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Identification of Land Use Changes Due to Changes in Coastlines in the Amurang Coastal Area, South Minahasa Regency

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Abstract: Indonesia's coastal areas are dynamic and vulnerable to physical, economic, and socio-cultural changes. This study aims to analyze land use change due to shoreline change in the coastal area of Amurang, South Minahasa Regency, 2005-2022. The main data used included Landsat 7 ETM+, Landsat 8 OLI/TIRS, and Landsat 9 OLI-2/TIRS-2 images, which were processed using GIS-based spatial analysis methods. Shoreline analysis was conducted using the Digital Shoreline Analysis System (DSAS) technique to measure changes in accretion and abrasion. The results showed significant changes in land use. In Kawangkoan Bawah Village, the water body turned into 9.23 hectares of green open space and 11.32 hectares of built-up area, in line with shoreline accretion with an average transect value of 68.11 meters. In contrast, in Lopana Village, green open space turned into 12.24 hectares of water body, corresponding to a dominant abrasion of -126.99 meters. An anomaly occurred in Kawangkoan Bawah Village, where built-up land turned into a water body of 2.36 hectares even though the shoreline in the area tends to experience accretion, which is due to the location of the land change not being directly in the area of shoreline change. This research confirms the importance of utilizing spatial analysis to understand the dynamics of coastal areas and the importance of adaptive spatial planning to manage the impacts of shoreline change.

Keywords: Abrasion Events, Accretion Events, Amurang Coastal Area, Coastal Disasters, Land Use Changes, Shoreline Changes

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Introduction

Indonesia is the largest archipelago in the world, with 17,504 islands and 108,000 kilometers of coastline (Pushidrosal, 2018). Based on statistical data, there are 12,852 villages or around 15.33% of villages located by the sea (BPS, 2020). From this data, it is known that the population in coastal areas is quite dominant. There are 140 million people or 60% of Indonesia's population living in coastal areas within 50 km inland from the coast (Sabet & Ari 2022).). This condition shows that coastal areas have a strategic role in regional development. However, coastal development often brings changes to the land use aspect, which is a tangible manifestation of human activity on the earth's surface (Lestari & Arsyad, 2018).

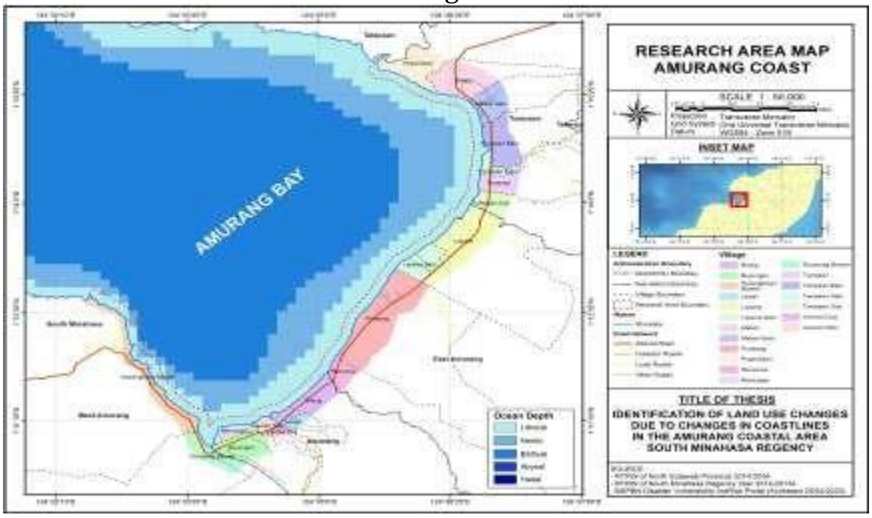
Land use change in coastal areas is influenced by population growth, the need for public service facilities, and land conversion due to government policies (Hidayah & Suharyo, 2018). According to Rondonuwu (2020), land use change is a natural resource that is utilized by the whole community and has a dynamic nature. These dynamics need to be anticipated so that land use does not cause problems in the future. One example is the land use change in the coastal area of South Minahasa Regency, especially in the Amurang area, which was driven by the construction of the 4.45-kilometre Amurang Boulevard. Coastal reclamation for this project transformed vacant land into a business park, but by June 2022, part of the infrastructure was washed out to sea, creating new shoreline changes and turning built-up land into water bodies. One of the causes of Amurang Beach abrasion is the geographical condition of Amurang Boulevard Beach which is directly adjacent to the Sulawesi Sea so that it can cause sea wave refraction when entering Amurang Bay (Kauntul, 2023).

The phenomenon of abrasion and shoreline changes such as what happened in Amurang is a problem that often occurs in coastal Indonesia. In North Sulawesi, there are 22 abrasion points out of a total of 207 points identified on Sulawesi Island. The main factors of shoreline change include natural phenomena, human activities and disasters, which cause abrasion, erosion or accretion. Human activities that occupy the coast for settlement, tourism, harbors and coastal protection buildings are examples that cause shoreline changes (Halim, H., & Halili, H., 2016). According to Lubis (2017), both directly and indirectly, these various forms of activities can change the balance of natural processes in coastal areas, causing damage.

This study differs from previous research by integrating shoreline change analysis with land use change patterns over a 17-year period (2005–2022). The research employs multitemporal satellite imagery and field observations to identify the impacts of abrasion and accretion on land use change patterns and their relevance to spatial planning. In this study, spatial data from the Spatial Planning of North Sulawesi Province and the Spatial Planning of South Minahasa Regency were used as the basis for spatial data processing and analysis (Regional Regulation of North Sulawesi Province No. 1 of 2014; Regional Regulation of South Minahasa Regency No. 3 of 2014). The data used include Landsat 8–9 OLI/TIRS and Landsat 7 ETM+ imagery, which were processed using Geographic Information Systems (GIS). This approach will produce information on the condition and potential of natural resources in coastal and marine areas (Syah, 2024). This study aims to produce spatial data-based recommendations for disaster mitigation and adaptive planning in coastal areas facing the threat of extreme waves, tsunamis and liquefaction while filling the gap in previous research.

