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# Abrasion and accretion at West of Buleleng subdistrict's coastal area, Bali (case study: Gerokgak Regency, Seririt Regency, Banjar Regency, and Buleleng Regency)

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**Abstract.** Gerokgak, Seririt, Banjar, and Buleleng coastal areas are located in the west of Buleleng Regency, Bali. These area are prone to abrasion and accretion. Abrasion and accretion is a natural phenomenon that's runs balanced. Human factor caused this phenomenon were change the balanced, it causes harm to humans. The purpose of the research were to analyze influece of abrasion and accretion toward land use wide at coastal area. The research used Landsat 5, 7, and 8 images with 3 periods which were 1990 and 1997, 1997 and 2007, and the last period was 2007 and 2017. The data were processed by calculate long, width, and wide of coastline change inter period. It were relate with wide's land use change at coastal area. The result showed that abrasion and accretion were happen along the coastal areas in research area. The worst abrasion were located in Gerokgak Subdistrict with extensive 217.109 m<sup>2</sup>. One of it's impact are some ponds and buildings around the Segara temple at Gerokgak Village's were destroyed.

## 1. Introduction

Gerokgak, Seririt, Banjar, and Buleleng coastal areas is located in the west of Buleleng Regency. Length of coast in the research area is 113,16 Km with spesification 76,69 Km at Gerokgak Subdistrict; 11,62 Km at Seririt Subdistrict; 8,06 Km at Banjar Subdistrict; and 16.52 Km at Buleleng Subdistrict [1]. The villager's livelihoods in this coastal areas is tend to tourism and fisheries activities [2]. The development of these four regency tends to lead to the coast. The southern part of Buleleng Subdistrict is the hill that its hard to make a development in that region. Landuse change at the Buleleng Subdistrict coastal areas has a lot of variation, there is Celukan Bawang Port and Celukan Bawang Power Pland Electricity, hotels, villas, settlement and another tourism facility. It can caused abrasion and accretion at research area were the abrasion is the erosion or degradation of mainland due to sea wave hydrodynamic work [3]. Coastal erosion is one of the serious problems of coastline degradation caused by wind, rain, currents and waves, and human activity [4]. Abrasion and accretion run balanced between each other, the human factor caused the phenomenon can occur unbalanced. This causes harm to people that living in coastal areas.

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The total length of coastline at Buleleng Subdisrict is 157,05 Km and damaged by abrasion along 44 Km [5]. It related to landuse change at the research area. This study was conducted with the aim of analyzing the relation of coastline changes to land use change in the west of Buleleng Regency coastal areas. This research used Geographyc Information System for analyze abrasion and accretion for 37 years period time (1990 – 2017).

## 2. Methodology

The time of this research is in the period of 1990 to 2017, there was a significant land use change and more of abrasion and accretion occured at Buleleng Subdistrict, especially at Gerokgak Regency [6]. The variables in this research is: (1) Land use; (2) Direction and Current Speed; (3) Bathymetry; and (4) Geology. The data processing include: (1) Landsat image analyze with grid wide 2x2 Km; and (2) The result are given the clarity for changes of coastal length and distance of it's change (Table 1).

**Table 1.** Class of Shoreline Change

Classification	Distance Changes Against Mainland	Changes of Coastal Length	Land Use Changes Ratio
Minor	<50 m	<100	0-0,002
Medium	50-200	100-500	0,0021-0,004
Major	>200 m	>500	>0,004

Conducting an accuracy test to compare pre field data with post-field verification to see abrasion and accretion and landuse change on each grid, as follow [7],

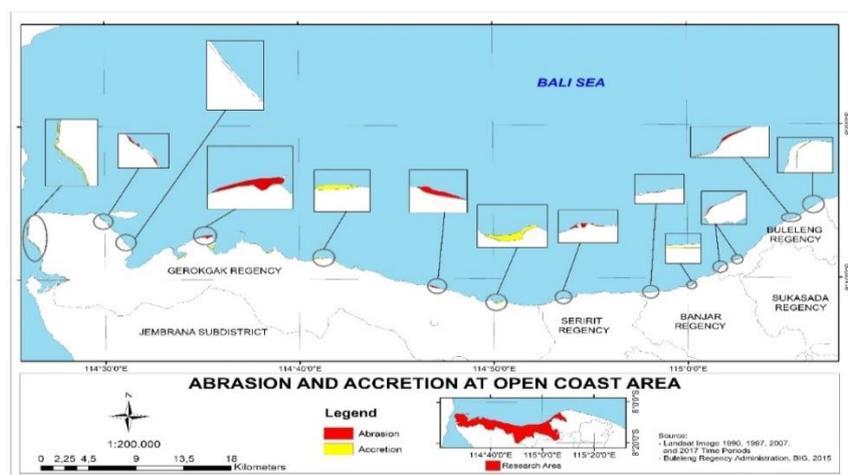
$$\text{Landuse coverage} = \frac{\text{Total of Corrected Sample}}{\text{Total of Sample Points}} \times 100\%$$

