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STUDY OF THE IMPACT OF COASTLINE CHANGES ON COASTAL SETTLEMENT AREAS ALONG TH EAST COAST OF MINAHASA

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KEYWORDS
Coastline Change Impact, Abrasion, East Coast of Minahasa, Desa Atep Oki

ABSTRACT
The natural phenomenon of abrasion on the east coast of Minahasa which occurred from 1980 to 2020 has brought about changes in the coastline which then threatens the existence of coastal residential areas. Land function data in this study uses data sourced from the USGS (United States Geological Survey) Landsat-5 TM Imagery web and also Google Earth Pro Data, the data is in the form of historical image data with 10-year intervals and starting from 2003 to 2023. In 20 years there has been an increase in the area of built-up land for settlement functions in each village. The function of plantation land has been reduced in area as a result of settlement development. Meanwhile, sandy coastal land has also experienced a reduction in area as a result of sea waves and abrasion. The results showed that Atep Oki Village had experienced the farthest coastal setback of 42.28 m, while Kamenti Village and Parentek Village, respectively as far as 27.27 m and 23.33 m. These findings have confirmed the impact of waves that damaged the coast of Atep Oki village in 2013. It also shows that the abrasion process will be continue on the coast of Atep Oki village and its surroundings. The measured coastline setback distance is around 23 - 43 meters which causes a reduction in the area of residential land as well as damage to house buildings, road infrastructure and boundary embankments. Residents must move their residence to an area that is safer from the threat of waves and abrasion processes. Damaged house buildings especially those made of wood and plywood require repair costs while most residents have limited income as farmers, cultivators and fishermen. This condition causes the threat of loss of living environment and increased spending due to abrasion disaster adaptation efforts.

INTRODUCTION

Coastal areas are potential places to live where there are many interesting coastal natural resources to manage so that most densely populated settlements are in coastal areas. Until now, there are 140 million or about 60 percent of Indonesia's population living in coastal areas. As an area with a high level of utilization, coastal areas face various negative impacts due to human activities and natural disasters (Ahyar and Wardhan, 2014). The coastal area directly facing the Maluku Sea has experienced changes in the coastline in the form of retreat of the coastline towards land or experienced erosion / abrasion caused by sea action in the form of coastal drift currents and waves (Opa, 2011).

Based on the results of measurements and mapping carried out in Bentenan village, Pusomaen district, Southeast Minahasa Regency, the coastal area in this village has changed by 165 m backward towards the mainland in the interval 1985 to 2008. Or the coastal areas of this region experience an average land reduction of 7.17 m every year, caused by marine activities such as storms, high waves and current patterns that accelerate the process of abrasion and sediment transport. East Lembean District, Minahasa Regency has a coastal settlement area, Atep Oki village which is directly facing the Maluku Sea. In 2013, Tawas et al conducted

research on the characteristics of breaking waves on Atep Oki Beach which underwent a dynamic process of abrasion/erosion.

The results of wave forecasting with wind data for 11 years found wave height transformations ranging from 0.7 m to 1.723 m at depths of 0.1 m to 25 m. The downrush distance to berms or coastal areas is 13.40 m while the downrush distance to residents' homes is 14.40 m. Researchers concluded that such waves can damage the beach and result in erosion by the release of energy from the waves and the generation of currents. Changes in the coastline in the form of retreat beaches that continue to take place have affected community settlement activities along the coast. Within 10 years the condition of coastal residential areas has experienced changes in land use, damage to infrastructure, damage to buildings and houses, and changes in socio-cultural and economic activities of the community.

Research on the impact of coastal abrasion on the social environment of people living in the northern coastal area of Central Java (Damaywanti, 2013) provides the following information: 1. Population dynamics in the form of population movement phenomena that experience loss/damage to residential land due to permanent seawatering; 2. Socio-economic changes in the field of livelihoods and the amount of income of the community; 3. The culture of the community cannot be maintained because something is lost after the village environment is separated by the sea due to abrasion. 4. The desire of the community to remain there despite the threat of increased abrasion intensity. The results of the study need to be traced the similarities and differences in the location of coastal settlements on the east coast of Minahasa. Basic research on the East Coast coastal area of Minahasa Regency that has experienced changes in coastline was developed to obtain basic information about changes in land functions, conditions of infrastructure and settlement facilities, conditions of buildings and houses and community activities.

