion rate is based on Landsat ETM+ (Enhanced Thematic Mapper) satellite data for a period of 25 years (1995 – 2020) which is analyzed by the Digital Shoreline Analysis System. The results showed that the magnitude of the abrasion speed of Ujong Blang Beach and KP3 Beach was -2.11 m/year and the farthest accretion occurred on the coast on transect 83 with an accretion distance of 111.34 m or around 4.45. Meanwhile, other factors were sea waves. with a period range of 2.33-10.25 s with an average of 4.57 s. Furthermore, the height of the coastal topography ranges from 0.00-8.60 m with an average of 4.30 m and the coastal slope observed at 8 observation locations obtained a coastal slope range of 2.90-4.47% with an average slope of 3,76%. The optimum risk-based management carried out by the ring road manager is the ALARP-principles approach to control very high to high risk (ALARP Zone), namely by building a preventive building in the form of a conventional type of breakwater with minimal handling costs to mitigate a greater impact on the environment. Damage to the Lhokseumawe City Ring Road if the risk occurs during the life of the road plan.

Keywords: *Infrastructure Management, Ring Road, Risk, Abras.*

1. Introduction

Lhokseumawe City is the center of government and all economic, political, social and cultural activities. Along with the density of the existing (existing) roads, namely Jalan Merdeka Barat with a road length of 5 Km, an average road width of 7 m consisting of 2 lanes in 2 directions (2/2 UD) which results in congestion, traffic accidents and increased travel time in and out of the city. between Ring Roads is an important infrastructure in the development of a city.

According to the research results of Rijalul Qadri et al (2017), that the annual average daily traffic volume (LHRT) on alternative roads was 4,279 vehicles/day in 2017; The difference in the total time value obtained is Rp. 189,877,-/vehicle and the difference in BOK is Rp. 3,289,-/vehicle; and the economic feasibility of the Lhokseumawe City Ring Road construction is obtained in 2036. The EIRR value obtained is at a discount rate of 17.27%, this indicates that the construction of the ring road/alternative is very feasible to carry out with bank loan interest rates of up to 17.27%.

The Lhokseumawe City Ring Road, which has been planned since 2012, is a ring road connecting Loskala - Ujong Blang - Pusong - Simpang Kandang which is intended as an alternative route to downtown Lhokseumawe which currently only has 3 access bridges. Furthermore, the existing line of Sp. Lestari – Loskala (Segment II) which is a ring road located along KP3 beach and Ujong Blang Beach. Currently, it has been built along 3 Km, starting from Loskala. The existence of the Lhokseumawe City Ring Road, especially Segment I between Sp. Lestari – Loskala is located along the shores of KP3 Beach and Ujong Blang is the focus of research. This is because along KP3 Beach and Ujong Blang Beach there has been coastal abrasion. Actually, KP3 Beach and Ujong Blang Beach are located on the same coastline that has undergone abrasion.

2. Literature Review

In general, coastal vulnerability consists of 2 (two) vulnerabilities, namely physical vulnerability and socio-economic vulnerability. Physical vulnerabilities include geomorphology, coastal slope, shoreline proximity, average tidal range, average wave height, shoreline changes, and erosion and accretion rates. Socio-economic vulnerabilities include population density, land use and growth (LuLc), percentage of urbanized area, dependent population (unproductive population), number of illiterate people, road network/infrastructure, tourist areas/cultural heritage/ethnographic interest tourists, economic activity (Nelson Rangel-Buitraso, 2020 & Nasser Ahmed, 2021).
The concept of risk determination is based on social vulnerability and physical vulnerability in identifying infrastructure risks in coastal areas. Determining the scale or range of risk, the CVI (Coastal Vulnerability Indexs) concept is more detailed in determining the rating of risk magnitude with variants and locations of large coastal areas (Fazly Amri Mohd, 2019). In general, it begins with risk identification, risk evaluation, risk analysis, risk allocation, and risk management. Specifically, Terje Aven (2016) and Pawel Szy-manski (2017) emphasize that the decision-making stage of evaluating risk, it is divided into 2 main stages, namely the stages carried out by experts based on facts (fact-based) on conditions in the field and the steps taken by value-based decision-makers by combining the risk information they receive with information from other sources and other topics, in order to achieve optimum risk management. Optimum risk management is a model approach to minimize project life cycle costs arising from corrective actions and replacement of other building parts and minimize maximum risk during the life cycle applied to coastal infrastructure buildings.

2.1 Determination of Coastal Abrasion Rate

The process carried out in this research consists of 2 (two) analyses, namely: analysis and interpretation of satellite imagery data (Landsat) for mapping changes in coastlines and statistical analysis for the rate of shoreline change over the last 25 (twenty-five) years. Landsat data analysis and interpretation consist of image cropping, image recovery, image enhancement, geometric correction, digitization, and overlaying. Statistical analysis to determine the level of shoreline change or the level of coastal abrasion was carried out using DSAS (Digital Shoreline Analysis System) software.

2.2 Identification of Other Risk Factors and Types

To obtain data on physical risk susceptibility other than abrasion and shoreline changes, namely: geomorphology, coastal slope, shoreline proximity, average tidal range, average wave height, topography and coastal slope as well as accretion and erosion rates, satellite data acquisition and / or survey at the research site. Meanwhile, to determine economic vulnerability, namely population density, land use and growth (LuLc), percentage of urbanized area, dependent population (unproductive population), number of illiterates, road network/infrastructure, tourist area/cultural heritage/ethnographic interest, tourists, and economic activities, using questionnaires and interviews with the community around Ujong Blang Beach and KP3 as well as several stakeholders who have been selected as respondents regarding risk information on the Lhokseumawe City Ring Road.