## 3. Results and Discussions

### 3.1 Abrasion and Accretion at Open Coast Area

The kind of beach in the study area is dominated by open beaches. The beach is directly facing to Bali Sea. The kind of coast in the research area are sandy's beaches which is dominated by black sand and only at Gondol Cape is white sand beach. Coastline change on the open beach are dominated by abrasion.

The number of villages whose coast was abrasioned in the 1990-1997 period time are amounted to eight villages (12 grids). The total number of villages in the research area is 37 villages. In the period 1997-2007 and 2007-2017 the number of coastal villages had abrasion amounted to 29 villages (32 grids). The damaged building is located in the vicinity Segara Temple in Gerokgak Village.



**Figure 1.** Abrasion and Accretion at Open Coast Area

The number of coastal villages has been accretion in the period 1990-1997 amounted to 12 villages (14 grids). In the period 1997-2007 and 2007-2017, the number of coastal villages has been accretion amounted to 16 villages (32 grids). The abrasion and accretion run well in the study area (Figure 1).

The largest shoreline changes on the open beach are in the subdistrict of Gerokgak. It is one of them has influenced by geology factor. The geological structure in the western part of Bali Island (Gerokgak sub-district) is composed by volcanic alluvial deposits of Mount Pulaki consisting of lava rock and Pliocene-age breccia [8]. The pliocene-aged sediments were crushed by alluvium-aged resin deposits. The precipitate is very susceptible to erosion by wave energy, currents, and weathering processes especially by water. This resulted in sand deposits in coastal areas easily eroded and deposited. The alluvium deposits extend from Gerokgak Sub-district to Banjar Sub-district which also suffers from severe abrasion and accretion after Gerokgak District. In the western region there is prapatagung formation consisting of limestone, limestone limestone, and napal.

The formation is located in the area of West Bali National Park and surrounding areas. Abrasion in this region is not so big because it has been planted mangrove forests. The geological structure in Buleleng sub-district up to Tanjung Penarukan is volcanic rock of Buyan-Bratan and Batur. The component of material is harder than the alluvium resin [8]. It doesn't significantly affect abrasion and accretion in this region. Abrasion and accretion at Buleleng Subdistrict are more influenced by human activities in coastal areas.

Another factor is the current speed and direction. The current characteristic of Bali Sea is composed current. The average current speed of the Bali Sea is 0-5 cm / sec [9]. In the west monsoon the direction of currents in the western part of Bali Sea away from the mainland towards the northwest, in Buleleng Subdistrict and surrounding currents near the mainland from the northwest. When the eastern monsoon is the opposite. The current around the coast of the Bali Sea is vulnerable to erode the mainland and also precipitated the sediment which is susceptible to cause abrasion and accretion, especially in the western part of northern Bali.

Mainland hydrological factors also affect the abrasion in the research area. There are 4 major rivers along the research area, there are Tukad Gerokgak were located in Gerokgak Village, Tukad Banyuaras in Banjar Asem Village, Tukad Saba in Seririt Village, and Penarukan Tukad in Penarukan Village. The four major rivers affect the erosion and sedimentation in the estuary area so that the area has abrasion in Muara Tukad Banyuaras and Tukad Saba and has been accretion in estuary of Tukad Gerokgak and Tukad Penarukan.

