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Human external and internal activities in the destruction of the north galesong coastal area

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Abstract

The research aims to find out what part of human activities on the outside and inside played in the destruction of the coastal area; in this case, it examines human activities carried out by residents and sand mining entrepreneurs around the north Galesong Sea, which have an impact on change structure of land use and abrasion of coastal areas—using a quantitative paradigm with quantitative methods as the primary method and qualitative as support. The quantitative method uses a geographic approach, namely a spatial approach using a Geographic Information System in its analysis. GIS uses spatially based data, namely geographically oriented data. Data used in this study are land use maps and village shorelines. The qualitative method used descriptive case studies. Qualitative data: The population of this study is Aeng Batu village. There are two types of research samples, namely area and human samples; area samples are taken from the description of conditions when abrasion occurs and after post-abrasion repairs occur. For the human sample, the respondents were community leaders, village officials, and the community to find out the purpose of digging beach sand and dumping trash on the beach in ex-dug holes. The data is described and supplemented with photographs of actual conditions in the field—analysis techniques using analytical descriptions. In conclusion, damage to coastal land caused by human activities does not only come from mining at sea but also the activities of residents who use beach land and beach sand (for residential construction and garbage disposal), the physical shape of the beach, the damage is exacerbated by high rainfall, wind, and waves, especially during the rainy season.

Keywords Coastal destruction · Abration · Anthropogenic · Rainy season · Sand mining

Introduction

The coastline surrounding the Indonesian mainland is around 81,000 km and is the second-longest tropical line in the world after Canada (Prasetyo et al. 2020). The length of the coastline shows that Indonesia is a country with many areas coastal areas. However, the coastline has shrunk in recent decades, so the land area is decreasing, endangering the coastal settlements bordering the beach (Heger and Vashold 2021). The shrinking of the coastline occurs due to damage to the coastline due to disruption of the natural balance of the coastal area.

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Disruption of the coastal areas' balance is usually caused by natural phenomena and human activities (Haddow et al. 2020). Indonesia's coastal areas have the potential to experience quite large disasters due to rising sea levels. The coastal area is home to around 65% of Indonesia's population. Beaches in coastal areas often experience changes in shape due to abrasion and sedimentation, and changes are a natural dynamic response of the beach to the sea (Triatmodjo (1999); Kalay et al. 2014). Natural factors that affect beach erosion are waves, currents, and tides. Generally, natural factors last a long time, but non-natural factors accelerate erosion. Soil erosion in coastal areas caused by destructive ocean waves and currents is sometimes called coastal erosion. Ongkosongo Otto Sudarmadji (2006) stated that about 70% of sandy beaches in the world experience coastal erosion, and the leading cause is various natural influences, which cause a reduction in the amount of sediment reserves available on the beach compared to the sediment that comes out (Ihsan and Pin 2019).

One of the regions of Indonesia, especially South Sulawesi, namely North Galesong, is experiencing abrasion. According to the Director of the South Sulawesi Indonesian Forum for the Environment, Muhammad Al. (WALHI South sulawesi 2018), the abrasion that occurred on the coast of North Galesong is very worrying; Mining activities trigger land erosion due to seawater intrusion, R.O.B., massive sand mining at sea in 2017–2019, and the increasing need for housing for coastal communities. Abrasion has destroyed the waters and coastal landscapes of the 74-km Galesong coast. Sharifa Ratu, Head of Aeng Batu Batu Village, Takalar District, reiterated that damage due to abrasion In her village had reached 100 m. His party has reported it to the Takalar District National Disaster Management Agency (B.N.P.B.). As a result, the local government has allocated a budget to purchase gabions so that the beach is resistant to abrasion (News One 2020), and in 2022, a coastal safety wall was built.

Several experts have conducted studies discussing abrasion, such as Ihsan and Pin (2019), that abrasion harms public facilities and residents' housing by impacting changes in coastlines and mangrove forests. There are community efforts to survive by planting mangroves and artificial wave barriers. E.M.T.K. Senevirathnaa et al. (2017) conducted a study on erosion and found that nature and anthropology experienced coastal erosion in the area. Wasana and Thennakoon (2018) analyzed the impact of anthropogenic activities on changes in the coastal landscape and identified changes in the coastal landscape and their effects. Haryani et al. (2019) studied the physical factors that most influenced beach abrasion and accretion in Pariaman City: currents, coastline shape, coastal typology, and vegetation cover, while the low wave factor had quite an effect. Toledo (2022) investigated the level of erosion caused by the frequency of incoming waves and the slope of the beach, as well as the reduced homogeneity of sediment grain size and beach wear behavior. Rentier and Cammeraat (2022) identified the impact of river sand pollution on the physical, biological, chemical, and anthropogenic environment through systematic literature reflection. Sand mining activities destroy river morphology and sediment transport. Juez and Franca (2022) investigated the main morphological (river channels, granulometric sediments) and socio-environmental (aquatic biota, human settlement) changes caused by sand mining in river systems.

Another researcher who also researched human activities that impact coastal damage is Khoirunisa (2020), who examines the human factors contributing to abrasion: the extraction of beach materials such as sea sand coral reefs and mining. The impact of beach abrasion eventually worsened the situation due to the strong waves at Pasir Panjang Beach, where the existing bridge broke. Chaibi and Sedrati (2009) regarding human-made constructions in coastal areas; Magoon et al. (2012) emphasize that builders need more awareness in constructing buildings close to the beach, which can damage the coastal environment. Abualhin (2022), the impact of human interventions on the shoreline could be more than on sea level in the short term.

To the best of the author's knowledge, researchers generally conduct research on abrasion due to human activities (sand mining) in river coastal areas, and other research looks at the impact of abrasion on public facilities. On the other hand, other cases of coastal abrasion are studied from natural and anthropometric aspects but in different areas. Differences in place can affect non-physical and physical aspects so that new similar research can be done in other areas. This research studies the influence of human activities on abrasion and the attitude of society and government in responding to it. Therefore, we consider it essential to research. The study's goal was to discover what part human activities on the outside and inside played in destroying the North Galesong Coastal Area.

Methodology

This study uses a quantitative paradigm, with quantitative methods as the primary and qualitative methods as support. The quantitative method uses a geographical approach, namely a spatial approach; the spatial approach is a method of understanding certain phenomena and obtaining more profound knowledge through the medium of space; in this case, the spatial variable gets a prominent position in each analysis, and many other variables are involved (Yunus 2010).

Several steps must be taken by researchers regarding spatial analysis, namely (1) Abstracting the appearance to be studied into primary forms such as points, lines, or areas

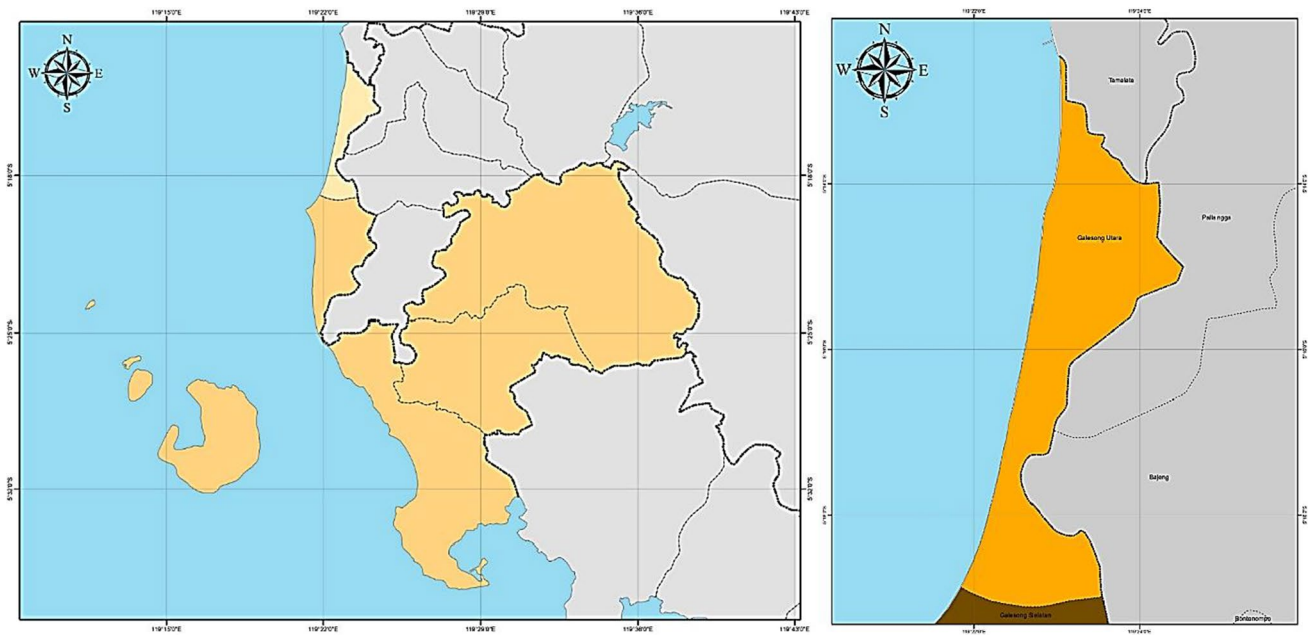
(areas); (2) Classifying the peculiarities of the distribution of spatial forming elements to be discussed; (3) Answering geographic questions addressed to certain people, such as village officials or the community who happened is at the research location (Yunus 2010).