The environmental, social and economic characteristics of communities in coastal settlements that experience coastal abrasion problems will determine the concept of coastal area spatial planning as well as building planning and coastal environment based on abrasion disaster mitigation along the east coast of Minahasa. In the leading field of disaster, this study will provide information on the form of mitigation and community adaptation to global climate change. So that the results of this research can be a reference for Unsrat in achieving targets in the maritime and disaster fields, especially to produce resilient settlement environmental planning policies against coastal abrasion disasters as part of efforts to mitigate and adapt to global climate change.

RESEARCH METHOD

Qualitative research methods were used to identify changes in land use and distant changes in coastlines that occurred in settlements along the east coast of Minahasa for 20 years in a 10-year period (2003,2013,2023). Primary data were obtained through field observations and interviews with communities around the East Coast of Minahasa, while secondary data were obtained by conducting literature reviews through books, journal and agency documents as well as online searches. Landsat 8 imagery data (2003,2013,2023), shapefile/vector data, field observations, and multitemporal google earth imagery from coastal settlements of the east coast of Minahasa become basic data in the analysis stage of land use change and coastline change.

The research location is a residential area along the East coast of Minahasa, namely Parentek Village, Atep Oki Village, and Kamenti Village which are located at coordinates 125°01'56" E, 1°10'30" N to 125°00'54" E, 1°07'54" N. The total length of the beach studied in each village is 2,513.84 m, also covering a sea area as far as 100 m from the coastline.

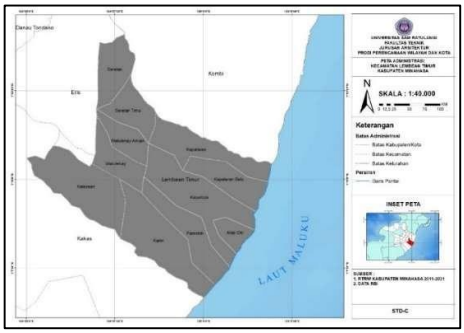

Figure 1. Map of Research Location

Table 1. Research Instruments

Name Instruments	Function	Output
Earth Explorer USGS	Satellite data provider	TIFF format Image Data
DSAS	*Toolbox for analysis*	Change distance and change area
ArcGis	Spatial data manager	Map Mapping Land function change, Distance of coastline change, Abrasion and Accretion Area
Google Earth Pro	Change Observation for land use	High Resolution Imagery
Microsoft Excell	Data Calculation	Tabulation Processing, and Data Recapitulation
Laptop/Komputer	*Hardware Data Management*	Research Results
Hand Phone	Taking field documentation and writing local interviews	Field documentation

Source: author analysis, 2023

RESULTS AND DISCUSSION

Land Function Change

In 20 years there has been an increase in the area of built-up land for settlement functions in each village. Settlement patterns developed along the coastline and increased in density over gently sloping land areas. Parentek Village experienced the largest increase in residential area of 1.82 Ha, followed by Kamenti Village of 0.88 Ha and Atep Oki Village of 0.71 Ha. The function of plantation land has been reduced in area as a result of settlement development. Meanwhile, sandy coastal land also experienced a reduction in area as a result of sea waves and abrasion. Atep Oki Village experienced a reduction in sandy beach land by 0.72 Ha, while Kamenti Village by 0.32 Ha and Parentek Village by 0.02 Ha. The land function that will no longer be found in 2023 is the mangrove habitat in Parentek Village (see table 2).

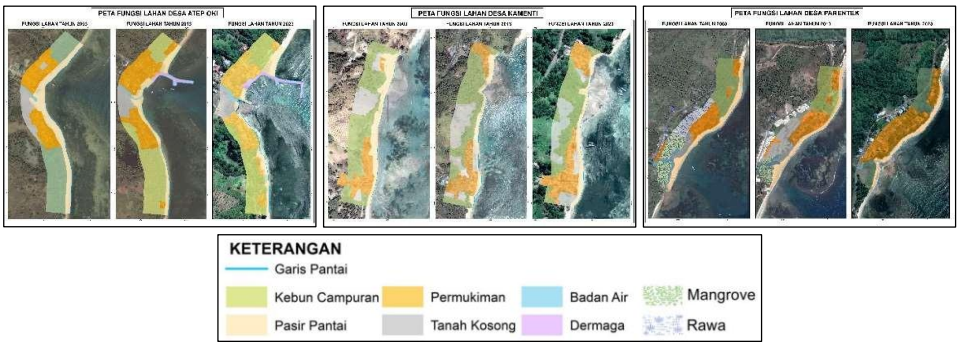

Figure 2. Land Function of Kamenti Village, Atep Oki, Parentek in 2003, 2013, 2023