Research Method

Qualitative research methods were used to identify land use change due to shoreline change in the Amurang coastal area over the last 17 years. The method was supported by a spatial analysis approach that also conducted quantitative analysis. The Amurang coastal areas included in the research are shown in Figure 1 below:



Source: Author's Processed, 2023

Figure 1. Map of the Research Area

Table 1. Study Area

Sub-district	Village	Area (ha)
	Bitung	57,76
	Buyungon	56,23
Amurang	Lewet	13,81
	Ranoyapo	22,58
	Uwuran Satu	13,76
	Uwuran Dua	7,41
West Amurang	Kawangkoan Bawah	81,46
	Rumoong Bawah	44,12
	Lopana	127,31
East Amurang	Lopana Satu	48,24
	Pondang	175,82
	Ranomea	29,43
	Matani	83,16
	Matani Satu	49,06
	Popontolen	73,50
Tumpaan	Tumpaan	36,65
	Tumpaan Baru	67,32
	Tumpaan Satu	20,96
	Tumpaan Dua	35,04
TOTAL AREA		1043,62

Source: Author's Processed, 2023

The research area in Amurang coastal area is 1,043.62 hectares. Geographically, the Amurang coastal research area is located at the coordinates 124°29'45" East-124°45'5" East and 1°6'30" LU-1°17'5" LU with a total length of 19.44 kilometers. The research area also includes the sea area as far as 200 m from the shoreline, and as far as the boundary of the affected area of disaster vulnerability on the coast of Amurang. In completing this research activity, a research activity work plan was prepared based on the flow of research design which will begin in the first week of October 2022 until the second week of September 2023. The following are the research instruments used.

Table 2. Research Instruments

Instruments	Functions	Output
Eart Explore USGS	Provider of multitemporal satellite data	TIFF image data
Local Government Agencies	Provider of spatial data of RTRW of South Minahasa Regency	Administrative & thematic Shapefile data
ENVI	Image Data Improvement	New image data
DSAS	Toolbox for analysis	Shoreline change vector data
ArcGis	Mapping spatial data processor	Change map
Google Earth Pro	Observation of changes that occur from the analysis results	High-resolution change imagery
Microsoft Excel	Calculating shoreline and land use changes	Tabulation of change data
Laptop / Computer	Research data management tool	Research report
Hand Phone	Recording of existing conditions during field observations	Field documentation

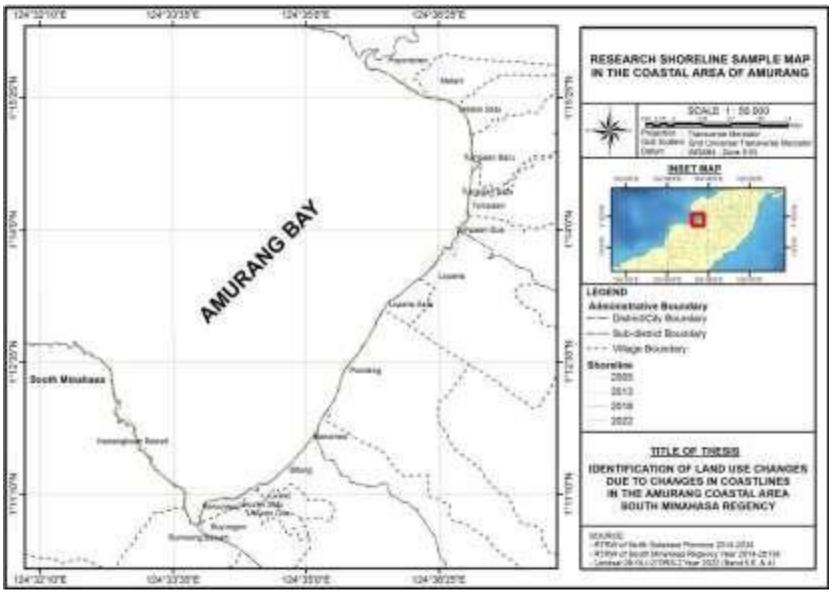
Source: Author's Processed, 2023

Landsat 7-9 data (2005, 2013, 2018 & 2022), shapefile/vector data, field observations, and multitemporal Google Earth images of the Amurang coastal area were used as the basic data of this research in conducting stages of analysis of land use change, shoreline change, and identification of the relationship of coastal land use change due to shoreline change.

Results and Discussion

3.1 Shoreline Sample

From the results of overlaying the shorelines extracted from each sample year's Landsat image data, differences in shoreline length within the study area were observed in all sample years. The results are shown in Figure 2.



Source: Author's Processed, 2023

Figure 2. Shoreline Samples Overlay Map

Table 3. Shoreline length

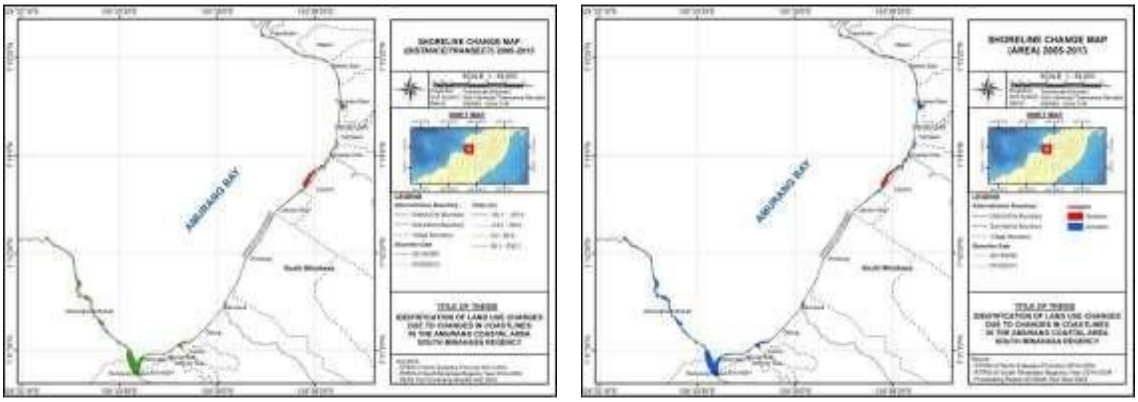
Sample Year	Shoreline Length (km)
2005	19,18
2013	17,41
2018	19,16
2022	19,88

Source: Author's Processed, 2023

In 2005, the length of the coastline in the Amurang coastal study area was 19.18 kilometers. In 2013, the coastline shrank to 17.41 kilometers. However, in the following year's sample, in 2018, the length of the coastline of the Amurang coastal research area increased to 19.16 kilometers and continued to increase until 2022 to 19.88 kilometers.