Spatial analysis is quite broad in scope. One spatial analysis is in GIS or Geographic Information System. A Geographic Information System also has a meaning as an information system that works using data that is spatially referenced or has geographic coordinates. The function of spatial analysis in GIS is to understand objects or phenomena spatially to make decisions to solve problems. GIS uses spatially based data, which is geographically oriented data. The geographical data used in this study is in the form of land use maps and village beach borders, which are then seen as changes in the area of land use every five years (2000–2015), after that every two years because Sand mining on a large scale by private parties for the needs of CPI (center Point of Indonesia in Makassar) reclamation began in 2016. The impact began in 2017 (village staff and local community info), and beach erosion began to occur frequently. These changes are then drawn in the form of a GIS and then graphed and described. In addition, other supporting spatial data is a map of mining locations by the private sector.

For qualitative methods using case studies, case studies are a form of research or study of a problem with specific characteristics. Descriptive case studies create descriptive or systematic, actual, and accurate descriptions of the facts, nature, and relationships between the investigated phenomena. For qualitative data, the population of this study is the entire area of Aeng Batu village. There are two types of research samples: regional and human. This research occurred in four hamlets: Jongobatu, Ujung, Karamak, and Ujung Kassi. For area samples (qualitative) taken from the description of the conditions when the abrasion occurred, the condition after there was a post-abrasion improvement. For the human sample, the respondents are community leaders, village officials, and people who build houses to determine whether the sand on the beach is used for housing and other infrastructure development needs. The data is described and supplemented with photographs of actual conditions in the field to support the analysis and use of analytical descriptions.

Research location

The research location is in Aeng Batu Galesong, North-Takalar-South Sulawesi – Indonesia. Area = 566.61 km^2 (BPS 2021). Total Population = 286,390 (DKCS 2021). It is part of the Takalar district, which has a topology of the coast, plains, and hills. In the west are the coastal areas and lowlands with a 0 – 3 degree slope. Hydrologically, Takalar has a tropical climate with rainy and dry seasons. The rainy season usually occurs between November and May. The average monthly rainfall during the rainy season ranges from 11.7 mm to 653.6 mm, with the highest average daily rainfall being 27.9 °C (October) and the lowest 26.5 °C (January – February). Throughout the year, temperatures usually vary from 23 °C to 32 °C and rarely go below 21 °C or above 34 °C. The hottest month in Galesong is October, with an average low of 24 °C and a high of 32 °C. The coldest month of the year in Galesong is January, with an average low of 24 °C and a high of 29 °C (weather spark. com-Galesong).



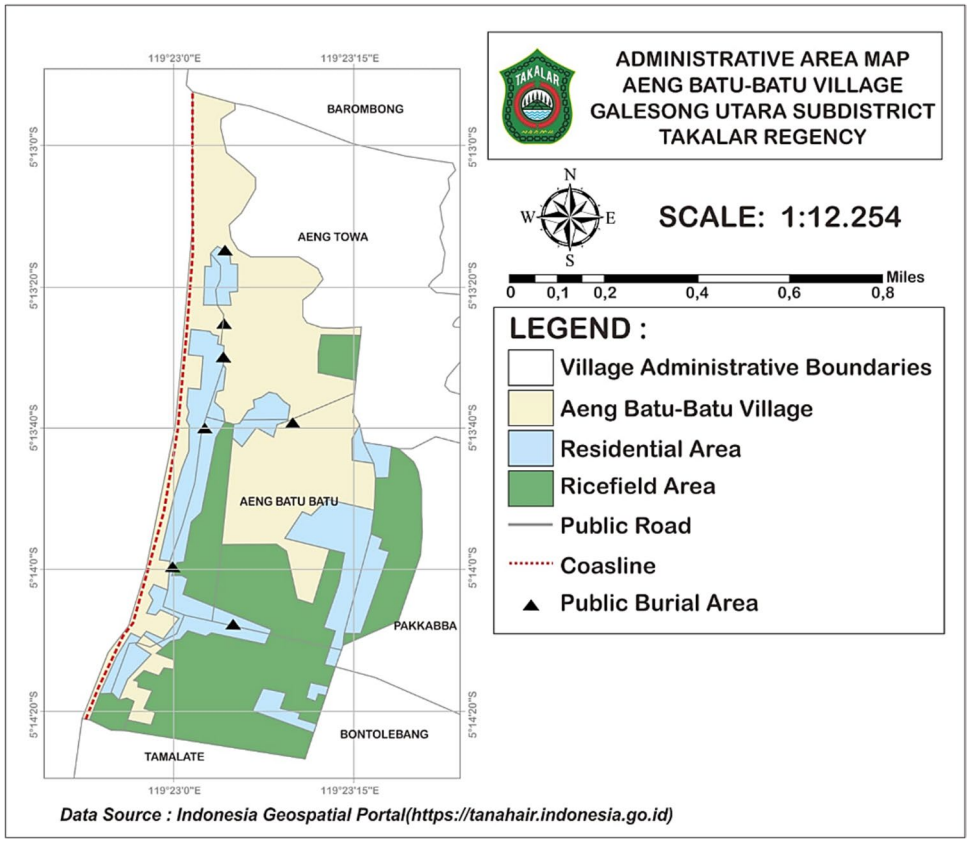


Fig. 1 Research Locations

Takalar Regency, North Galesong District

The left figure is the entire area of the Takalar district, and the correct figure is the northern Galesong subdistrict, which is the research location. The research area is in the coastal area adjacent to the Makassar Strait. To the north, it borders the Tamalate sub-district of Makassar Municipality, and to the east, it borders the Pallangga and Bajeng sub-districts of Gowa Regency. Galesong people generally work as fishermen and seaweed cultivators (Fig. 1).

The figure shows a map of the administrative area of Aeng Batu Batu village, North Galesong subdistrict, and the allocation or use of village land. Figures show that rice fields, gardens, and ponds still dominate the Aeng Batu Batu village area.

Research result

The following are the results of data analysis using a spatial analysis approach, namely GIS or Geographic Information System. The following is graphic data showing changes in land use in Aeng Batu village (consists of 4 village areas, namely, Ujung Kassi, Karamak, Pandanga, and Jonggobatu hamlet) from 2000–2022 (Fig. 2).

There has been a change in the residential areas, green open space, and pond + plantation areas. Green open space increased yearly, while residential areas decreased until 2015, almost stabilized until 2020, then dropped again until now. Different from the case with garden and pond land, which increased sharply from 2005 to 2010, then fell until 2015, and almost did not experience significant changes until 2022. For green open space, the land continues to increase.

Residential land continues to increase, while green open space land, but not sharply but slowly, and agriculture and farming are also experiencing a slow decline, but rather sharply from 2021 to 2022.