Table 2. Land Functions of Kamenti, Atep Oki, and Parentek Villages in 2003,2013,2023

Village	Land Function	Total Area (Ha)		
		2003	2013	2023
Kamenti	Settlements/Built-up Land	1,03	1,27	1,91
	Beach Sand	1,08	0,66	0,76
	Mixed Garden	2,71	2,15	1,97
	Vacant Land	0,77	1,18	1,08
Atep Oki	Settlements/Built-up Land	2,11	2,80	2,82
	Beach Sand	1,86	1,27	1,14
	Mixed Garden	2,46	3,29	2,92
	Vacant Land	0,76	0,57	0,54
	Water Bodies	0,07	0,09	0,11
	Dock	-	0,27	0,43
Parentek	Settlements/Built-up Land	1,04	1,41	2,86
	Beach Sand	1,07	1,05	1,04
	Mixed Garden	1,43	1,40	1,40
	Vacant Land	0,27	1,26	0,20
	Water Bodies	0,22	0,14	0,08
	Mangrove	0,90	0,43	-
	Swamp	0,62	-	-

Source: author analysis, 2023

Coastline Changes

Changes in land use area that have occurred in 20 years are significant evidence of changes in the coastline in the eastern coastal area of Minahasa. Through the digitization process of parts of the coastline using Google Earth Pro Software based on the year of imagery, namely 2003, 2013 and 2023, information on the pattern and length of the coastline of each coastal village was obtained (see table 3). Furthermore, shoreline data is processed using the Digital Shoreline Analyst system (DSAS) method contained in ArcGis 10.8 software to determine changes in coastline distance in the observation years 2003, 2013 and 2023. The results obtained show that Atep Oki Village has experienced the farthest coastal setback of 42.28 m, while Kamenti Village and Parentek Village, respectively as far as 27.27 m and 23.33 m (see table 4).

Table 3. The length of the coastline of Kamenti Village, Atep Oki, Parentek in 2003,2013,2023

Village	Coastline Length (m)		
	2003	2013	2023
Kamenti	545,65	584,44	570,89
Atep Oki	769,37	1043,20	1317,86
Parentek	597,45	600,95	625,09

Source: author analysis, 2023

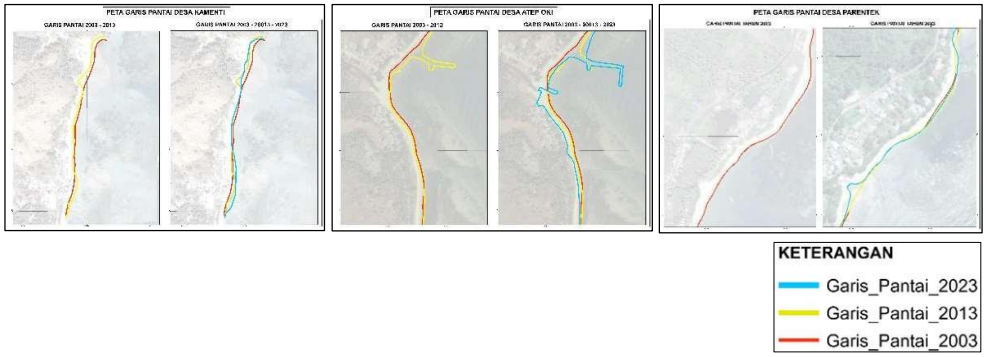

Table 4. Distance from the coastline of Kamenti Village, Atep Oki, Parentek in 2003, 2013, 2023

Village	Character of Changes	Perubahan Jarak Garis Pantai	
		Luas (Ha)	**Panjang** (m)
Kamenti	Abrasion	0,18	1,70 - 27,27
	Accretion	0,12	1,21 - 7,13
Atep Oki	Abrasion	0,82	7,02 - 42,48
	Accretion	0,83	3,41 - 62,71
Parentek	Abrasion	0,31	1,31 - 23,33
	Accretion	0,23	3,76 - 17,23

Source: author analysis, 2023

Characteristics of Land Use Change

There are eleven characteristics of land function change in coastal settlements in the East coast of Minahasa obtained through observations in the period 2003 to 2023. Two characteristics of land use change indicated by abrasion impacts are the change of beach sand to sea and settlements to sea (see table 8). Atep Oki Village experienced two characteristics of land function change as a result of the abrasion. While Kamenti village and Parentek village, each only experienced one characteristic, namely beach sand into the sea.