3.2 Shoreline Changes for the Period 2005-2013

From the condition of the changes that occurred, the Amurang coastal area had the most significant changes in Lopana village for the abrasion category and Rumoong Bawah village for the accretion category, with a total area of shoreline changes in the 2005-2013 period reaching 420,004.98 sq m as shown in Figure 4a and 4b.



Source: Author's Processed, 2023

Figure 4a and 4b. Map of Length and Area of Shoreline Change in the Period of 2005-2013

Tables 4a and 4b. Length and Area of Most Significant Shoreline Changes

Category	Longest (m)	Shortest (m)	Average (m)
Abrasion	-107,07	-0,01	-16,86
Accretion	223,3	0,01	31,40

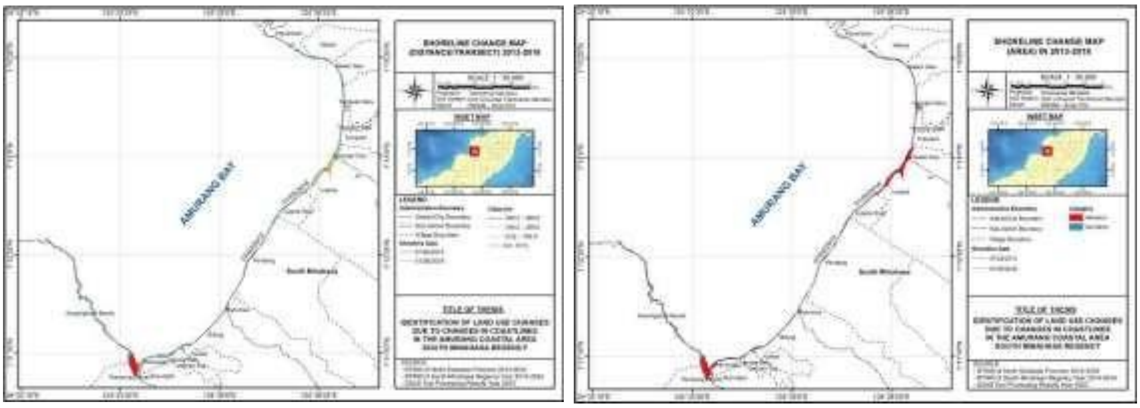
Category	Largest (sq m)	Smallest (sq m)	Average (sq m)	Total Area (sq m)
Abrasion	759,64	0,00	33,36	105.812,46
Accretion	14.511,60	0,00	66,89	314.192,52

Source: Author's Processed, 2023

The largest abrasion event was in Lopana village, with a change length of -107.07 meters and a change area of 53,596.15 sq m. The longest accretion process is in Rumoong Bawah village, with a change length of 223.3 meters and a change area of 129,439.88 sq m.

3.3 Shoreline Changes for the Period 2013-2018

The most significant change is in Rumoong Bawah for the abrasion category and Ranomea village for the accretion category. The change area reaches 440,118.63 as shown in Figure 5a and 5b.



Source: Author's Processed, 2023

Figure 5a and 5b. Map of the Length and Area of Shoreline Change in the 2013-2018

Tables 5a and 5b. Length and Area of Most Significant Shoreline Changes

Category	Longest (m)	Shortest (m)	Average (m)
Abrasion	-251,63	-0,02	-29,50
Accretion	57,46	0,00	13,38

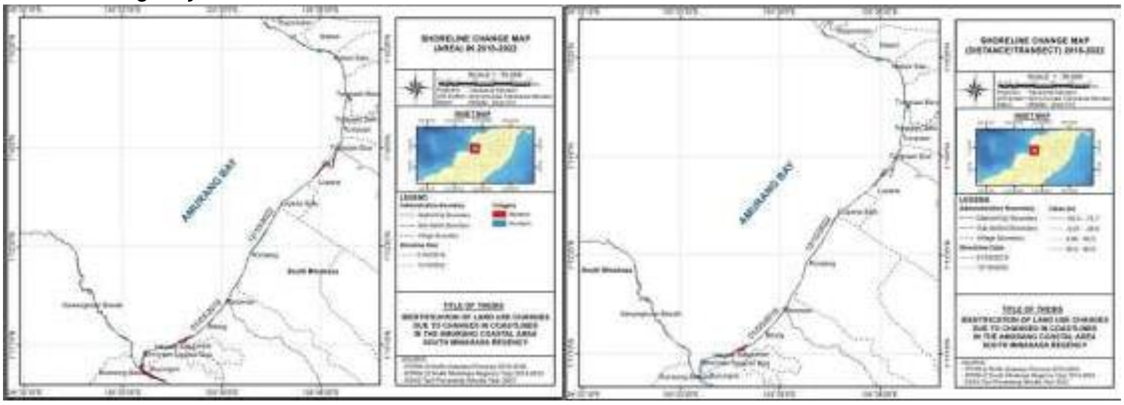
Category	Largest (sq m)	Smallest (sq m)	Average (sq m)	Total Area (sq m)
Abrasion	7.555,59	0,00	62,00	409.376,82
Accretion	3.521,56	0,01	32,47	30.811,81

Source: Author's Processed, 2023

The most significant change for abrasion was in Rumoong Bawah village, with a length of change of -251.63 meters and an area of change of 111,316.19 sq m. The accretion occurred in Ranomea village with a length of change of 57.46 meters and an area of change of 10,361.09 sq m.

3.4 Shoreline Changes for the Period 2018-2022

The Amurang coastal area that has the most changes is between Uwuran Satu-Bitung village for the abrasion category. In comparison, the accretion event occurred in Pondang village, with a total area of change reaching 287,368.25 sq m as shown in Figure 6a and 6b below.



Source: Author's Processed, 2023

Figure 6a and 6b. Map of length and area of shoreline change in the 2018-2022

Tables 6a and 6b. Length and Area of Most Significant Shoreline Changes

Category	Longest (m)	Shortest (m)	Average (m)
Abrasion	-75,71	-0,00	-16,39
Accretion	90,65	0,00	12,37

Category	Largest (sq m)	Smallest (sq m)	Average (sq m)	Total Area (sq m)
Abrasion	7.557,14	0,00	56,54	166.070,12
Accretion	2.242,53	0,00	25,09	121.298,14

Source: Author's Processed, 2023

Abrasion events with the most significant changes occur between Uwuran Satu village and Bitung village, with a change length of -75.71 meters and a change area of 27,969.41 sq m. Meanwhile, changes in the coastline in the accretion event reached a length of 90 meters in the Tumpaan sub-district, precisely in Matani village, with an area of change of 28,312.87 sq m.