The condition of changes in land use in Karamak and Pandawa is almost the same, building area continues to increase and green open space and agriculture and farming lands are decreasing.

Residential land has increased, and agriculture and farming have decreased, but green open space, in general, has experienced an increase in land area.

Ujung Kassi, Karamak, and Pandang show almost the same conditions; residential units are experiencing development, while agriculture farming and green open space are decreasing in area. Slightly different from Jonggobatu, the residential area has increased, but the green open space area has also increased, but agriculture and farming have decreased (Fig. 3).

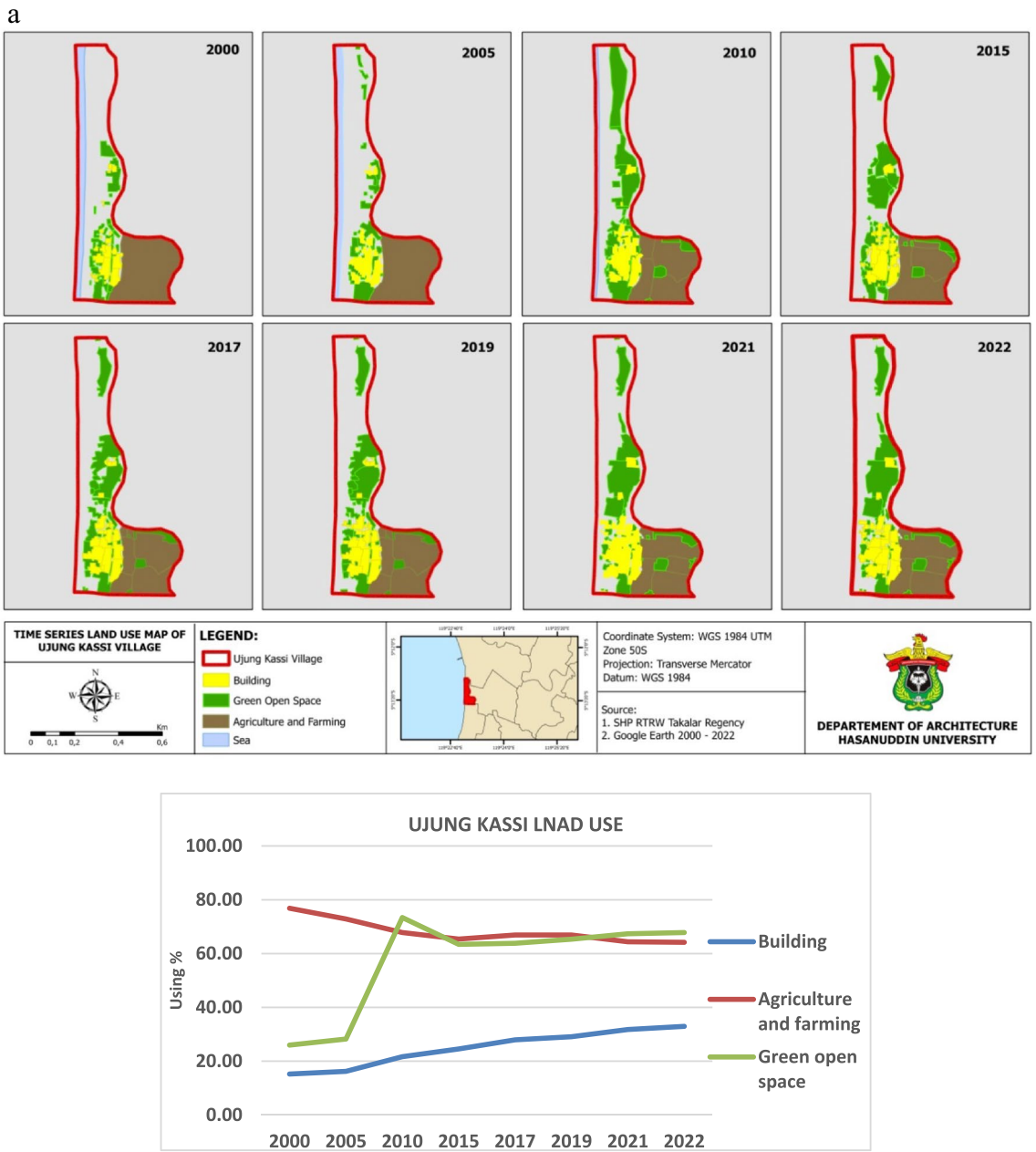


Fig. 2 **a** Changes in land use in Ujung Kassi hamlet. **b** Changes in land use in Karama Hamlet. **c** Changes in land use in Pandanga hamlet. **d** Changes in land use in Jonggobatu hamlet

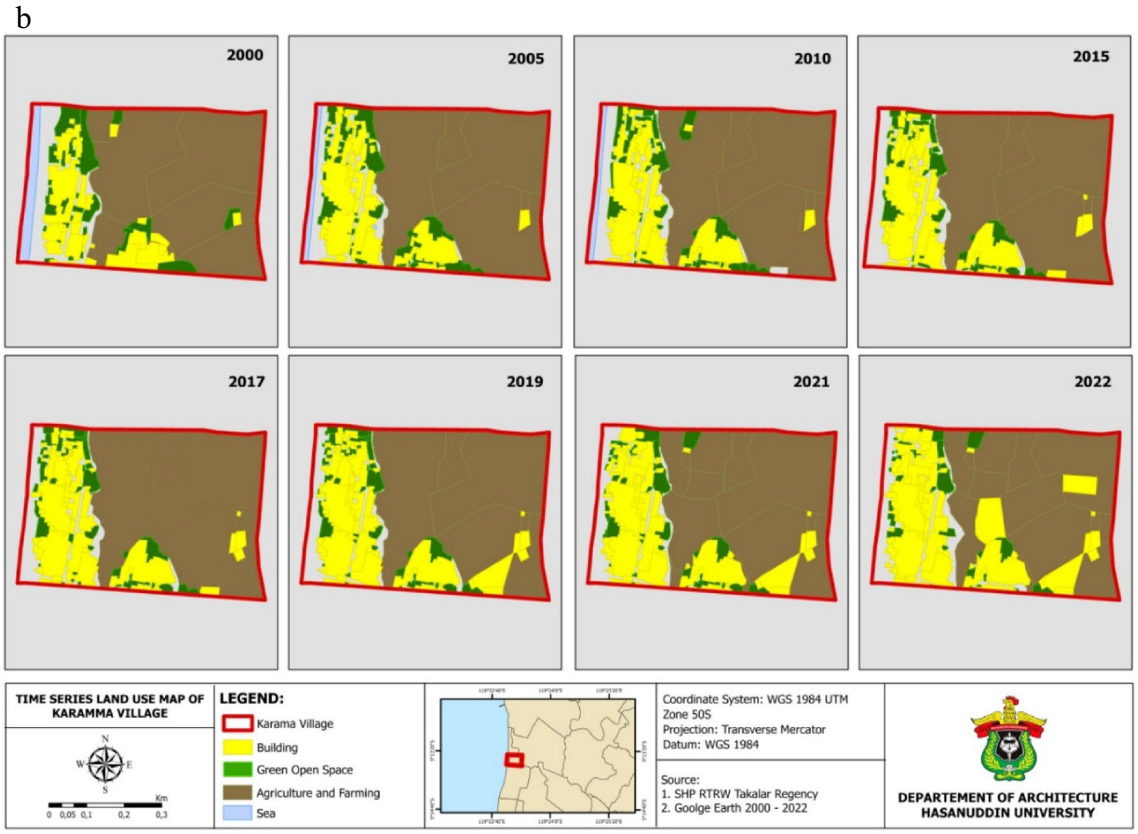
For the use of coastal borderland, Karama, Pandanga, and Jonggo Batu hamlets have almost the same conditions; from 2005 to 2015, the area of coastal borderland increased, then from 2015 to 2019, it is almost evenly distributed, but from 2019 to 2023 it has decreased in the area. The coastal border area of Ujung Kassi Hamlet experienced significant development from 2005 to 2015, then experienced less change until 2018, then increased in 2019 and then almost the same until 2021, and decreased in 2021 until 2023.