2.3 Risk Evaluation and Response with the ALARP Principle

Risk evaluation aims to determine decisions regarding which risks need to be handled and the priority of implementing risk hedging actions based on the results of risk analysis after comparing the level of risk with the risk tolerance limit. The need for risk management is determined based on the results of comparisons that have been made or called the risk matrix. The risk matrix is used to prioritize the risks faced and to assess which risks are acceptable (risk appetite) or unacceptable. The first step in creating a matrix is to determine the scale of assessment for the impact of risk both qualitatively and quantitatively.

Table 1. Risk Impact Assessment Scale on Road Damage

Impact Criteria on Handling Fee	Rating	
	Description	Score
Potential Handling Cost 25% Total Construction Cost	Very Light	1
Potential Handling Cost > 55% Total Development Cost	Light	2
Potential Handling Cost > 70% Total Development Cost	Currently	3
Potential Handling Cost > 85% Total Development Cost	Heavy	4
Potential Handling Cost 100% Total Development Cost	Very heavy	5

Table 2. Rating and Description of Risk Determination

Level	Probability	Description	Percentage (%)
5	Very high	Very Likely Definitely Hap-pens/Often	> 80 %
4	High	Most Likely Happening	60 % < P ≥ 80%
3	Currently	Then the Chances are Happening and Not Happening	40 % < P ≥ 60%
2	Low	Small Chance of Happening	10 % < P ≥ 40%
1	Very low	Tend Not Might happen	≤ 10 %

Source : Jasa Marga, Indonesia Highway Corporation (2021)

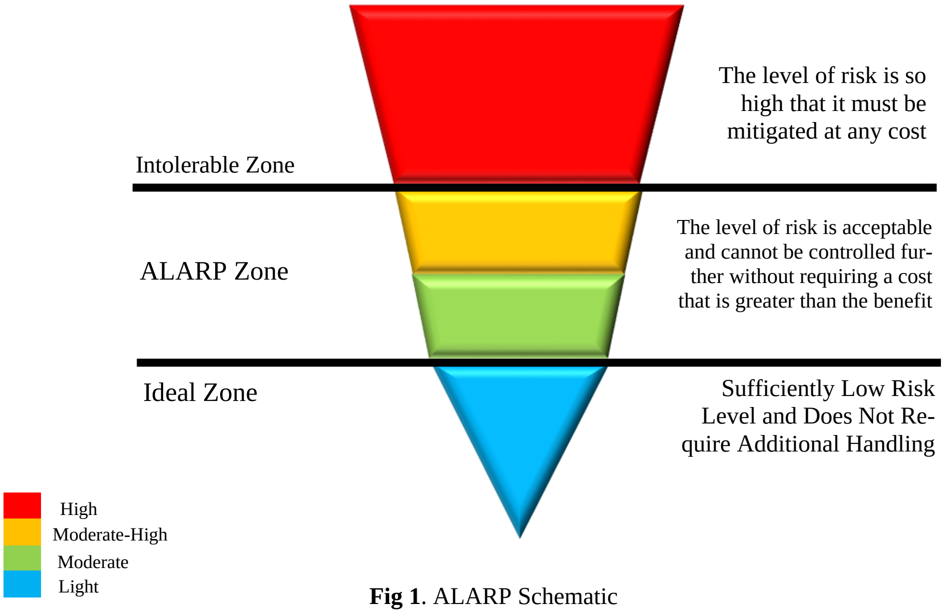


Fig 1. ALARP Schematic

Road Handling Cost Analysis with LCCA Method

The Life Circle Cost Analysis (LCCA) method is an economic assessment of scope, area, location a,nd facility using a variety of competing alternative designs while considering all the important costs of ownership over the life of the project (Dell'Isola, 1981). The components of the LCC calculation are estimating construction costs, management fees, user fees an,d environmental costs (Scheving, 2011). The steps taken in conducting LCCA are based on the data information that has been collected, in the order: (1) forming alternative designs, (2) determining the time of the activity, (3) estimating costs (managers and users), (4) calculating life cycle costs, (5) analysis of results (MDOT, 2012).

Determination of the Optimum Risk-Based Management Model

This study presents a concept of an optimum risk management model, namely minimizing the cost of road maintenance and the maximum risk during the cycle of road construction located on the coast which is prone to coastal abrasion.

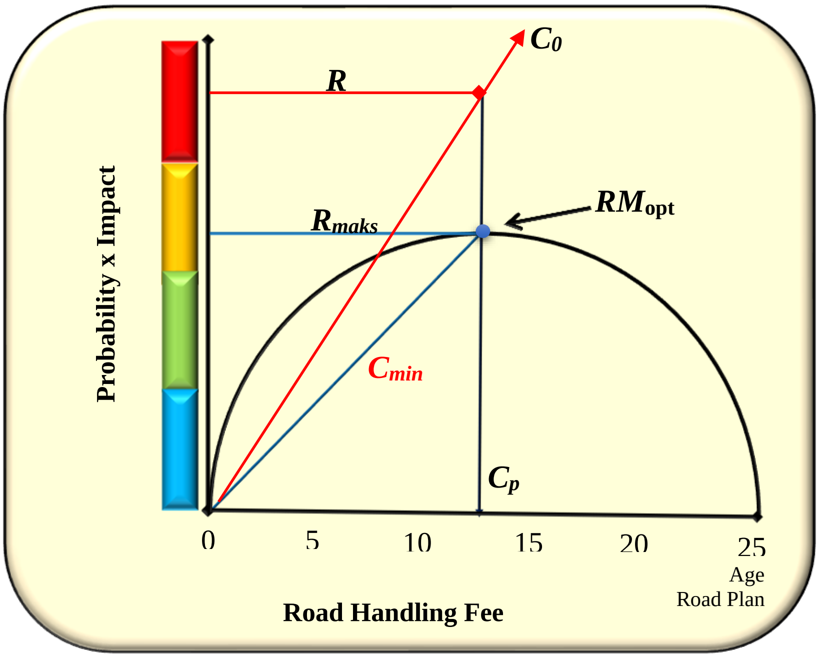


Fig 2. Probability and Impact Relationship with Road Handling Cost (RMopt)