The results of this analysis show that the occurrence of abrasion and accretion occur in all areas of the coastline on the coast of Amurang Bay. The research of Arif & Hamdi (2022) also stated that the Minahasa Peninsula area is prone to abrasion, especially in the coastal area in Amurang which is very at risk of erosion due to human activities, ocean tides, and lack of coastal protection plants. This is further corroborated by the results of research on shoreline changes in the coastal area of Amurang Subdistrict within 5 years averaging -1.81 Ha of Abrasion with a total of -7.23 Ha and Accretion averaging 1.47 Ha with a total of 5.8 Ha (Kirana, 2024). Research on changes in the coastline of the Paiton coast of East Java (Prameswari, 2014), the West Coast of Tanah Laut, South Kalimantan (Darmiati, 2020) and the coast of Gianyar, Bali Batang (Hariyanto, et al., 2018) are similar studies on the dynamics of shoreline changes that also occur in several coastal areas of Indonesia.

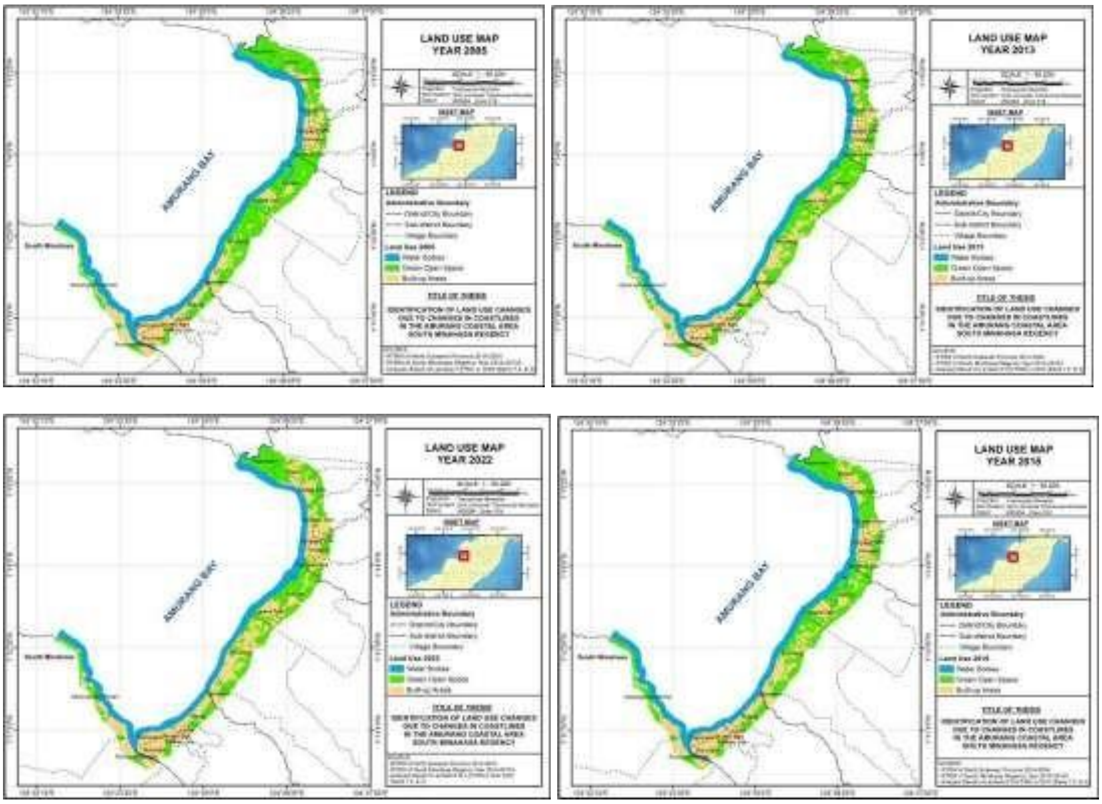
3.5 Land Use Change in 2005-2022

The identification of land use in 2005, 2013, 2018, and 2022 shows that land use changes continue to increase towards built-up areas land use, and conversely, the types of land use of water bodies and green open space are shrinking in area. Detailed information is provided in Table 7 below.

Table 7. Land Use Area 2005-2022

Land Use	Year (ha)			
	2005	2013	2018	2022
Water Bodies	409,05	370,32	394,37	373,02
Green Open Space	608,01	580,77	548,69	477,72
Built-up Areas	385,04	450,87	458,89	551,34

Source: Author's Processed, 2023



Source: Author's Processed, 2023

Figure 7a, 7b, 7c and 7d. Land Use Map 2005, 2013, 2018 and 2022

Source: Author's Processed, 2023

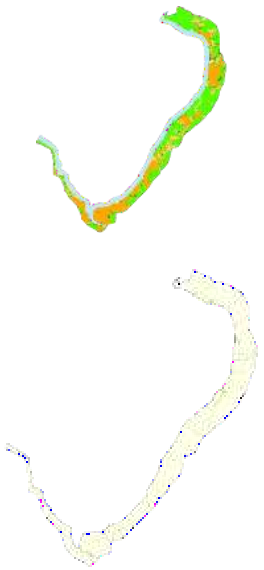
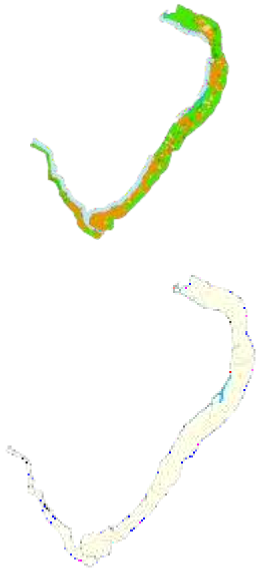
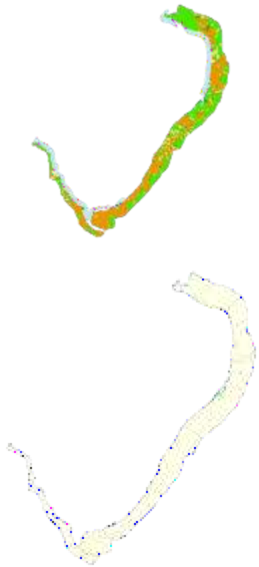
Figure 8. Land Use Change in 2005-2022

From the land use change data obtained, the land use of the water body category has shrunk, except in the 2013-2018 range, where there was an addition of 24.05 hectares. Meanwhile, land use in the green open space (RTH) category continued to shrink by -130.30 hectares from 2005-2022. Conversely, the use of built-up areas land has increased in area from year to year, with an additional area of 166.30 hectares.