The following picture shows the sand mining area around Galesong Takalar. Karama and Kassi end of the location.

Totaling 19 sand mining companies. 4 companies mining sand very close to the beach, still in shallow seas. Map of the 9,000-hectare mining concession area in Spermonde Makassar waters (Chandra 2020).

The following image shows a map of fishing grounds and conservation areas around Takalar waters.

Figures 4 and 5 show the sand mining area, and other images show the location of people's fishing activities. In



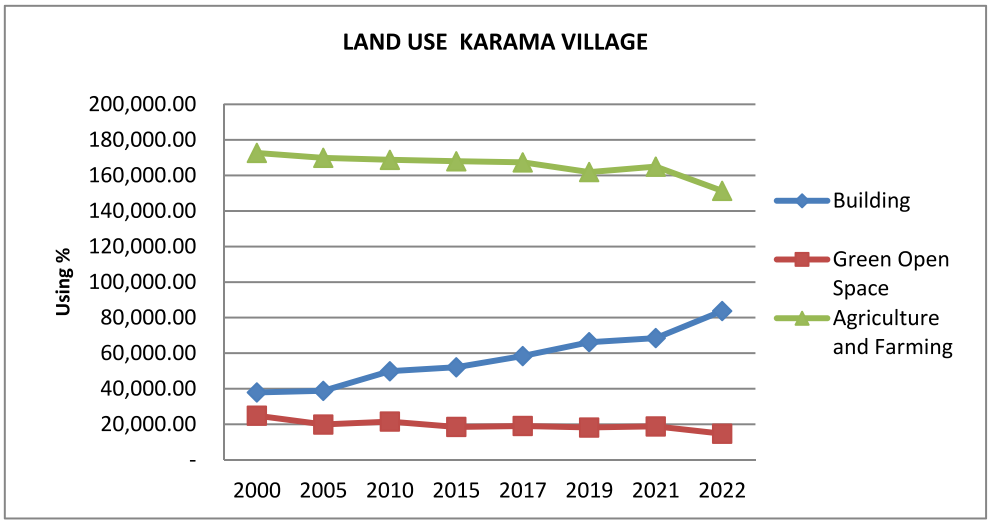


Fig. 2 (continued)

Fig. 2, we can see that the sand mining area is a fishing area. In addition, it is pretty close to the north Galesong beach and is still in a shallow sea area; the most relative distance is about 2.5 km from the coastline, and the farthest is about 20 km (WALHI South Sulawesi 2018).

The following figures show the condition of the beach when the abrasion occurred in 2021, the efforts of the community and the government to overcome it, and the conditions after the construction of the beach wall in early 2022.

When abrasion occurs, the local government, assisted by residents, has built gabions to prevent further abrasion (pictured left), but during the rainy season, accompanied by the wind and waves caused the waves to hit the gabions again, abrasion occurred again up to the walls of the

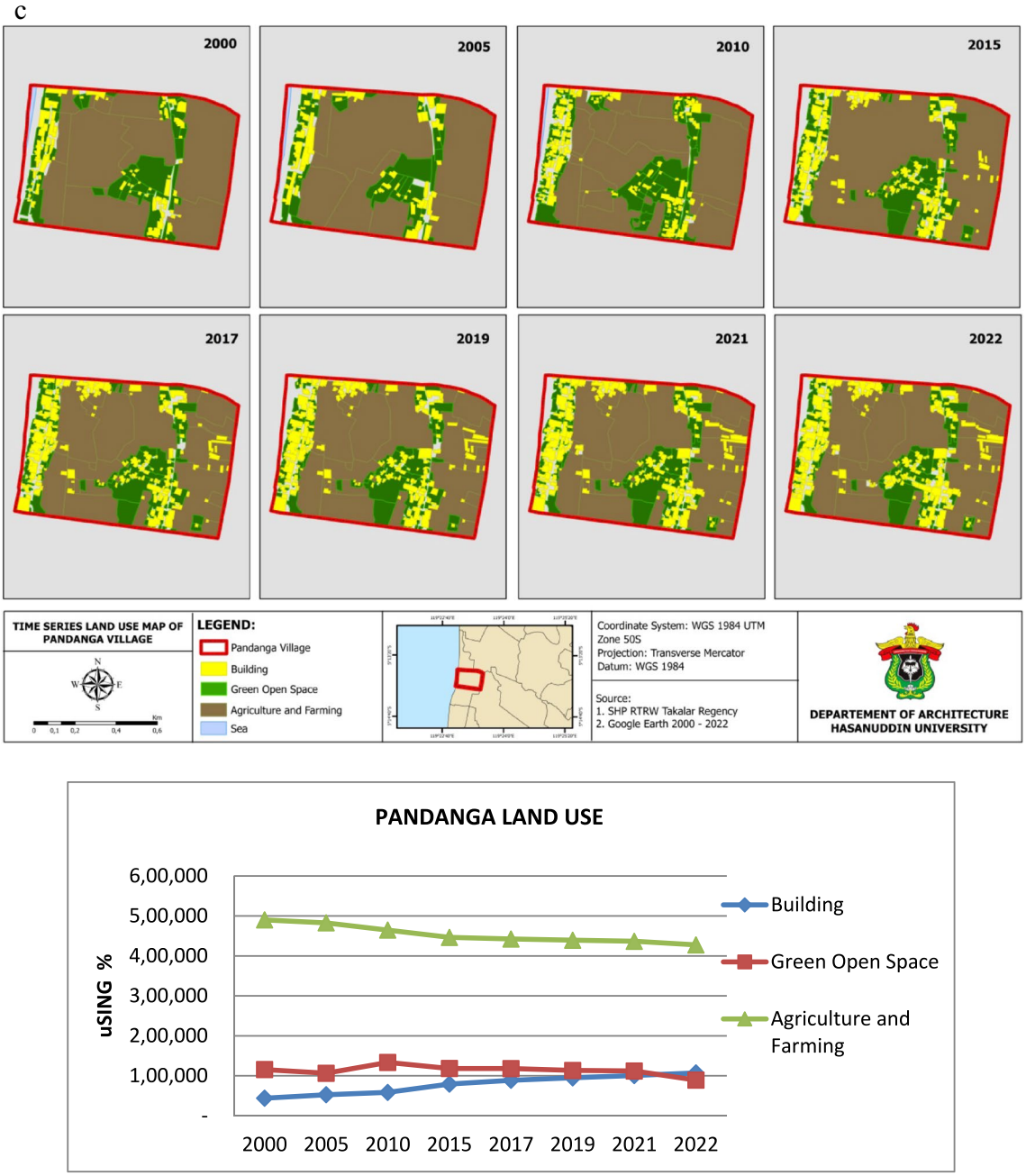


Fig. 2 (continued)

house (pictured right) causing damage to the terraces of residents' homes.

The community uses various methods to prevent abrasion from getting worse, including tree branches and sandbags. The community has used multiple methods to avoid abrasion. From informing residents who live in the area of the highest tide limit, they have moved the gabion and sandbag locations 3 times. For every gabion and sandbag submerged in water, a new one is made again, and so on, until it has been done three times.