Figure 2 describes that optimal risk-based management (RMopt) is a relationship between road cost management before a high risk has a large impact (R0) with a large handling cost (C0) to the maximum risk (Rmax) at the time of risk (Tx). up to the smallest possible handling cost (Cmin) during the design life of the road. The maximum risk (Rmax) is a very high risk with a large impact (R0) which has been treated (Cp) or a high risk that has become moderate-moderate (ALARP ideal scheme) according to the type of risk that occurs. In this context, all risks that occur on the Lhokseumawe City Ring Road during the design life of the road cannot be avoided or diverted, because this road is the main alternative road for exiting and entering Lhokseumawe City.

3. Method

This research is focused on 2 (two) stages of observation of coastal vulnerability categories that affect the rate of abrasion of Ujong Blang and KP3 Lhokseumawe beaches, namely physical vulnerability and socio-cultural vulnerability. Physical vulnerability is vulnerability that affects abrasion caused by several natural factors and sea surface conditions (natural factors) and social-cultural vulnerability is vulnerability caused by treatment or man-made conditions (human factors). In general, the stages or research steps follow the following stages:

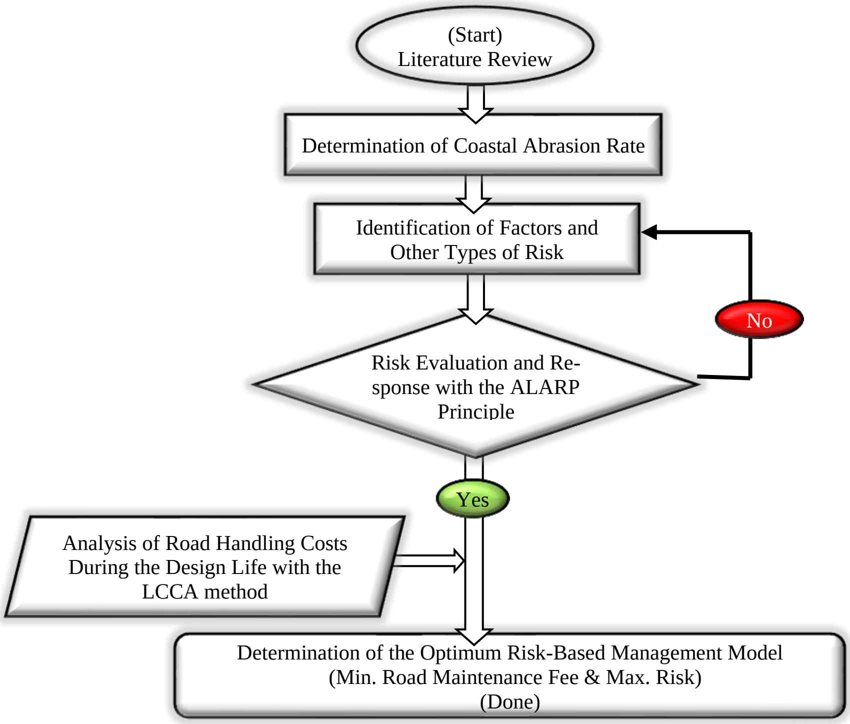


Fig 3. Flowchart of Research Stages

3.1 Determination of Coastal Abrasion Rate

In determining the rate of coastal abrasion as stated above, namely by determining the physical vulnerability that occurs along Ujong Blang Beach and KP3 Lhokseumawe, then 8 (eight) points of location for measuring the slope of the coast (slope), 1 (one) tidal observation point are set. low tide and 1 (one) point of observation of sea waves as described in Figure 3 above.

3.2 Tools and materials

The tools used include the software used for data analysis ArcGIS, Ocean Data View and Digital Shoreline Analysis System (DSAS). The data used are Landsat 5 TM, Landsat 7 ETM + and Landsat 8 OLI satellite images, tidal data, tidal data, and bathymetry and topography data.

3.3 Data analysis

MHWS (Mean Highest Water Spring) is the highest average water height at full tide, MHWN (Mean Highest Water Neap) is the highest average water height at neap tide, MLWN (Mean Lowest Water Neap) is the lowest average water height at neap tide, MLWS (Mean Lowest Water Spring) is the lowest average high water at full tide, TR (Tidal Range) is tidal range, TRS (Tidal Range Spring) is full tidal range, TRN (Tidal Range Neap) is the new tide and S0 is the mean sea level (MSL/Mean Sea Level).

3.4 Coastline Change Analysis

The analysis of shoreline changes in this study uses the Digital Shoreline Analysis System (DSAS) software which is integrated with ArcGIS software. Analysis of shoreline changes using the NSM (Net Shoreline Movement) module. The NSM module is a module for calculating the distance between the oldest and youngest coastlines for each transect. In this study, a virtual transect was used with a distance between transects of 10 m. From the results of making virtual transects along the coastline of the research location, 601 virtual transects were obtained. To ensure the distance between transects, measurements/matches of actual distances were also carried out in the field.

3.5 Socio-Economic Vulnerability

Population density or relative population is a statistical calculation that relates to the average number of inhabitants of an area and the physical space it covers. The Ujong Blang Beach area and KP3 are located in 3 main villages in Banda Sakti District, Lhokseumawe City with an area of 11.24 Km2 with a population of 14,000 people. The area along Ujong Blang Beach and KP3 is relatively dense. Ujong Blang Beach area and KP 3 are mostly designated as tourist areas.