3.6 Land Use Change of Amurang Coastal Area

In the process of identifying land use change towards shoreline change, a selection of land use change along the coast of Amurang was conducted as shown in Table 8 below.

Table 8. Selection of Amurang Coastal Land Use Change

Land Use Change Period		
2005-2013	**2013-2018**	**2018-2022**
		

Source: Author's Processed, 2023

Tables 8a, 8b and 8c. Amurang Coastal Land Use Change Area for the Period of 2005-2022

Changes 2005	Changes 2013	Area (ha)	Percentage (%)
Water Bodies	Green Open Space	29,22	58,14
Water Bodies	Built-up Areas	15,28	30,39
Green Open Space	Water Bodies	3,02	6,01
Built-up Areas	Water Bodies	2,74	5,46
Total Area		50,26	100,00

Changes 2013	Changes 2018	Area (ha)	Percentage (%)
Water Bodies	Green Open Space	1,37	3,48
Water Bodies	Built-up Areas	6,28	15,96
Green Open Space	Water Bodies	25,08	63,73
Built-up Areas	Water Bodies	6,62	16,83
Total Area		39,35	100,00

Changes 2018	Changes 2022	Area (ha)	Percentage (%)
Water Bodies	Green Open Space	7,61	17,41
Water Bodies	Built-up Areas	24,99	57,15
Green Open Space	Water Bodies	7,97	18,22
Built-up Areas	Water Bodies	3,16	7,22
Total Area		**43,72**	**100,00**

Source: Author's Processed, 2023

The results of the selection of Amurang coastal land use change showed that the most significant change occurred in 2005-2013, with an area of 50.26 hectares. Meanwhile, the most significant pattern of land use change in the Amurang coastal area is the characteristic of water body to be built up with an area of 46.55 hectares from 2005-2022.

In previous research, it was found that the triggering factor of land use change in Amurang was population growth and very high mobility. Geographically, Amurang is located along the Trans Sulawesi route that connects districts/cities and provinces (Pinangkaan, 2019). Significant land use change on the Amurang coast has also been researched by Langoy (2019) which states that land use change on the Amurang coast tends to increase every year, namely changes from undeveloped land to built-up land of 7.39 ha. The research was based on the construction of the Boulevard Road in the Amurang Bay coastline area.

3.7 Identification of Coastal Land Use Change towards Shoreline Change

In identifying the pattern of change that occurred, the change data for each analysis period was combined for one characteristic of change, where the analysis results showed four characteristics of land use change.

Table 9. Characteristics of Land Use Change 2005-2022

Characteristics of Land Use Change		
Water Bodies	Becoming	Green Open Space
Water Bodies	Becoming	Built-up Areas
Green Open Space	Becoming	Water Bodies
Built-up Areas	Becoming	Water Bodies

Source: Author's Processed, 2023

Table 10: Characteristics of Water Bodies Change to Green Open Space

Sub-district	Village	Period Year of Analysis								
		2005-2013			2013-2018			2018-2022		
		Shoreline Changes (m)		Land Use Changed (ha)	Shoreline Changes (m)		Land Use Changed (ha)	Shoreline Changes (m)		Land Use Changed (ha)
		Abrasion	Accretion		Abrasion	Accretion		Abrasion	Accretion	
Amurang	Bitung	-22,74	133,98	1,63	-46,28	39,92		-74,8	14,97	0,08
	Buyungon			0,12						
	Ranoyapo	-5,98	23,78		-44,47	27,89		-32,6	16,99	
	Uwuran Satu	-15,74	116,32	0,62	-42,01	24,99		-75,7		
West Amurang	Kawangkoan Bawah	-36,47	94,50	8,02	-62,22	47,23	0,27	-75,5	62,60	0,94
	Rumoong Bawah		223,67	0,95	-252,9		0,02	-18,1	28,42	0,33
East Amurang	Lopana	-107,05	61,90	5,69	-205,2			-68,7	26,58	2,17
	Lopana Satu	-12,78	20,71	1,05	-37,01		0,09	-13,8	3,10	0,32
	Pondang	-15,49	27,16	1,8	-38,93	19,45	0,13	-7,81	45,12	0,49
	Ranomea	-50,37	9,09	0,81	-15,13	57,46		-63,9	5,11	0,04
Tumpaan	Matani	-19,2	49,64	3,1	-16,4	45,96	0,12	-9,43	90,65	0,52
	Matani Satu	-12,48	18,64	0,31	-22,09	6,39		-9,16	27,88	
	Popontolen	-72,33	35,18	2,84	-119,9	15,97	0,3	-36,7	79,15	2,54
	Tumpaan	-4,99	50,59	1,13	-15,46	6,93	0,04	-10,7	19,53	
	Tumpaan Baru	-0,64	207,67	0,49	-149,5		0,35	-4,72	89,44	0,12
	Tumpaan Satu	-0,29	170,31		-27,7			-0,67	14,74	
	Tumpaan Dua	-1,97	42,57	0,76		93,03		-19,8	1,55	0,01
TOTAL AREA				**29,32**			**1,32**			**7,56**

Source: Author's Processed, 2023

The most significant land use change is in Kawangkoan Bawah village, with a total area of 9.23 ha. When viewed from each period of change analysis, the villages with the most significant changes occurred in Kawangkoan Bawah village with an area of 8.02 ha (2005-2013) which experienced abrasion shoreline changes along -36.47 m and accretion along 94.50 m, Tumpaan Baru village with an area of 0.35 ha (2013-2018) which experienced abrasion shoreline changes along -149.50 m, and Popontolen village 2.54 ha (2018-2022) which had abrasion shoreline changes along -36.7 m and 79.15 m for the accretion category.