Abrasion occurred again at the end of 2022 until early 2023. Abrasion shifted to the south of the village. Based on data from BMKG, WMO ID: 97,182, station name: Paotere maritime meteorological station, at latitude: -5.11375, and longitude: 119.41983, elevation: 5. Then data was obtained between December 2022-February 2023 (at that time, the condition of the North Galesong beach was experiencing abrasion events as shown in Fig. 2c above), where the maximum wind speed data was 11 m/s, the average wind speed was 6 m/s, the wind direction when the full speed was

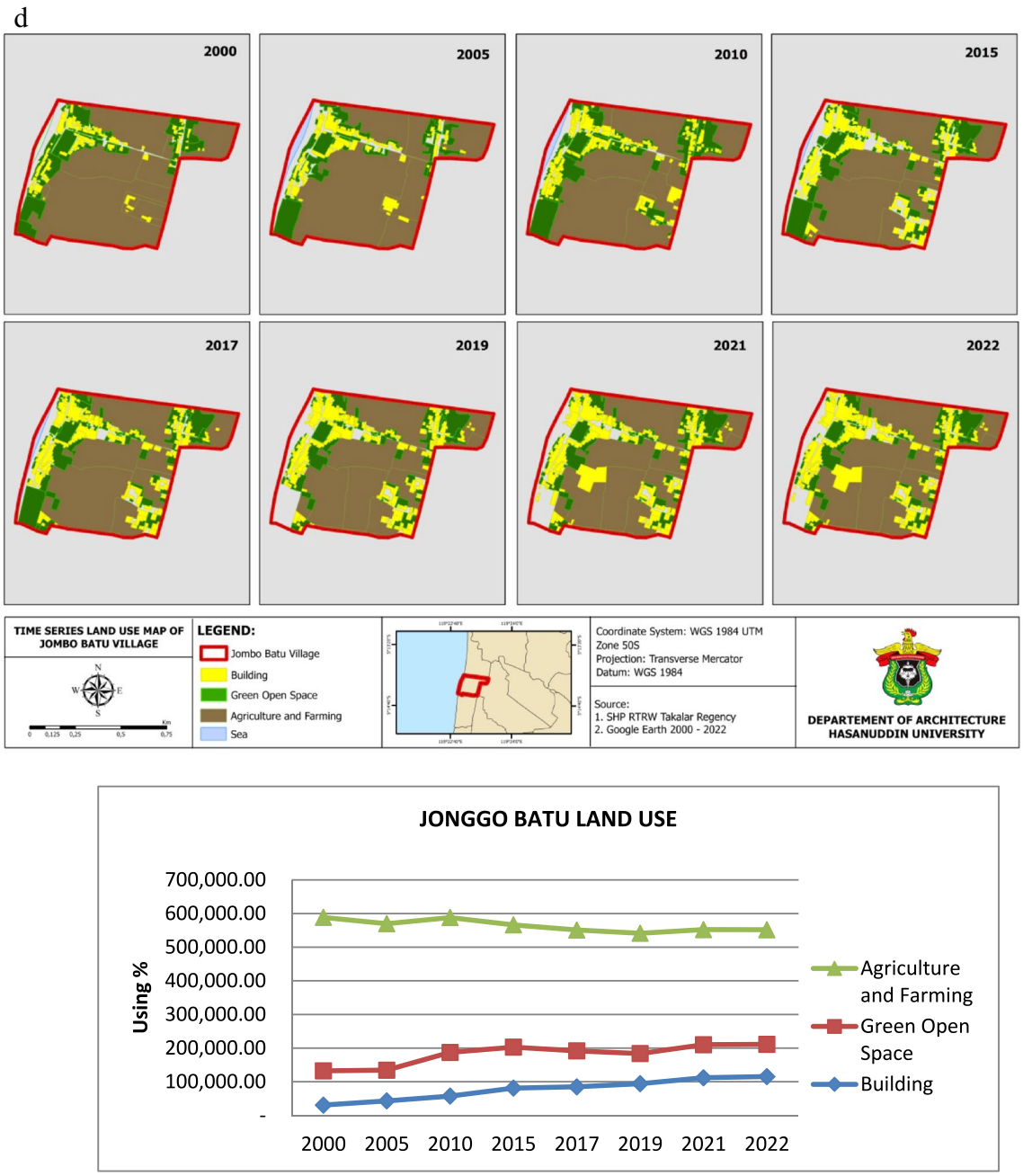


Fig. 2 (continued)

300–315 to the northwest, and the dominant wind direction was to the east. By converting the top wind speed of 11 m/s to 40 km/hour, according to the Beaufort scale, the value of 40–50 km/hour includes strong wind gusts. The rainfall at that time was 70.8 mm. Based on BMGK, rainfall ranges from 50 – 100 mm/day (orange), which is categorized as heavy rain.

The beach of Aeng Batu village is gently sloping, with an angle of 0–30 from the lowest water level to the highest tide level. The distance from the lowest tide line to the highest varies, from 15 to 20 m, the wider it is towards the north. The abrasion prevention building built in Aeng Batu Batu Village uses a Curved Concrete wall combined with a Detached Breakwater.

The community stockpiles various materials, namely sand, soil, garbage, twigs, and leaves, to develop residential areas. So in the rainy season (the average December and January with the highest rainfall reaching 413–400 mm) and the wind speed in January is around 16.4 kph (https://id.weatherspark.com/y/133113/Cuaca-Rata-rata-pada-bulan-in-Galesong-Indon

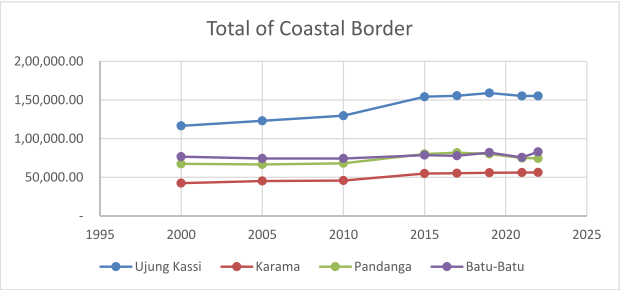


Fig. 3 Changes in the area of the coastal border area

esia-Sepanjang-Tahun#google_vignette) accompanied by strong winds, at that time floods often occur until they reach the highest tide limit or residential areas, then sand or soil that has been mixed with garbage it will quickly decompose and can cause landslides (as shown in Fig. 6e).

Based on (Asmal and Latief 2023), 70 community families, especially those who live in the coastal border area, throw garbage onto the beach or empty spaces in residential areas, with 296 houses. Biringkassi Village (Karamak Nd Ujung Kassi Hamlets) is a division of Aeng Batu Village, North Galesong District, Takalar Regency. The estimate is that the amount of waste along the coast will overflow a total of 54.78 kg/100mi/3 weeks X 20.041 m = 1097.8 kg/3 weeks. So, within one season (6 months for the humid tropics), the waste production will reach 8,782.4 kg. This amount is spread over the disposal sites, and 1/3 of it is dumped on the beach to pile up sand dugouts.

The housing units built have entered the beach area, no longer in the coastal border area, this is very dangerous for the house and its inhabitants as well as for the beach environment itself.

The community has conventionally made various efforts to prevent abrasion: 1. By filling sacks with sand, 2. They are placing tree branches, 3 and making bamboo fences filled with concrete or sand. Everything is placed at the highest tide line or on the home page, and according to residents, they have moved the placement of the gabions three times; every time they are affected by abrasion, they make a new one that is placed more in the border area (especially in pandanga hamlet).

Coastal countermeasures using a combination of curved concrete walls and detached breakwater. The sand sediment