Figure 4. Map of Area Changes in the Coastline of Kamenti, Atep Oki and Parentek Villages in 2003,2013,2023

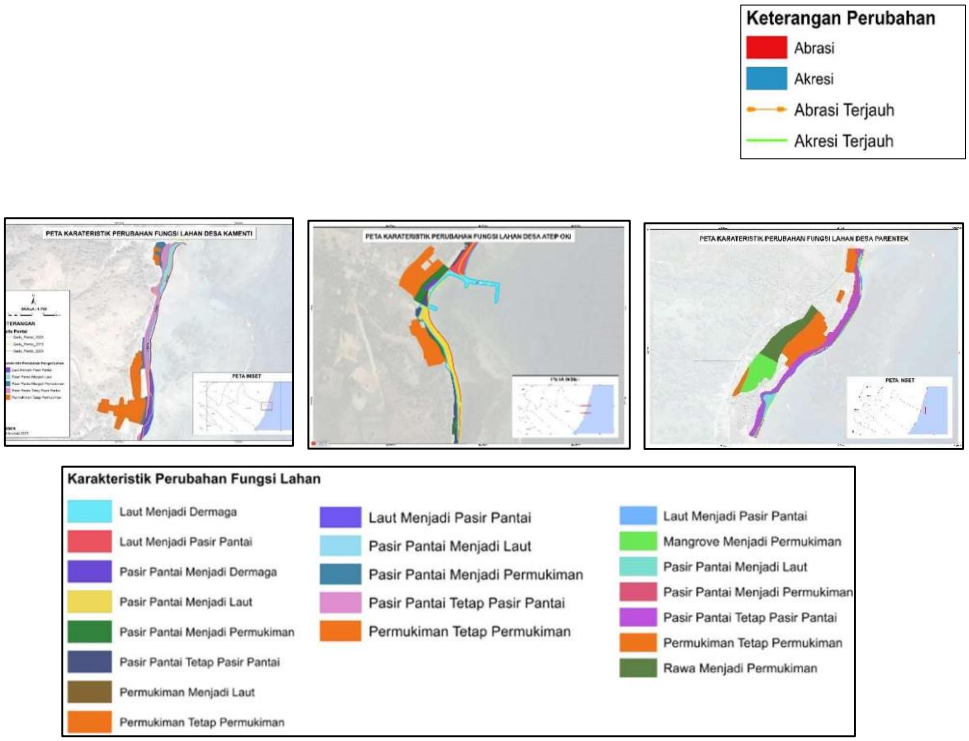

Figure 5. Characteristics of Land Function Change in Kamenti Village, Atep Oki, Parentek in 2003-2023

Table 5. Land Function Change in Kamenti Village in 2003-2023

Land Function		Character of	Area
2003	**2023**	**Changes**	**(Ha)**
Beach Sand	Beach Sand	-	0,264
Beach Sand	Settlements	-	0,200
Beach Sand	Mixed Garden	-	0,527
Settlements	Settlements	-	0,163
Beach Sand	Sea	Abrasion	0,045
Sea	Beach Sand	Accretion	0,916

Source: author analysis, 2023

Table 6. Land Function Change in Atep Oki Village in 2003-2023

Land Function		Character of	Area
2003	**2023**	**Changes**	**(Ha)**
Laut	Dermaga	Akresi	0,435
Sea	Beach Sand	Accretion	0,364

Beach Sand	Sea	Abrasion	0,752
Beach Sand	Beach Sand	-	0,467
Beach Sand	Dock	-	0,066
Beach Sand	Settlements	-	0,475
Settlements	Sea	Abrasion	0,013
Settlements	Settlements	-	1,847