Table 11. Characteristics of Water Bodies Change to Built-Up Areas

Sub-district	Village	Period Year of Analysis: 2005-2013 Shoreline Changes (m) Abrasion	2005-2013 Shoreline Changes (m) Accretion	2005-2013 Land Use Changed (ha)	2013-2018 Shoreline Changes (m) Abrasion	2013-2018 Shoreline Changes (m) Accretion	2013-2018 Land Use Changed (ha)	2018-2022 Shoreline Changes (m) Abrasion	2018-2022 Shoreline Changes (m) Accretion	2018-2022 Land Use Changed (ha)
	Bitung	-22,74	133,98	2,07	-46,28	39,92	1,39	-74,8	14,97	2,53
Amurang	Buyungon			0,14			0,22			1,23
	Ranoyapo	-5,98	23,78	0,69	-44,47	27,89	1,15	-32,6	16,99	1,3
	Uwuran Satu	-15,74	116,32	0,43	-42,01	24,99	0,34	-75,7		0,02
West Amurang	Kawangkoan Bawah	-36,47	94,50	6,12	-62,22	47,23	1,24	-75,5	62,60	3,91
	Rumoong Bawah		223,67	0,69	-252,91		0,05	-18,1	28,42	1,13
	Lopana	-107,05	61,90	2,02	-205,22			-68,7	26,58	
East Amurang	Lopana Satu	-12,78	20,71		-37,01			-13,8	3,10	0,12
	Pondang	-15,49	27,16	0,26	-38,93	19,45	0,57	-7,81	45,12	4,37
	Ranomea	-50,37	9,09	0,79	-15,13	57,46	0,43	-63,9	5,11	0,85
	Matani	-19,2	49,64	0,22	-16,4	45,96	0,08	-9,43	90,65	3,5
	Matani Satu	-12,48	18,64	0,73	-22,09	6,39	0,28	-9,16	27,88	1,6
	Popontolen	-72,33	35,18		-119,9	15,97		-36,7	79,15	0,5
	Tumpaan	-4,99	50,59	0,18	-15,46	6,93		-10,7	19,53	0,05
Tumpaan	Tumpaan Baru	-0,64	207,67	0,11	-149,5		0,37	-4,72	89,44	2,14
	Tumpaan Satu	-0,29	170,31	0,6	-27,7		0,1	-0,67	14,74	1,55
	Tumpaan Dua	-1,97	42,57	0,41		93,03		-19,8	1,55	0,11
TOTAL AREA				15,46			6,22			24,91

Source: Author's Processed, 2023

The most significant land use change is in Kawangkoan Bawah village, with a total change area of 11.27 ha. When viewed from each analysis period, the villages with the most significant changes occurred in Kawangkoan Bawah village with an area of 6.12 ha (2005-2013) which experienced abrasion shoreline changes along -36.47 m and accretion along 94.50 m, Bitung village with an area of 1.39 ha (2013-2018) which experienced abrasion shoreline changes along -46.28 m and accretion along 39.92 m, and Pondang village 4.37 ha (2018-2022) which had abrasion shoreline changes along -7.81 m and 45.12 m accretion.

Table 12: Characteristics of Green Open Space Change to Water Bodies

Sub-district	Village	Period Year of Analysis: 2005-2013 Shoreline Changes (m) Abrasion	2005-2013 Shoreline Changes (m) Accretion	2005-2013 Land Use Changed (ha)	2013-2018 Shoreline Changes (m) Abrasion	2013-2018 Shoreline Changes (m) Accretion	2013-2018 Land Use Changed (ha)	2018-2022 Shoreline Changes (m) Abrasion	2018-2022 Shoreline Changes (m) Accretion	2018-2022 Land Use Changed (ha)
Amurang	Bitung	-22,74	133,98	0,09	-46,28	39,92	1,18	-74,8	14,97	
	Buyungon						0,12			

Sub-district	Village	Period Year of Analysis								
		2005-2013			2013-2018			2018-2022		
		Shoreline Changes (m)		Land Use Changed (ha)	Shoreline Changes (m)		Land Use Changed (ha)	Shoreline Changes (m)		Land Use Changed (ha)
		Abrasion	Accretion		Abrasion	Accretion		Abrasion	Accretion	
	Ranoyapo	-5,98	23,78		-44,47	27,89		-32,6	16,99	
	Uwuran Satu	-15,74	116,32		-42,01	24,99	0,51	-75,7		
West Amurang	Kawangkoan Bawah	-36,47	94,50		-62,22	47,23	2,32	-75,5	62,60	0,89
	Rumoong Bawah		223,67		-252,91		0,51	-18,1	28,42	0,08
	Lopana	-107,05	61,90	0,14	-205,22		8,56	-68,7	26,58	3,54
East Amurang	Lopana Satu	-12,78	20,71	0,03	-37,01		1,29	-13,8	3,10	0,35
	Pondang	-15,49	27,16	0,47	-38,93	19,45	1,61	-7,81	45,12	0,36
	Ranomea	-50,37	9,09		-15,13	57,46	0,41	-63,9	5,11	
	Matani	-19,2	49,64		-16,4	45,96	0,41	-9,43	90,65	
	Matani Satu	-12,48	18,64	0,05	-22,09	6,39	0,09	-9,16	27,88	
	Popontolen	-72,33	35,18	2,17	-119,9	15,97	5,87	-36,7	79,15	1,84
	Tumpaan	-4,99	50,59		-15,46	6,93	0,44	-10,7	19,53	0,29
Tumpaan	Tumpaan Baru	-0,64	207,67		-149,5		0,19	-4,72	89,44	
	Tumpaan Satu	-0,29	170,31		-27,7			-0,67	14,74	
	Tumpaan Dua	-1,97	42,57	0,04		93,03	1,49	-19,8	1,55	0,58
TOTAL AREA				2,99			25			7,93

Source: Author's Processed, 2023

The most significant land use change was in Lopana village, with a total change area of 12.24 ha. When viewed from each period of analysis of land use change, the village with the most significant change occurred in Popontolen village with an area of 2.17 ha (2005-2013), which experienced changes in the coastline of abrasion along -72.33 m and accretion along 35.18 m, Lopana village with an area of 8.56 ha (2013-2018) which experienced changes in the coastline of abrasion along -205.22 m, and again in Lopana village of 3.54 ha (2018-2022) which had changes in the shoreline of abrasion along -68.7 m and 3.54 m of accretion.