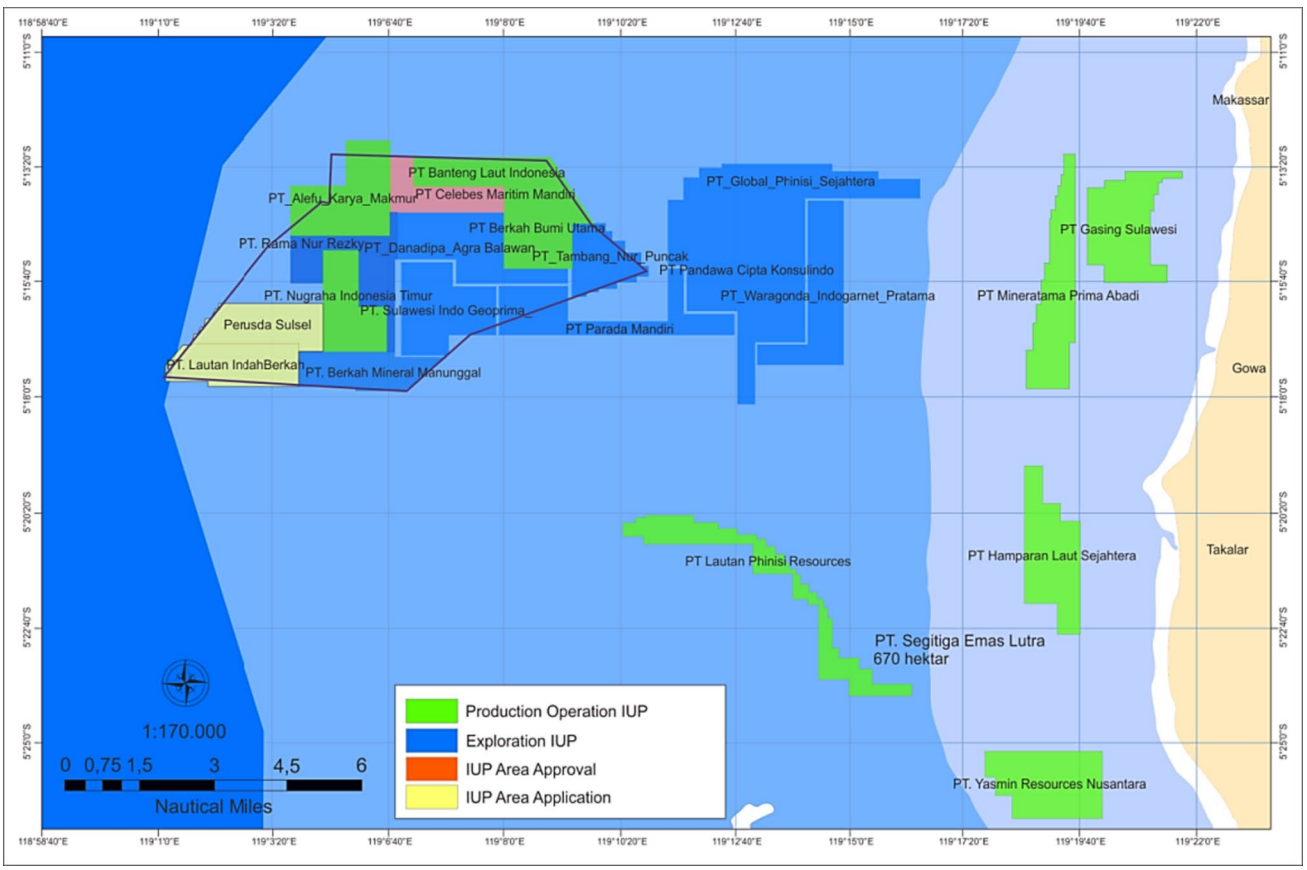


Fig. 4 Sand mining locations (Mongabai 2020)

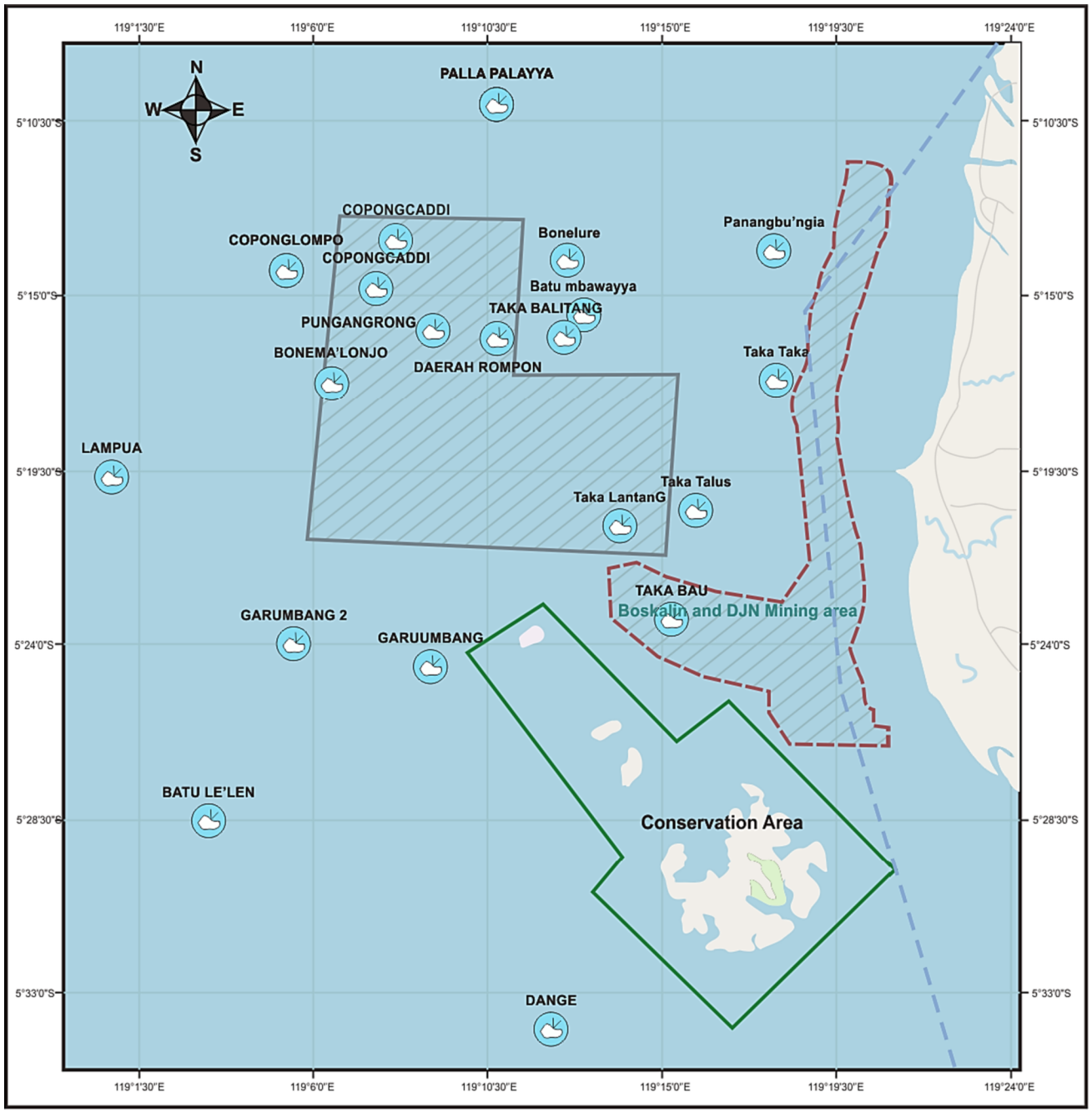


Fig. 5 Map of fishing grounds and conservation areas around Takalar waters (WALHI South Sulawesi 2018)

formed in the detached breakwater has become a new beach area for fishermen to park their boats. The local government has implemented a strategy to prevent abrasion from worsening: Construct abrasion-prevention structures, namely Curved Seawalls and Detached Breakwater (Krib) (Fig. 8), usually large structures made with concrete mixtures. Curved seawall has a concave shape designed to deflect incoming wave energy upwards and away from the bottom of the seawall to reduce scour at the base of the wall. In addition, the government also made a detached breakwater for coastal protection against erosion; this type is not connected directly to the coastline, is made perpendicular to the beach, and is at a certain distance from the shoreline. This building protects the beach behind it from wave attacks, which can cause erosion. This breakwater is made separately offshore but is still in the breaking wave zone.

Fig. 6 **a** The waves crash against the gabions holding the shoreline (January, 2020). **b** A combination of piles of gabions, tree branches, and sacks filled with sand as an effort to prevent abrasion. **c** Abrasion has reached the walls of residents' houses which are located close to the beach (December 2022-January 2023). **d** Beach slope angle. **e** Piles of garbage as a component of beach sand. **f** Residential expansion to the shoreline area (left side and middle part figures) and sand digging in the coastal area (right side figure)

Discussion

The coastal area of Aeng Batu village has experienced shrinkage, especially in the hamlets of Jonggobatu, Pangganga, and Karamak. Depreciation occurs due to human and natural activities (Figs. 2a and 4 show the shrinkage conditions). According to Prasetyo et al. (2020), the coastline has been shrinking for several decades, so the land area is decreasing and can endanger the people around the coast. Disruption of the natural balance of the region due to damage to the coastline is the cause of the shrinking of the coastline. The case of North Galesong Beach, apart from being caused by nature, namely tidal waves, also occurs due to human activity (anthropogenic). Natural factors come from the influence of hydro-oceanographic processes in the sea, which can cause waves to fall, changes in current patterns, tidal variations, and climate change (Supriyanto 2003).