3.6 Road Handling Fee

The cost of handling this road is estimated to determine an alternative pavement strategy design for the Lhokseumawe Ring Road development that is effective and efficient, then using Life Cycle Cost Analysis (LCCA) using sensitivity analysis using variations in interest rates and variations in inflation rates based on the management costs of each alternative design. pavement thickness. The use of LCCA is in accordance with the rules of the Road Pavement Design Manual Number 02/M/BM/2013 Ministry of Public Works Directorate General of Highways (namely: implementation of discounted life cycle cost minimization).

4. Results and Discussion

The results of tidal data analysis show that the mean sea level (MSL) of the waters of Ujong Blang Beach and KP3, Aceh is 2.24 m. At high tide, the sea level in the waters of Ujong Blang Beach and KP3, Aceh is at an altitude of 3.35 m, while at low tide the sea level is at an altitude of 1.12 m (Figure 4). The results of the analysis of tidal characteristics show that the tidal range is 1.16 m with the highest height at full tide 2.61 m and the lowest height at low tide at spring tide conditions is 2.44 m. Meanwhile, at neap tide, the highest height at high tide is 2.03 m with the lowest height at low tide is 1.86 m..

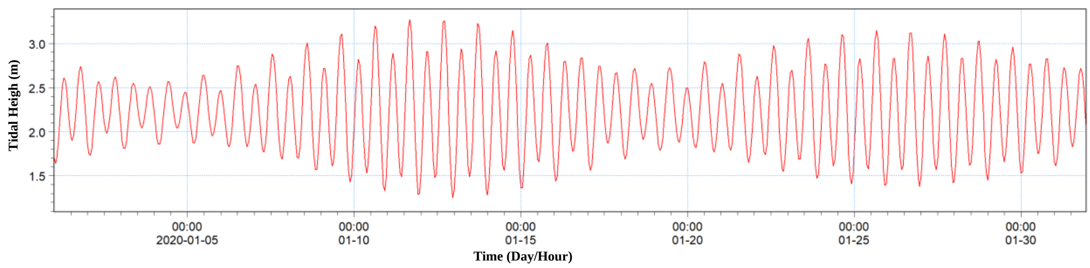


Fig 4. Footage of tidal patterns at the research site

The condition of sea waves around the research location for 25 years (1995-2020) it is known that the range of tidal heights is between 0.10-2.01 m with an average of 0.48 m while the range of the period of sea waves is 2.33-10 .25 s with a mean of 4.57 s. For 25 years (1995-2020) sea waves are very dominant moving from the northwest, northeast and north with a perpendicular propagation pattern towards the coast.

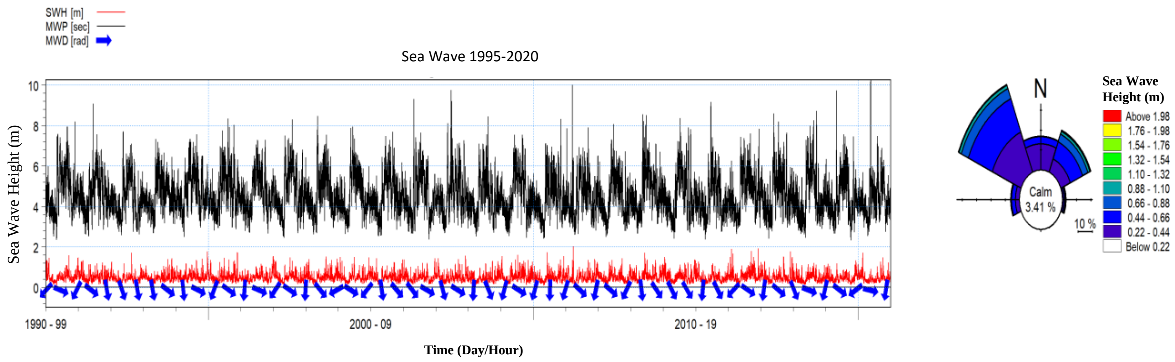


Fig 5. Characteristics of ocean waves at the research site in 1995-2020.

The coastal areas of Ujong Blang Beach and KP3 Lhokseumawe, Aceh have a coastal topography of 0.00-8.60 m high with an average of 4.30 m. These topographical conditions make the Ujong Blang coast a coastal area with a high level of vulnerability (Joesidawati, 2016; Suhana et al., 2020). The coastal slope observed at 8 observation locations obtained a coastal slope range of 2.90-4.47% with an average slope of 3.76%.