### *3.2 Abrasion and Accretion at Bay Area*

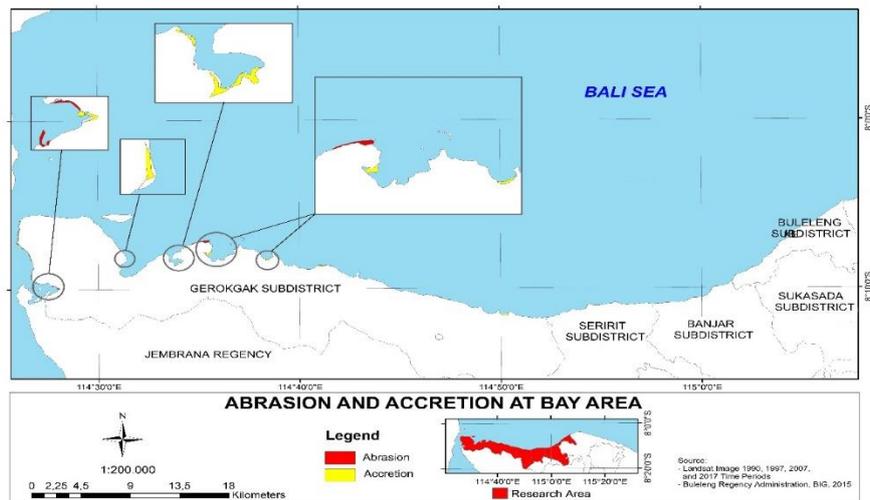
The number of bays in the research area is only four which is located on the west of West Bali National Park, east of West Bali National Park, and coastal areas around the fishpond area at Pajarakan Village. Abrasion at bay in the 1990-1997 period time until 2007-2017 period time occurred in only 3 bays that's located in 2 villages. Total of grids around the bay are 15 grids. The number of grids has been abrasion in the 1990-1997 period time until 2007-2017 period time amounted to 4 grids. There is no damage caused by abrasion in the bay area because there're protected by mangroves.

Accretion in the bay has been occurred in 3 bays at 1990-1997 period time and 1997-2007 period time and 4 bays in 2007 and 2017 period time. Total of villages were accreted in the 1990-1997 until the 2007-2017 period time are 2 villages. The number of grids around the bay are 15 grids. The number of grids that were accreted during the 1990-1997 and 1997-2007 period time amounted to 4 grids and the number of grids that accreted during 2007-2017 period time amounted to 5 grids (Figure 2).

Geological structure in the area of West Bali National Park as a whole to the western bay of Pajarakan Village are consist of Prapatagung limestone formation. The east bay at Pajarakan village consists of volcanic alluvial deposits. Both formations are susceptible to weathering mainly by water and erosion by wind, currents and waves [8].

Current speed in the four bays averages 0-5 cm / sec [9]. The direction of the current depends on the monsoon. The composed stream can erode the material around the coastal area. The alluvium-aged resin sludge is a region susceptible to the wasting of currents, waves, and weathering.

There is no large river in the bay in the study area. There are only 3 small rivers. There are Tukad Krapyak, Pangkung Palengkong, and Tukad Teluk Bajul. All rivers in the bay area have an effect on the accretion, but there is an accretion caused by reclamation that is accretion in the eastern part of Pajarakan village, at the estuary of Tukad Teluk Bajul.



**Figure 2.** Abrasion and Accretion at Bay Area

### 3.3 Land Use Change in Coastal Areas

Land use in the 1990-1997 period time has not undergone significant changes. Irrigated rice fields experienced the largest reduction, which amounted to 37.56 Km<sup>2</sup>. Buildings in coastal areas during this period increased by 0.37 Km<sup>2</sup>. Settlement area decreased by 0.27 Km<sup>2</sup>. The area of ponds, forests and moorings increased by 0.03 Km<sup>2</sup>, 25.54 Km<sup>2</sup> and 3.19 Km<sup>2</sup> respectively in Mangroves area are remains 0.1 Km<sup>2</sup>.

Land use change in the period 1997-2007 have seen significant and more varied. The largest wide of land use change is irrigated rice field with an increase of 31.45 square kilometers. The smallest change is the mangrove with a wide increase of 0.68 Km<sup>2</sup>. Extensive area also occurred in the building area of 1.22 Km<sup>2</sup>, settlement area of 2.97 Km<sup>2</sup>, fishpond area of 0.69 Km<sup>2</sup>, and forest area of 6.12 Km<sup>2</sup>. Widespread reduction occurs on the moor by 9 Km<sup>2</sup>. The widespread reduction is due to changes in land use from mooring to settlements and buildings.