Source: author analysis, 2023

Table 7. Land Function Change in Parentek Village in 2003-2023

Land Function		Character of Changes	Area (Ha)
2003	2023		
Beach Sand	Sea	Abrasion	0,153
Sea	Beach Sand	Accretion	0,072
Beach Sand	Beach Sand	-	0,806
Beach Sand	Settlements	-	0,100
Settlements	Settlements	-	1,006
Mangrove	Settlements	-	0,517
Swamp	Settlements	-	0,609

Source: author analysis, 2023

Table 8. Characteristics of Land Function Change in Kamenti, Atep Oki, and Parentek Villages in 2003-2023

No	Characteristics of Land Use Change	Village		
		Atep Oki	Parentek	Kamenti
1	Abrasion - Beach Sand turns into Sea	√	√	√
2	Abrasion - Ssettlements turns into the sea	√		
3	Accretion - The Sea turns into Beach Sand	√	√	√
4	Accretion - The Sea turns into a Jetty	√		
5	Beach sand turns into a settlement	√	√	√
6	Beach sand turns into a pier	√		
7	Beach sand turns into a mixed garden			√
8	Mangroves turns into Settlements		√	
9	Swamp turns into settlement		√	
10	Beach Sand Remains Beach Sand	√	√	√
11	Permanent Settlements Settlements	√	√	√

Source: author analysis, 2023

Impact on Infrastructure, Facilities, Buildings and Communities

Atep Oki Village is a village that has six (6) characteristics of land function change, both categorized as abrasion and accretion impacts. Through direct observation at the location and interviews with the community, information was obtained on the condition of infrastructure and buildings that were damaged by the coastal decline process in 20 years.

Atep Oki Village consists of two hamlets separated by a water body in the form of the Atep Oki River. In the ‘dusun satu’(1) there is an infrastructure of breakwater dikes and ship demaga as part of the Fish Auction Site facility (2013) built by the Public Works Office. In 2023 observations, it was found that there was medium damage to the breakwater embankment due to tidal waves (figure 9). Beach retreat is not found in this area, and the building area is on

land so there is no damage. In contrast to 'dusun dua' (2) which suffered damage to road infrastructure and land retaining talud built independently by the community (figure 10). Severe damage was suffered to houses on the coast, where parts of the house were destroyed when the tidal wave damaged the retaining talud of the land where the houses were located (table 9).

Figure 9. Dusun 1 Desa Atep Oki

Figure 10. Dusun 2 Desa Atep Oki

Table 9. Impact of Abrasion on Residential Buildings in Atep Oki Village

No	Name (age)	Year of Reside	No	Name (age)
1	Oma Betsy (80)	Since 1960s	Copra Farmers and Fishermen	The location of the house near the beach often enters the water during high tide. Currently it has moved a house 100 meters away from the coastline.
2	Abdulah Husni (73)	Since 1950s	Copra Farmers and Fishermen	The location of the house near the beach often enters the water

				during high tide. Currently it has moved a house 100 meters away from the coastline.
3	Santi (40)	Since 2008	Farmers and Fisherman	Houses near the beach are always damaged kitchen parts so they have to pay repair costs
4	Stela Lantang (52)	Since 994	Farmers	Houses near the beach are always damaged kitchen parts so they have to pay repair costs
5	Marina Umboh (44)	Since 2016	Farmers and Fisherman	The house near the beach has been destroyed so it has to move the location of the house, but the current house has also been destroyed and has to pay for repairs, there are even plans to moving again

Source: Processed by Author, 2023

CONCLUSION

Residential areas on the east coast of Minahasa, have undergone characteristic changes, especially in land functions and coastline positions during the period 2003 to 2023. The impact of settlement development in three coastal villages has reduced the area of agriculture/plantations, while sandy coastal land has also experienced a reduction in area as a result of sea waves and abrasion. The results obtained showed that Atep Oki Village had experienced the farthest coastal setback by 42.28 m, while Kamenti Village and Parentek Village, respectively as far as 27.27 m and 23.33 m. Atep Oki Village experienced a reduction in sandy beach land by 0.72 Ha, while Kamenti Village by 0.32 Ha and Parentek Village by 0.02 Ha. The land function that will no longer be found in 2023 is the mangrove habitat in Parentek Village. The area of settlement turned into the sea occurred in Atep Oki Village amounting to 0.13 Ha. The impact of abrasion found in dusun dua (2) of Atep Oki village was damage to house buildings, embankment walls and local roads.

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