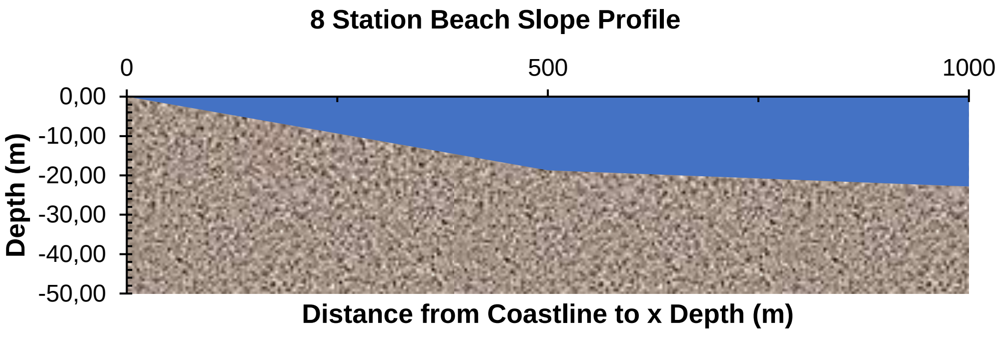


Fig 6. The slope profile of Ujong Blang Beach at several observation locations

4.1 Coastline Change

For 25 years (1995-2020) Ujong Blang Beach and KP3 Lhokseumawe, Aceh have undergone many changes in the beach profile, both caused by natural physical processes on the beach and human activities around Ujong Blang Beach and KP3. During this period Ujong Blang Beach and KP3 experienced the furthest abrasion of -52.70 m (transect 598) or about -2.11 m/year and the furthest accretion occurred on the coast on transect 83 with an accretion distance of 111.34 m or approx. 4.45 m/year. When viewed from its position, it is possible that the accretion that occurred around transect 83 could be caused by the sedimentation process that occurred at the mouth of the river around the area experiencing accretion. Given the geographical position of the coast on transect 83 and there are rivers around the area, it is possible that the accretion in this section was caused by sedimentary material carried from the sea to the river or from the river to the sea and accumulated in the area around the transect area 83 (Figure 7).

Meanwhile, in the part of the coast that experienced the furthest abrasion on the 598 transects, the abrasion that occurred was most likely caused by the process of propagation of sea waves and currents along the coast around the location.With thee geographical position of the coast on the 598 transect which forms an indentation towards the sea and tends to be perpendicular to the sea, it is possible that the coastal section around the 598 transects will be easily eroded by the current along the coast and the waves that come from the deep sea towards the coast. This process can cause the release of sedimentary materials that make up the coast and be carried to other places, resulting in significant abrasion around the area.

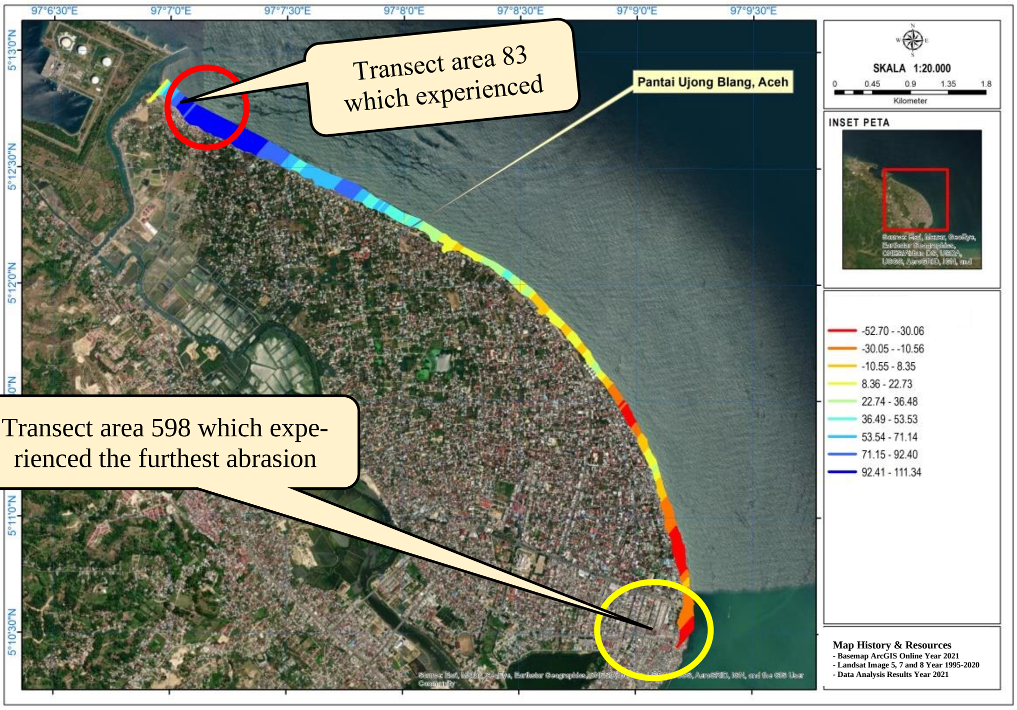
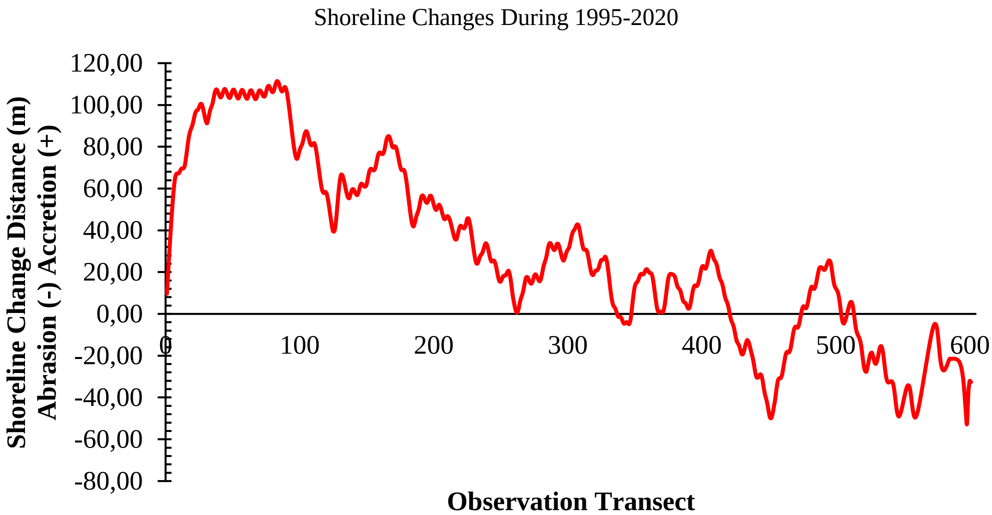


Fig 7. Changes in coastline on Ujong Blang Beach for 25 years (1995-2020)