Land use change in the period 2007-2017 are quite significant and more varied. The largest wide of land use change is irrigated rice field which decreased by 28,42 km<sup>2</sup>. Reduced land use area also occurred in forests of 7.13 Km<sup>2</sup> and mangroves by 0.36 Km<sup>2</sup>. Other land uses have increased area. The largest increase is the area of 18.24 km<sup>2</sup>, while the smallest increase is 0.9 Km<sup>2</sup>. The additional area extension of 5.51 km<sup>2</sup>, Fishpond area of 1.61 Km<sup>2</sup>, and garden area of 3,04 Km<sup>2</sup>.

### 3.4 Relationship between Abrasion and Accretion with Land Use Change

The research has doing the accuracy test. The total sample size is 24, for abrasion samples there are 16 samples. The 12 samples are accurate and the other 4 are not accurate because the sample be handled by the government by building abrasion embankment. The accurate samples are located at Celukan Bawang Port area, fishpond area near SDN 4 Gerokgak Village, Building around Segara Temple at Gerokgak Village, Lovina Beach, the area around Celukan Bawang Port and Power Plant Electricity, Beach in front of Pulaki Temple, western area of West Bali National Park, the eastern coastal area of Pajarakan village, the eastern part of the village in Banyupoh village, the fishponds around the areas of

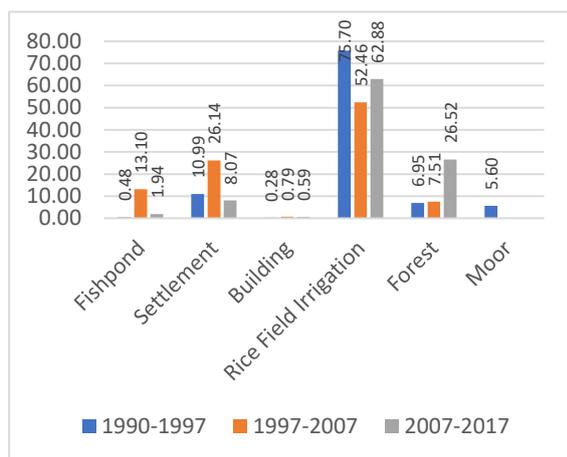
Pajarakan village, and the western village of Banjar. Inaccurate sampling at Penimbangan Beach, Villa in Kalapaksa Village, Beach at the east of Penarukan Village, and Nalika Beach. It shows an accuracy value of 60%.

The total area of land use that was abraded in the 1990-1997 period time was the largest irrigated rice field with an area of 11.52 Km<sup>2</sup>; followed by settlement of 1.67 Km<sup>2</sup>; forests of 1.06 Km<sup>2</sup>; mooring of 0.85 Km<sup>2</sup>; ponds of 0.07 Km<sup>2</sup>; and buildings of 0.04 Km<sup>2</sup>. The percentage of each area that was abstract was 75.7% for irrigated rice fields; 10.99% for settlement; 6.95% for forests; 5.6% for mooring; 0.48% for ponds; and 0.28% for.

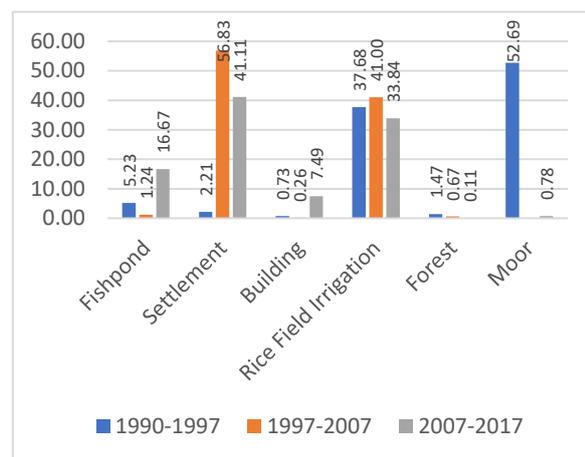
The total area of land use that was abraded in the 1997-2007 period time was smaller than the previous period. Total of land use wide was abstracted in this period is 15.21 Km<sup>2</sup>. Currently the landuse that abreted are fishponds, settlements, buildings, irrigated rice fields, and forests. The moor is not abraded in this period. The largest land use has been abraded is rice field with the total wide is 6.48 Km<sup>2</sup>; followed by settlement 3.23 Km<sup>2</sup>; fishpond of 1.62 Km<sup>2</sup>; forests 0.93 Km<sup>2</sup>; and buildings 0.1 Km<sup>2</sup>. Percentage abraded area is 2,46% for ricefield irrigation; 26.14% for settlement; 13.1% for fishponds; 7.51% for forests; and 0.79% for building.