Fig. 6 (continued)

(e)

(f)

On the other hand, anthropogenic factors in human behavior contribute to coastal erosion. One of them is the imbalance of the marine ecosystem, where there is massive exploitation by humans of the wealth of marine resources such as fish, coral reefs, and other biota. So, if there is a current or large wave that will go straight to the beach, it can cause abrasion.

Destruction of Aeng Batu beach due to anthropogenic factors

Increase in population and increase in residential land

One of the causes of coastal damage due to anthropogenic factors is the use of coastal border areas as residential locations. Figure 2a, b, c, and d show residential areas, green open spaces, and agricultural and farming land, which have generally experienced changes; residential land is increasing, and green open space and agricultural and farming are decreasing, which causes a decline in environmental quality. These three changes occurred due to the village population continuing to increase yearly. Land degradation often occurs in conditions of rapid population growth. According to Yuliani et al. (2018), increasing population pressure will reduce environmental quality because the ecological burden is too significant. In addition, increased population growth will increase vulnerability to climate. Residents who live in the coastal area of Aeng Batu village who work as fishermen are low-income communities (Asmal and latief 2023), and according to Jiang and Hardee (2011), it is the poorest countries and groups most affected by climate change, such as floods, droughts, and landslides.

This population growth is in line with the development of the need for residential space, but there is limited availability of residential space, causing people to use coastal border space as a place to live; not only that, there has even been an expansion of residential areas up to the coastline (Fig. 6f). Several opinions and research results explain the impact of population development on coastal environmental degradation. Kwong Fai and Gunasiri (2014) state that the expansion of residential areas and urbanization often harms coastal regions and negatively influences coastlines due to human activities in coastal areas. Thompson (1937) said that the population of the coastal regions grows faster in many countries than in non-coastal areas. According to Creel (2003), about half of the world's population lives within 200 km of a coastline, about 3 billion people. By 2025, that number will likely double, so we can imagine how many people need a house, which will impact the situation. Those who live in coastal areas will carry out various activities, and Prasetya (2007) states that human activities influence coastline changes over time, causing coastal erosion. Creel (2003) says that besides land intervention in coastline areas, anthropogenic activities also significantly impact coastal environmental damage like abrasion.

Another area for improvement with the provision of housing, which impacts coastal environmental degradation, is the emergence of a trend among the Aeng Batu coastal community, which currently prefers to build stone

houses rather than wooden ones. Furthermore, according to Padar (2021), stone houses are usually chosen to be built on the beach and in forest areas. Murat P further said that stone houses are very durable and resistant to all kinds of bad weather, from thunderstorms to extreme heat. Stone also provides significant insulation, making these homes highly energy efficient and lowering energy bills. In addition, currently, there is no need to use wood materials because, according to Tsai and Wonodihardjo (2018), solid wood materials are generally expensive and difficult to find. The reason is that residents prefer to sell them to the furniture market rather than build traditional houses. The Aeng Batu community and village officials also expressed similar things, saying there is no longer any construction of wooden houses in their area because wood, apart from being expensive, is also challenging to find.

In addition, the community sees the area's potential, namely beach sand. Sand is one of the building materials for stone houses. They use beach sand as a filler (sand filling) for stone houses and roads. To save costs, the community digs sand in the coastal area to meet the needs for building materials. As a result, holes appear on the beach, and the community closes or fills these holes with garbage. When the ROB occurs in floods or high tides, the waves will hit the beach, so the sand sediment carried by the waves to the beach will be mixed by waves with non-solid rubbish and quickly decompose. This material is easily washed back into the sea because the beach sand structure is easily eroded (Fig. 6e and f /figure on the right**),** resulting in abrasion.

Sea sand mining

Apart from the change in population development, which is in line with residential land development, sand mining is another important factor that impacts abrasion in the Aeng Batu beach area. In 2016, sand mining in the sea near the Galesong area began by mining companies and affected the coastal environment's degradation. In Figs. 4 and 5, in 2019—2021, it can be seen that along the coast of Aeng Batu Village, there has been a decrease in the coastal border area. Furthermore, in 2020, there was severe erosion on the beach of Pandanga hamlet (Figs. 6a and b). After this incident, the local government built a break wall (Curved Concrete Wall combined with a Detached Breakwater) (Fig. 8) to prevent further continuous erosion in the hamlet. Hence, the coastal land area becomes more stable. However, abrasion will occur again in late 2022 to early 2023 (Fig. 6c). Poor management of sand mining will disrupt the balance and function of the environment, such as causing damage to fishermen's fishing areas, erosion of the topsoil, the formation of large holes, and a decline in the quality of the environment. Some abrasion is natural and easy to spot. However, abrasion can be made worse by human activities such as sand mining activities, because in these activities, the land cover changes to open land, thereby triggering high rates of erosion in sand mining areas (Suhermana et al. 2015) (Dhiaurrahma. 2018). Apart from that, dredging beach sand also facilitates erosion, and it is possible that the height of the sand on the coastline will decrease, and holes will form in the former dredged area. According to Acting Head of BLH Seruyan Sugian Noor (Repoblica. co.id. 2014), because of its mutually covering nature, the sand on the beach will likely fall into the sea to cover the holes in the ocean due to dredging of sea sand.

Location of sand mining

The sand mining zone regulated in Panperda RZWP3K is about six nautical miles (9.6 km) from the shoreline. Whereas for the farthest distance of up to about 15 nautical miles (24 km) from the coastline, likewise in Law number 27 of 2007 as amended into Law number 1 of 2014, the South Sulawesi Province RZWP3K covers land planning areas starting from coastal districts to waters with a maximum area of 12 nautical miles measured from the coastline, but in Figs. 4 and 5 it can be seen that in the sea sand mining zone the closest distance is about 2.5 km from the coastline. The farthest is about 20 km, which is still a fishing area for traditional fishermen. From this description, it is not by the Republic of Indonesia Law about the sand mining site.

Mining of sea sand can change the geomorphology of the seabed because, according to the P3GL report (2000), the morphology of the seabed, which should form a contour pattern of depth parallel to the shoreline, is now rounded to form a deep hole (Sofiyani et al. 2012). The deep holes formed by sand mining are not far from the beach (according to the nearest sand mining location, which is 2.5 m), and with high tides, these holes are likely to be filled again soon by waves of sand carried through the water, so that the tides accelerate beach abrasion. Tides occur because water is an essential means of transportation for sediment (Rentier and Cammeraat 2022). Sediments move from one place to another through the process of erosion. Erosion removes and transports rock or soil; erosion can move sediments through water, ice, or wind (Evers et al. 2022).

Sand dredging can have both direct and indirect impacts on beaches. Filling the dredged area with material from the coast via trans-coastal sediment transport is considered to have an immediate impact. However, even when the dredging pits are not loaded, disrupting the coastal cycle can indirectly affect the shoreline by changing tides (Demir et al. 2003).

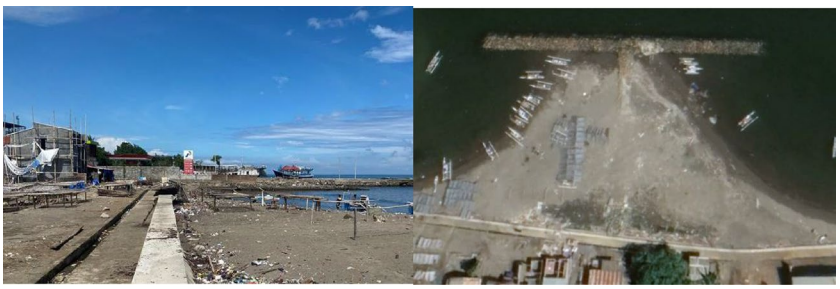
Sea sand mining is prohibited as regulated in Law of the Republic of Indonesia Number 27 of 2007 and revised by Law of the Republic of Indonesia Number 1 of 2014 concerning Management of Coastal Areas and Small Islands. Article 35 states that sand mining is prohibited if it can damage aquatic ecosystems. Article 35, paragraph (1) states that sand mining in an area that technically, ecologically, socially, and culturally causes environmental damage and pollution, harms the surrounding community, and violates Article 109 of the Republic of Indonesia Law. From Indonesia no. 32 of 2009 concerning Environmental Management. The coastal area is a transitional area between the sea and the land, and this condition causes the coastal area to be under pressure from various activities and phenomena that occur on land and in the sea (Damaywanti 2013, Ihsan and Pin 2019).