Based on the results of the field survey and recording of existing data, the following is tabulated to present several conditions, magnitude and level of socio-economic vulnerability of the people living in the villages of Northwest Hagu, Ulee Jalan and Ujong Blang or along the Ujong Blang Beach area and KP3, Lhokseumawe:

Table 3. Survey Results and Socio-Economic Vulnerability Data Records

Vulnerability Socio-Economic	Condition/Amount/ Vulnerability Level	Data Source
Population Density (Km2)	Tourist and Residential Areas	Field survey
Land Use and Land Cover (LuLc)	22 %	Field survey
Percentage of Urbanization Area	47.39	BPS City Lhokseumawe 2021, Processed
Dependent population (Unproductive population; %)	0,20	BPS City Lhokseumawe 2021, Processed
Total Illiterate Population/ (%)	1 – 2 Km	BPS City Lhokseumawe 2021, Processed
Road Network	Marine Tourism Area	Field survey
Tourist Area	Tourist and Residential Areas	North Aceh Regency Government Data Record

Road Handling Fee

The value of construction costs (initial costs) for each alternative can be seen in Figure 8. While maintenance costs and re-placement costs are costs that will be incurred in the next few years, the calculation is influenced by inflation and interest rates. The final value is the issued value. The road life for the top layer is 20 years and the bottom layer is 40 years.

The results of the LCC analysis of each alternative pavement thickness can be presented in the following graph:

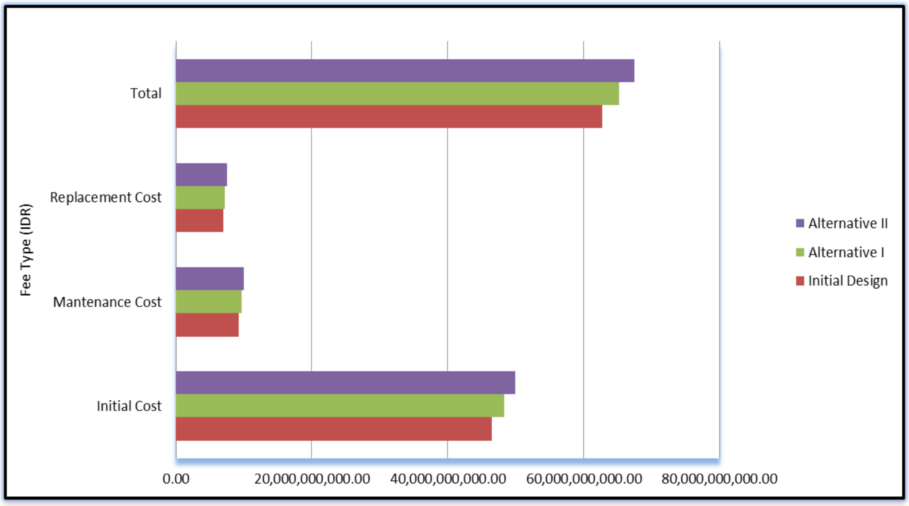


Fig 8. LCC Analysis Results for each Alternative Pavement Thickness

Risk Identification and Measurement

Based on the results of observations and surveys, both observations of physical and socio-cultural vulnerabilities found in the Ujong Blang Beach area and KP3 Lhokseumawe, Aceh can be concluded as follows:

Table 4. Identification of Vulnerability and Risk Impacts of Ujong Blang Beach and KP3

Vulnerabilty Criteria	Criteria	Classes	Rank	Vulnerablity
Physical	Geomorphology	Sloping Sandy Beach	3	Moderate
	Proximity to Coastline	< 1 Km	5	Very High
	Average Tidal Range	1,12 – 3,35 m	5	Very High
	Average Sea Wave Heigh	0,10 – 2,01 m	4	High
	Coastal Slope and Topography	2,90 – 4,47 %	3	Moderate
	Shorline Changes	-2,11 m/year	4	High
	Erosion and Accretion Rate (m/year)	< - 2,0 (Erossion)	5	Very High
Socio-Economy	Population Density (Km2)	1,256 Km	4	High
	Land Use Land and Cover (LuLc)	Tourist and Residential Areas	5	Very High
	Percentage of Urbanization Area	22 %	2	Low

	Dependent population (Unproductive population; %)	47.39	2	Low
	Total Illiterate Population/ (%)	0,20	5	Very High
	Road Network	1 – 2 Km	4	High
	Tourist Area	Marine Tourism Area	4	High

Table 5. Identification of the Probability of Ujong Blang Beach and KP3

Vulnerabilty Criteria	Citeria	Probabilty	Rank	Vulnerabilty
Physical	Geomorphology	Almost Never Occur	1	Very Low
	Proximity to Coastline	Occasionally Occur	3	Moderate
	Average Tidal Range	Nearly Occur	5	Very High
	Average Sea Wave Heigh	Rare Occur	2	Low
	Coastal Slope and Topography	Occasionally Occur	3	Moderate
	Shorline Changes	Occasionally Occur	3	Moderate
	Erosion and Accretion Rate (m/year)	Often Occur	4	High
Socio-Economic	Population Density (Km2)	Occasionally Occur	3	Moderate
	Land Use Land and Cover (LuLc)	Rare Occur	2	Low
	Percentage of Urbanization Area	Rare Occur	2	Low
	Dependent population (Unproductive population; %)	Occasionally Occur	3	Moderate
	Total Illiterate Population/ (%)	Occasionally Occur	3	Moderate
	Road Network	Occasionally Occur	3	Moderate
	Tourist Area	Occasionally Occur	3	Moderate

Furthermore, based on the Impact and Possible Risks, it can be seen the risk values that occur along the coastline of Ujong Blang KP3 as follows::