The total land use wide in the 2007-2017 period time is greater than the previous period. This is a factor that human activitu can make abrasion worse than the previous period. Total of landuse was abraded during this period was 26.94 Km<sup>2</sup>. In this periods, the landuse change was abraded the same as the previous period, which is fishponds, settlements, buildings, irrigated fields, and forests. The moor is not abraded in this period. The largest landuse has been abraded is rice field irrigation of 16.94 km<sup>2</sup>; then followed by a forest of 7.15 Km<sup>2</sup>; settlement of 2.17 Km<sup>2</sup>; ponds of 0.52 Km<sup>2</sup>; and buildings of 0.16 Km<sup>2</sup>. Percentage of area has been abraded were 62,88% for rice field irrigation; 26.52% for forests; 8.07% for settlement; 1.94% for ponds; and 0.59% for buildings (Figure 3).

In the accretion area there are 8 accurate samples and no inaccurate samples. The accurate samples are located in the reclamation area east of the weighing coast, the Celukan Bawang power plant electricity, the old port of Buleleng, Menjangan Port, Gondol Cape Beach, and Cement of Tonasa Industrion, Water Police Station in Sumber Klampok Village, and the area around Bugis Village. It shows an accuracy value of 100%. Not all accretion in the study area is caused by natural factors. Of the 22 affected locations, only 7 locations (31.8%) of the accretion was occured by nature, while 15 other locations (68.18%) accretion was affected by reclamation for settlements, buildings, and ponds.



**Figure 3.** Percentation of Landuse has been Abrasion between 1990-1997, 1997-2007, and 2007-2017.



**Figure 4.** Percentation of Landuse has been Accretion between 1990-1997, 1997-2007, and 2007-2017.

The extent of land use that increased in the accretion area in the 1990-1997 period time amounted to 7.71 Km<sup>2</sup>. Land use wide has been increasing in this period is fishponds, settlements, buildings,

rice fields irrigation, forests, and moor. The largest land use area was increased moor with wide of 4.06 Km<sup>2</sup> (52.69%); followed by rice field irrigation of 2.9 km<sup>2</sup> (37.68%); fishponds of 0.4 Km<sup>2</sup> (5.23%); settlement of 0.17 Km<sup>2</sup> (2.11%); forests of 0.11 Km<sup>2</sup> (1.47%) and buildings of 0.06 Km<sup>2</sup> (0.73%).

The moor didn't increase in the accretion region during this period. The largest increase in land use is settlement with wide by 6.99 km<sup>2</sup>; then followed by irrigation rice field by 5.05 Km<sup>2</sup>; ponds of 0.15 Km<sup>2</sup>; forests of 0.08 Km<sup>2</sup>; and buildings of 0.03 Km<sup>2</sup>. Percentage of each area is 56.83% for settlement; 41% for irrigated rice fields; 1.24% for ponds; 0.67% for forests; and 0.26% for buildings.

The increased land use area in the accretion area in 2007-2017 period time is smaller than the previous period. The total area of land use that increased in this period was 11.64 Km<sup>2</sup>. In this period the landuse increased in the accretion area is fishponds, settlements, buildings, rice fields irrigation, forests, and moorings. The moor was again increased during this period. Largest land use wide increases is a settlement with wide of 4.78 km<sup>2</sup> (41.11%); followed by irrigated rice fields of 3.94 km<sup>2</sup> (33.94%); fishpond of 1.94 Km<sup>2</sup> (16.67%); building of 0.87 Km<sup>2</sup> (7.49%); mooring of 0.09 Km<sup>2</sup> (0.78%); and forests of 0.01 Km<sup>2</sup> (0.11%) (Figure 4).

#### 4. Conclusion

Abrasion and accretion at west of Buleleng Regency has a relation to landuse change, especially abrasion. Abrasion in the study area is all due to natural factor, human factor have an effect on the natural factors to accelerate. Accretion also has relationship to land use change, but accretion in research area is more influenced by human factor that is reclamation with percentage equal to 68,18% than natural factor with percentage equal to 31,81%. The phenomenon caused harm to the local population as evidenced by the destruction of buildings in the abrasion area.

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