Flat beach conditions

According to BPS Kabupaten Takalar (2021), the Aeng Batu area has a coastal, plain, and hilly topology. The western area of the village is a coastal and lowland area with a slope of 0–3 degrees and a flat shape. The flat beach conditions (Fig. 6.d) have a high abrasion potential. According to Pitman (2014), a flat or gentle beach slope can also indicate coastal environmental erosion because sand is removed from the beach faster than it accumulates. In addition to the flat topography of the beach, residents fill the former sand pits with rubbish (leaves, tree branches, and plastic rubbish), causing a mixing of sand and rubbish. Composing during high tide, strong winds, and high waves is effortless. Abrasion occurs because the surface of the beach sand is not congested enough. Figure 6e shows this condition. Apart from that, the tide-carrying sand aggregate will also fill the hole so that the sand and piles of rubbish mix, causing the beach structure to become less dense and porous. Aggregate stability is critical for infiltration, root growth, and water and wind erosion resistance. Unstable aggregates disintegrate during rainstorms (Daniells 2012).

Degraded land can significantly impact other resources, including ecological and human resources. Highly compacted soils contain few large voids, a more minor total pore volume, and consequently a greater density. Because compacted soil has less porosity, less water infiltration, and

Fig. 7 Abrasion mitigation by local people



Curved Concrete Wall DetachedBreakwater.

Fig. 8 Abrasion prevention strategy by local government

less soil runoff and erosion, this condition is suitable for coastal land to avoid erosion. Soil compaction increases bulk density and strength and reduces soil porosity and hydraulic properties (Shaheb et al. 2021). Beach erosion is a process of sediment loss on the beach, resulting in reduced sediment reserves (Anthony 2021).

Abrasion prevention strategy

The government and society have implemented several strategies to reduce abrasion, and its impact on society has been ongoing. Figures 7 and 8 show the efforts of local communities and local governments to prevent abrasion, namely:

1. Local people use wood, bamboo, tree branches, trunks, sandbags, and gabions. In developing countries, coastal protection with log piles may be a low-cost and environmentally friendly countermeasure option that local communities or individuals can readily implement. However, the effectiveness of these piles in a realistic environment has yet to be scientifically proven (Takagi et al. 2020). Local people build bamboo structures to protect young mangrove forests from incoming waves. Bamboo acts as a breakwater and is considered an environmentally friendly permeable structure to reduce wave energy and stimulate sedimentation (Armono et al. 2022). Dao et al. (2018) plotted the effect of wooden fence parameters on wave attenuation. Using wood, bamboo, and gabions to anticipate abrasion is typical for coastal communities, but using wood or gabions can be used for temporary buildings. Even so, local people have their ways of using this material, one of which is by arranging bamboo to resemble a fence. However, they fill the bamboo with sand or concrete so that it is heavier and does not collapse easily when waves hit it. Therefore, it is necessary to consider if, in an emergency, the government still needs to provide for the construction of a sea wall.
2. The sea wall structure made by the government is in the form of a combination of curved concrete embankments and Kribs, preferably with soft structures in the form of plants (protective trees) to protect the coastal border area. Apart from strengthening the structure of the coastal land, its function is also as a barrier from wind and seawater intrusion to the mainland and a habitat for animals that live on the beach. Vegetation stabilizes dunes in two ways. First, roots hold the sand together; second, above-ground vegetation traps sand particles as they are blown to the surface. When the dunes are less vegetated, they remain unstable, so they migrate (Coasts of Erosion (n.d.) http://thebritishgeographer.weebly.com/coasts-of-erosion-and-coasts-of-deposition.html).
3. Seawalls construction uses hard rock as an erosion management tool when coastal erosion occurs. However, this complicates the erosion problem by making erosion worse or by shifting the location of erosion to the surrounding area (Jayappa and Deepika 2017). Erosion happens in the research area, where abrasion moves yearly to places that have not built sea walls.
4. Making a breakwater should meet the criteria; technically, the breakwater must withstand waves, penetrate water and sediment, be light in construction, materials are easy to obtain, and its implementation does not require heavy equipment (Suripin et al. 2017).
5. Avoid throwing garbage in the beach area and clean the beach of trash sent from the sea and within the settlements themselves (Fig. 6e). Law enforcement must not make waste a pile for residential land around the beach because it makes the soil structure unstable.
6. Avoid living (house built) in coastal areas, especially on the shoreline (Fig. 6f)
7. Avoid Digging sand on the beach area (Fig. 6f)

Conclusion

Human activity is the leading cause of abrasion, namely sand mining in sea areas close to settlements by several companies to fulfill the reclamation needs of the Central Point of Makassar and excavation of beach sand by local communities for building material needs. Sand mining in the sea and on beaches will leave holes, and mining in the sea and on beaches will leave holes in shallow seas; ROB and sea currents will bring back beach sand to fill the holes. On the other hand, residents will cover the holes in the beach area with tree branches and rubbish, making the beach structure less dense. This activity is conducive because beach sand has been mixed with trash and made worse by the sloping surface of the beach. ROB floods and high tides make it easier for sand to erode. This continuous erosion eventually becomes an abrasion. The community and government have made various efforts to prevent that, and Community efforts include using sandbags, gabions, tree branches/trunks, bamboo poles, and wood. The community has installed gabions and sandbags three times, but they are always buried when annual floods and high tides occur and cannot prevent abrasion. The position of the gabions and sandbags is getting closer to residential areas, at the position of the highest tide limit; some are even in front of the terrace of the house. The government attempts to overcome this problem by building a beach wall, namely a curved construction wall combined with a Detached Breakwater. The curved concrete walls have rocky foundations, making it difficult for fishing boats to dock nearby, while fishermen always park their boats near residential areas. Meanwhile, Attached to the Breakwater,

the outer side is protected by reducing wave energy to reduce the waves and current behind it. However, on both sides/ends of the Breakwater, there is space, so this space becomes a gap where the waves enter and hit the beach harder so that this side experiences abrasion again. Prevention efforts must include government and community efforts in the form of awareness and education regarding the prohibition against carrying out development in coastal border areas, especially beach areas, as well as not excavating sand and piling rubbish in the dug holes. Meanwhile, the government must be more disciplined in sand mining locations so that they are further away from the beach area (according to applicable regulations) and make regulations in the form of prohibitions regarding this matter and also regarding residential construction and dredging of beach sand, as well as the addition of beach walls and crypts along the coast, especially those that stretch against abrasion.

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Authors' contributions Idawarni is the primary author and correspondent author, who is the coordinator of research and all related to this article assisted by members Samsuddin Amin, M. Yahya, and Sapta Asmal conducted field surveys and primary data collection to see field conditions and distributed questionnaires to the community as well as interviews related to surveillance. Edward Syarif, Fridawati, and Rudi Latief assisted in preparing the article, including the search for secondary data and analysis, including the syntax space description. Ridwan assisted in editing articles and submitting them to selected journals. All authors have read and agree to the published version of the manuscript.

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Data Availability Reny Sri Ayu (2020) stated that Walhi South Sulawesi recorded that at least 23 million cubic meters of sea sand were taken from the Galesong coast for CPI (Centre Point of Indonesia)reclamation.

Declarations

Ethics approval All author members gave their informed consent for inclusion before they participated in the study.

Consent to participate All authors strongly agree to participate in writing improved articles in the population and environment journal.

Consent for publication All authors strongly agree to include this article in the population and environment journal availability of data and materials: The data presented in this study are available in the article.

Conflict of interest No conflict of interest.

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