Table 6. Score and Risk Rating of Ujong Blang Beach and KP3

Nr.	Vulnerabilty Criteria	Probabilty	Impact	Risk Score	Vulnerabilty
A	**Physical Vulnerablity**				
1.	Geomorphology	1	3	3	Very Low
2.	Proximity to Coastline	3	5	15	High
3.	Average Tidal Range	5	5	25	Very High
4.	Average Sea Wave Heigh	2	4	8	Moderate
5.	Coastal Slope and Topography	3	3	9	Moderate
6.	Shorline Changes	3	4	12	High
7.	Erosion and Accretion Rate (m/year)	4	5	20	Very High
B	**Socio-Economic Vulnerabilty**				
1.	Population Density (Km2)	3	4	12	High
2.	Land Use Land and Cover (LuLc)	2	5	10	High
3.	Percentage of Urbanization Area	2	2	4	Low

4.	Dependent population (Unproductive population; %)	3	2	6	Low
5.	Total Illiterate Population/ (%)	3	5	15	High
6.	Road Network	3	4	12	High
7.	Tourist Area	3	4	12	High

Based on the determination of the type and rating of the risk assessment that greatly affects the Lhokseumawe Ring Road is the result of the physical vulnerability of the coast, namely the tides where in 1 (one) day there are two high tides and two low tides (very often) and the accretion and erosion (maximum risk). Another influential factor is the change in coastline which is relatively close to the ring road. Meanwhile, another risk that can also affect the existence of the ring road is the number of illiterate residents, because most of them are fishermen.

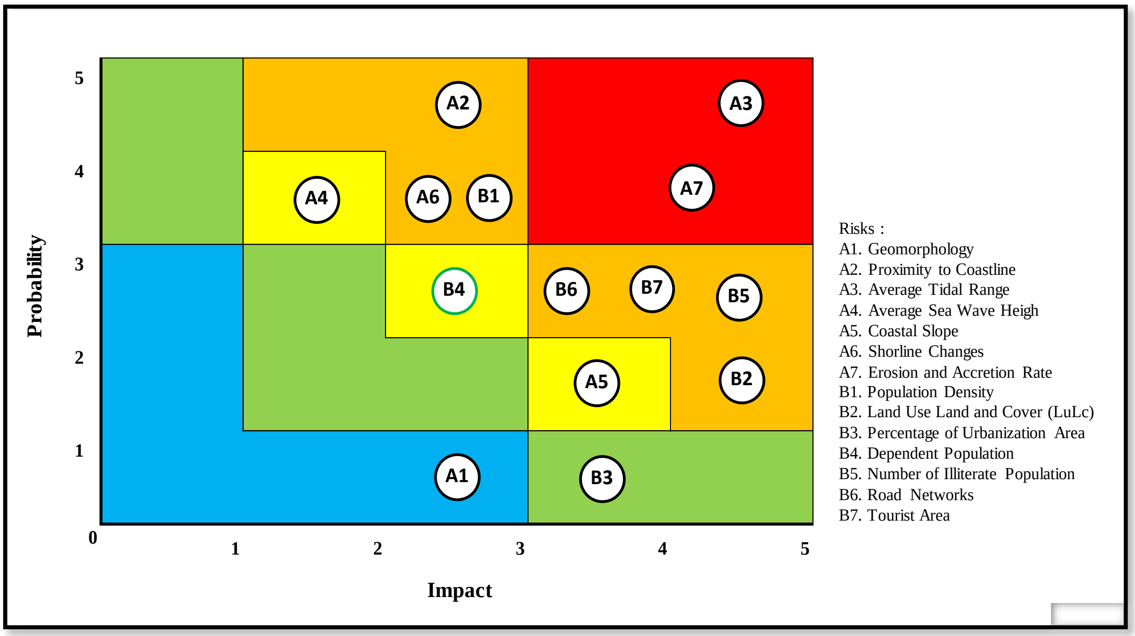


Fig 9. RACM of Ujong Blang Beach Area and KP3, Lhokseumawe (Before Control, Inherent Risk)

Based on the conditions resulting from the identification and risk analysis (Figure 9), the Ujong Blang Beach area and KP3 Lhokseumawe have a very high tidal risk (A1) and a very high level of accretion and erosion (A7) (inherent risk). Both types of risk must be controlled by the manager. Furthermore, for risk control, a risk evaluation is carried out using the ALARP principle scheme.
It takes a ring road management policy in determining the maturity level of road damage handling and risk control/mitigation using the ALARP principle. The ALARP principle is used by ring road managers as an acceptable risk limit (risk appetite). Following are the results of the evaluation and risk response based on the ALARP principles:

Table 7. Evaluation Results and Risk Priority based on the ALARP Principles

Risk Type (Vulnerabilty Criteria)	**Score Risk**	**Risk Priority**	**Skema - Principle ALARP**	
			Risks that Need to be Controlled	**Category**
Average Tidal Range	25	I		Intolerable Zone
Accretion and Erosion Rate	20			
Proximity of Coastline	15	II		**Zone ALARP**
Number of Illiterate Population	15			
Shorline Changes	12			
Population Density	12			
Road Network	12			
Tourist Area	12			
Land Use and Land Cover (LuLc)	10			
Coastal Slope	9	III		

Sea Wave Height	8		
Dependent Population	6	IV	Zone Ideal
Percentage of Urbanization Area	4		
Geomorphology	3	V	

Based on the ALARP scheme, tidal risk and accretion and erosion levels are categorized into into tolerable zones, meaning that the manager must be able to control both of these risks. To minimize the impact of tidal accretion and erosion risk (maximum risk) with minimum prevention costs (constraints) and the availability of building materials, conventional type breakwater buildings are used. So with risk control, the acceptable risk value (risk appetite) is in accordance with the ALARP principles, so that the RACM of the Ujong Blang Beach area and KP3, Lhokseumawe after controlling, (residual risk):