Table 13: Characteristics of Built-up Areas Change to Water Bodies

Sub-district	Village	Period Year of Analysis								
		2005-2013			2013-2018			2018-2022		
		Shoreline Changes (m)		Land Use Changed (ha)	Shoreline Changes (m)		Land Use Changed (ha)	Shoreline Changes (m)		Land Use Changed (ha)
		Abrasion	Accretion		Abrasion	Accretion		Abrasion	Accretion	
	Bitung	-22,74	133,98		-46,28	39,92	0,56	-74,8	14,97	1,2
Amurang	Buyungon			0,54			0,61			0,01
	Ranoyapo	-5,98	23,78	0,13	-44,47	27,89	0,18	-32,6	16,99	0,07
	Uwuran Satu	-15,74	116,32	0,04	-42,01	24,99		-75,7		0,96
West Amurang	Kawangkoan Bawah	-36,47	94,50	0,28	-62,22	47,23	1,78	-75,5	62,60	0,3
	Rumoong Bawah		223,67	0,18	-252,91		0,84	-18,1	28,42	0,1
	Lopana	-107,05	61,90	0,33	-205,22		0,89	-68,7	26,58	
	Lopana Satu	-12,78	20,71		-37,01		0,07	-13,8	3,10	
East Amurang	Pondang	-15,49	27,16		-38,93	19,45		-7,81	45,12	0,19
	Ranomea	-50,37	9,09	0,01	-15,13	57,46	0,15	-63,9	5,11	0,02
	Matani	-19,2	49,64	0,21	-16,4	45,96	0,16	-9,43	90,65	
Tumpaan	Matani Satu	-12,48	18,64	0,14	-22,09	6,39	0,42	-9,16	27,88	
	Popontolen	-72,33	35,18		-119,9	15,97		-36,7	79,15	

https://doi.org/10.14710/jwl.13.2.20-38

Sub-district	Village	Period Year of Analysis								
		2005-2013			2013-2018			2018-2022		
		Shoreline Changes (m)		Land Use Changed (ha)	Shoreline Changes (m)		Land Use Changed (ha)	Shoreline Changes (m)		Land Use Changed (ha)
		Abrasion	Accretion		Abrasion	Accretion		Abrasion	Accretion	
	Tumpaan	-4,99	50,59		-15,46	6,93		-10,7	19,53	0,1
	Tumpaan Baru	-0,64	207,67	0,89	-149,5		0,24	-4,72	89,44	
	Tumpaan Satu	-0,29	170,31	0,12	-27,7		0,68	-0,67	14,74	0,07
	Tumpaan Dua	-1,97	42,57			93,03	0,43	-19,8	1,55	
TOTAL AREA				2,87			7,01			3,02

Source: Author's Processed, 2023

The most significant land use changes in 2005-2022 were in Uwuran Satu and Bitung villages, with a total change area of 2.72 ha. When viewed from each period of land use change analysis, the villages with the most significant changes occurred in Tumpaan Baru Village, with an area of 0.89 ha (2005-2013) which experienced changes in the coastline of abrasion along -0.64 m and accretion along 207.67 m, Kawangkoan Bawah Village with an area of 1.78 ha (2013-2018) which experienced changes in the coastline of abrasion along -62.22 m and accretion along 47.23 m, and Uwuran Satu-Bitung Village of 2.72 ha (2018-2022) which had changes in the shoreline of abrasion along -74.8 m and 14.97 m of accretion.

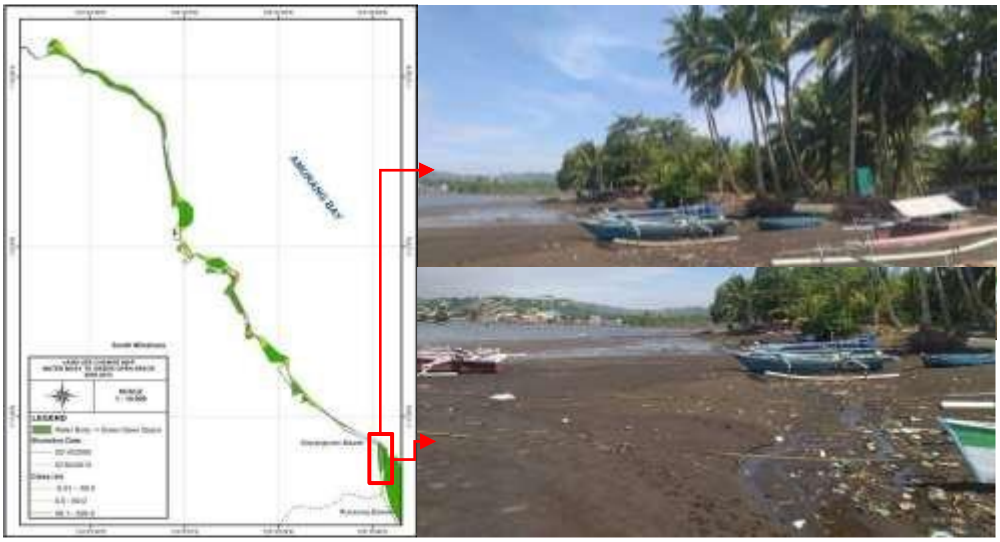
3.8 Conformity of Change Analysis to Field Observation

A. Change of water bodies to green open space

The results of satellite image observation at location 1 show the conformity between the results of spatial analysis with the existing conditions of land use change of water bodies into green open space with the current function is coconut and mangrove plantation land. Location 2, which was surveyed it is a place where the accretion process occurs where waves and part of the river estuary carry sand deposits.

Source: Google Earth Multitemporal Imagery

Figure 9. Satellite image of water bodies changed to green open space in Kawangkoan Bawah village



Source: Field Observation, 2023

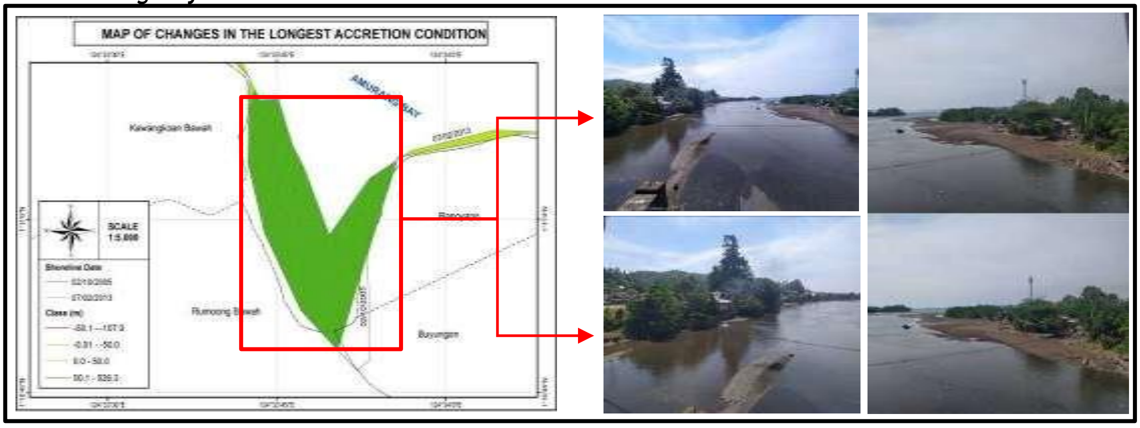
Figure 9. Existing Conditions of Shoreline Change (Accretion) and Land Use