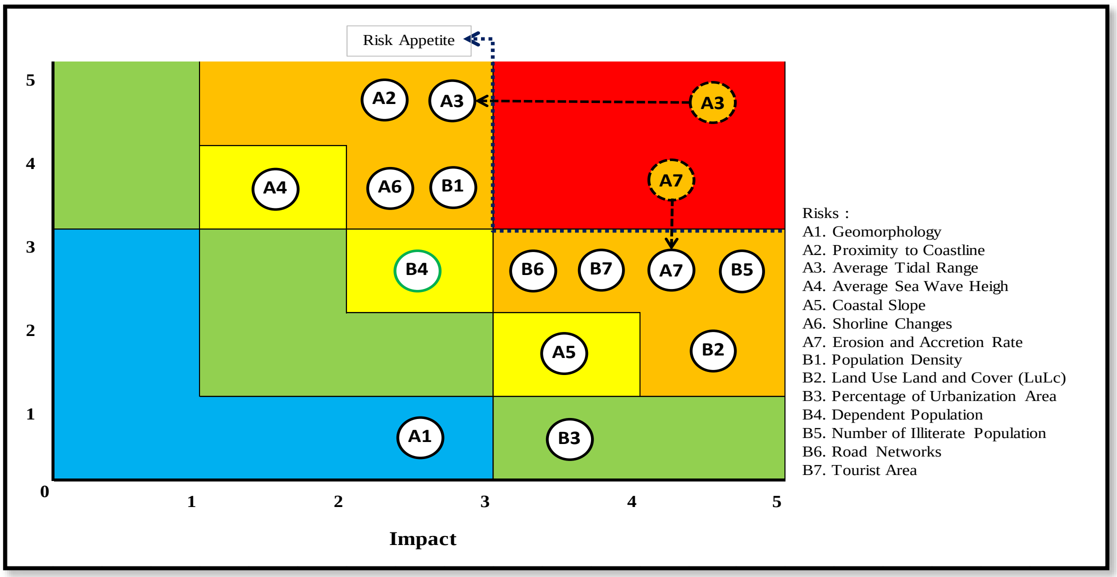


Fig 10. RACM of Ujong Blang Beach Area and KP3, Lhokseumawe (After Control, Risk Appetite)

Determination of the Optimum Risk-Based Management Model

The following presents the potential magnitude of the damage to the Lhokseumawe Ring Road construction based on the risks that may occur along the Ujong Blang Beach area and Lhokseumawe KP3 for the next 25 years (without control):

Table 8. Potential Impacts of Damage to the Lhokseumawe City Ring Road

RISK CRITERIA	RISK VALUE RANGE (SCORES)	RISK SCALE	RATE THE CONDITION OF ROAD DAMAGE (PCI INDEX)	POTENTIAL COSTS DUE TO IMPACT (%)	"ROAD CONSTRUCTION COSTS (Initial DESIGN, X Rp. 1 M)"	POTENTIAL COST IMPACT OF LHOKSEUMAWE CITY RING ROAD DAMAGE (x IDR 1,000,000)"													
						PHYSICAL RISK							SOCIAL ECONOMIC RISK						
						A1	A2	A3	A4	A5	A6	A7	B1	B2	B3	B4	B5	B6	B7
VERY HIGH	16 - 25	5	0 - 25	≥ 100				46,481				46,481							
HIGH	10 - 15	4	25 -55	≥ 85			39,509				39,509		39,509	39,509			39,509	39,509	39,509
MODERATE	7 - 9	3	55 - 70	≥ 70	46,481				32,537	32,537						32,537			
LOW	4 - 6	2	70 - 85	≥ 55											25,565				
VERY LOW	1 - 3	1	85 - 100	≤ 25		11,620													
TOTAL AVERAGE						35,525							36,521						
TOTAL AVERAGE (COMBINED)						36,023													

So to determine the minimum cost (Cmin) that can be allocated by the ring road manager to prevent the impact of the risks that occur are:

$$RM_{OPT} = C_{min} = \left[\frac{(R_0 - Rmaks)}{(R_0)} \; x \; C_0\right] \leq C_p$$

$$RM_{OPT} = C_{min} = \left[\frac{(25 - 15)}{(25)} \; x \; 36.023.000.000\right] \leq 46.481.000.000$$

$$RM_{OPT} = C_{min} = 24.015.333.333 \leq 46.481.000.000 \ldots \text{OK}$$

5. Conclusion

The magnitude of the abrasion speed of Ujong Blang Beach and KP3 Beach is around -2.11 m/year and the farthest accretion occurs on the coast on transect 83 with an accretion distance of 111.34 m or around 4.45. A significant abrasion phenomenon occurred in 2012-2013 as shown by transect 1 with an abrasion distance of -217.62 m which could affect the damage to the Lhokseumawe City Ring Road route. Risk factors other than abrasion are sea waves with a period range of 2.33-10.25 s with an average of 4.57 s which are very dominant moving from the northwest, northeast and north with a perpendicular propagation pattern towards the coast, then The coastal topographical heights ranged from 0.00-8.60 m with an average of 4.30 m and the coastal slope observed at 8 observation locations obtained a coastal slope range of 2.90-4.47 % with an average slope of 3, 76%. The optimum risk-based management carried out by the ring road manager is the ALARP-principles approach to control very high to high risk (ALARP Zone), namely by building a preventive building in the form of a conventional type of breakwater with minimal handling costs to mitigate a greater impact on the environment. Damage to the Lhokseumawe City Ring Road if the risk occurs during the life of the road plan.

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