B. Change of water bodies to built-up area

The results of satellite image observation at location point 1 show the conformity between the spatial analysis results with the existing conditions of land use change of water bodies into built-up with the current function is the land of water transport facilities in the form of Amurang Class II Port. At the point of location 2 that was surveyed is a place where the accretion process occurs where there are sand deposits carried by the flow of the river estuary, as shown in the Figure 11 of coastline changes in Rumoong Bawah village in 2013.

Source: Google Earth Multitemporal Imagery

Figure 11. Satellite Image of Water Bodies Changed to Built-Up Area in Kawangkoan Bawah Village



Source: Field Observation, 2023

Figure 12. Existing Conditions of Shoreline Change (Accretion)

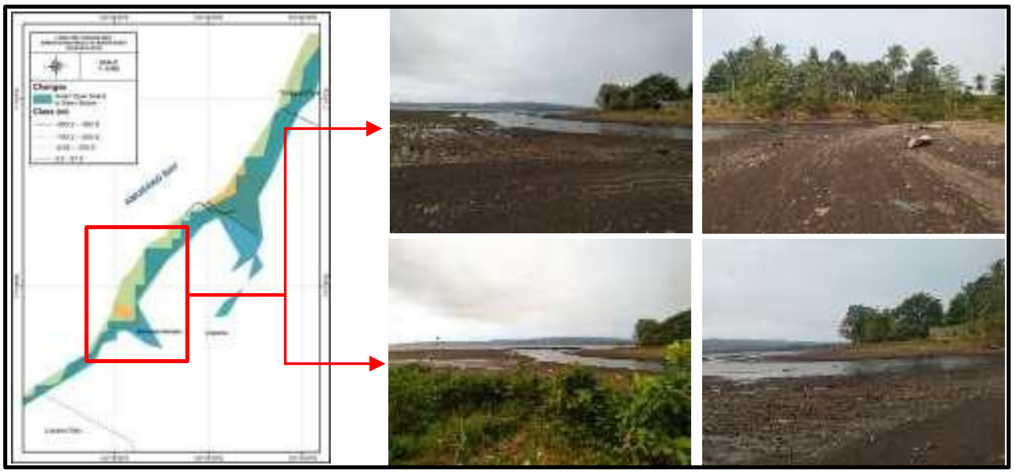
C. Change of green open space to water bodies

The results of satellite image observation at location point 1 show the conformity between the results of spatial analysis with the existing conditions of land use change of green open space into water bodies with the current function is community gardening land in the form of coconut trees and also the remaining sediment from the abrasion process that occurred in the period 2005-2022.

Source: Google Earth Multitemporal Imagery

Figure 13. Satellite Image of Green Open Space Change to Water Bodies in Lopana Village

https://doi.org/10.14710/jwl.13.2.20-38



Source: Field Observation, 2023

Figure 14. Existing Conditions of Shoreline Change (Abrasion) and Land Use

D. Change of Built-up Area to Water Bodies

The results of satellite image observation at location point one show the conformity between the results of spatial analysis with the existing conditions of changes in the use of built-up land into water bodies with existing functions before abrasions are community settlements and traditional markets in Uwuran Satu Village and Bitung Village as shown in Figure 15 and 16. Currently, the existing conditions in the field are coastal safety construction to prevent additional abrasion.

Source: Google Earth Multitemporal Imagery

Figure 15. Satellite Image of Built-Up Area Change to Water Bodies in Uwuran Satu Village and Bitung Village

Source: Field Observation, 2023

Figure 16. Existing Conditions of Shoreline Change (Abrasion) and Land Use

From the land use change data for the four characteristics above, it can be seen that there is a correlation between coastline changes that cause land use change. Research conducted by Purba (2019) in Timbulsloko Village, Demak also shows the relationship between shoreline changes and the land use on it in the range of 2000-2010 the initial 92.39 ha of inundation became ponds of 39.46 ha and changes in 2010-2015 ponds which were originally 353.05 ha became inundation of 136.43 ha.

Conclusion

From the identification of land use change due to shoreline in Amurang coastal area, South Minahasa Regency, shoreline change in Amurang coastal area occurs in two conditions, namely abrasion and accretion conditions. Judging from the three years of analysis (2005-2013, 2013-2018, and 2018-2022), the most significant shoreline changes in the abrasion condition occurred in Lopana Village with a transect length of -107.07 meters and an area of shoreline change of 53,596 m^2. Conversely, the most significant shoreline changes in accretion conditions occurred in Rumoong Bawah Village with a transect length of 233.3 meters and an area of 129,439.88 m^2.

The results of identification of land use change towards shoreline change between 2005-2022, there are four patterns of land use change. The first is land use change from water body to green open space with a total change area of 9.23 ha. Second, land use change from water bodies to built-up land with a total area of change of 11.32 ha. These two patterns of change occurred in Kawangkoan Bawah Village which corresponds to the dominant shoreline change, namely the accretion category with an average transect value of 68.11m. Third, land use change from green open space to water bodies with the largest total area of change occurring in Lopana Village of 12.24 ha. Changes in use in Lopana Village follow the dominant value of shoreline change, namely the abrasion category with a transect length of -126.99m. Fourth, changes in the use of built-up land into water bodies with the largest total area of change occurred in Kawangkoan Bawah Village, with an area of 2.36 ha, and Uwuran Satu and Bitung Villages with an area of 2.76 ha. The characteristics of these changes indicate the incompatibility of land use change with shoreline change. This condition can then be understood when overlaying the change data, where the analysis results show that land use change does not fully occur above the shoreline change area.

This research is one of the foundations that prove that coastal areas are vulnerable to changes in both physical and land use. Spatial research methods and quantitative analysis in this study show how much change has occurred without being limited by the area and time of the research data processed. So that then mitigation can be done against coastal disasters that may occur and become the basis for the government to regulate land use and processing policies in sustainable coastal areas.

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